Managing Bushfire Risk, Now and into the Future

Ku-ring-gai Principal LEP Background Study

March 2012

Ku-ring-gai Council

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Abbreviations

APZ	Asset Protection Zone
BTE	Bureau of Transport Economics
BFMC	Bushfire Management Committee
BFRMP	*Bushfire Risk Management Plan, 2010*
CCAM	Conformal Cubic Atmosphere Model
CFA	Country Fire Authority (Victoria)
CO_2	Carbon dioxide
COAG	Council of Australian Governments
CRC	Co-operative Research Centre
DCP	Development Control Plan
ENSO	El Niño-Southern Oscillation
EP&A Act	*Environmental Planning and Assessment Act 1979*
ESD	Ecologically Sustainable Development
FFDI	Forest Fire Danger Index
GHG	Greenhouse Gas(es)
Ha	Hectares
IPCC	International Panel on Climate Change
KLEP	*Ku-ring-gai Local Environment Plan (Town Centres) 2010*
Km	Kilometres
LEP	Local Environment Plan
LGA	Local Government Area
LPMA	Land and Property Management Authority
NPWS	National Parks and Wildlife Service
NSP	Neighbourhood Safer Places
PBP	*Planning for Bushfire Protection 2006*
ppm	Parts per million
RFS	NSW Rural Fire Service
RTA	NSW Roads and Transport Authority
SEPP	State Environmental Planning Policy
TEC	Threatened Ecological Community (incorporating Endangered Ecological Communities and Critically Endangered Ecological Communities, listed under either state or federal legislation)

Executive summary

Bushfire risk represents a clear and present danger to the Ku-ring-gai community, both now and into the future. Future risks need to be given special consideration given the potential that changes in climate may have on historical bushfire patterns.

The main purpose of this background study is to guide the preparation of the Principal Local Environmental Plan (LEP), to reduce risks from bushfire events to an acceptable level, consistent with the objectives and actions of state and regional legislation, plans and strategies, taking into account the full range of other strategies available to Council, fire agencies and the community to address these risks.

The study uses a risk management approach to assess the management of bushfire risks, now and under future climate change situations. It examines the context within which the risks occur, including the behaviour of bushfires, likely changes under climate change, the vulnerability and resilience of the Ku-ring-gai community (physically, socio-economically and environmentally) and the current response capacity in the area. The study then considers the future consequences of bushfires, recognising that historical consequences in Ku-ring-gai may not be an adequate guide when considering a changing climate.

The residents of Ku-ring-gai come from a diverse background, are well educated and have high average incomes. However, the ability to prevent the loss and damage of lives, property, biodiversity and the natural environment is not merely a question of economics, community spirit or education. The extent of bushland within and adjoining the Local Government Area (LGA) and the steep, rugged topography of the area results in a significant risk from fire for residents, public and private assets and the integrity of natural systems.

Most of the development close to the hazard has been constructed without due consideration of bushfire, (ie. prior to the passing of relevant legislation), with the bushland/urban interface extending to over 91 kilometres in length. 13,698 existing households are located within bushfire prone lands, as identified on the Bushfire Prone Lands Map certified by the NSW Rural Fire Service. This places Ku-ring-gai as having the highest proportion of interface properties within the Sydney Metropolitan Area (Chen 2005).

Development has also occurred in a number of locations where the local community is surrounded by extensive areas of bushfire prone vegetation, often with inadequate road networks to enable safe evacuation. Pressure to increase development in these areas has led to increasing evacuation risk to residents and workers, including a high number of elderly and very young residents.

According to current climate change predictions developed by the Department of Environment, Climate Change and Water (2008), the Sydney region is expected to experience significantly increased spring and summer rainfall, decreased winter rainfall, higher maximum temperatures and evaporation rates and an increased severity and frequency of heatwaves and droughts.

Hazard reduction burning is sometimes identified in the media as a panacea for addressing bushfire risk. However, in a good year 60 out of a total of 1,100 hectares of bushland in Ku-ring-gai is burnt as part of hazard reduction. Even at this level, local fire management resources are stretched and it is well below the area requiring prescribed burning to effectively manage the risks of fire to properties in any given year (Bradstock *et al* 1998). It is anticipated that the gap between what is achievable and ideal with respect to hazard reduction burning will likely be exacerbated under climate changes, as the appropriate conditions for prescribed burning will be decreased.

Council has undertaken extensive consultation with experts and the community in regard to potential options for adaptations to bushfire risk from climate change (Ku-ring-gai Council 2010). These adaptations consider the impacts on life, property and the environment and include preventative as well as defensive actions. It also recognises that adapting and responding to climate change related bush fire risk will not be without cost.

Many measures to address bushfire risk involve the removal of vegetation and habitat which has a negative consequence for biodiversity and other ecological processes. Increasing frequency and intensity of fire in the landscape may result in a permanent alteration of the structure and composition of ecological communities within Ku-ring-gai already exacerbated by urban fragmentation and degradation. Flora and fauna species, habitat and communities may be lost and ecological services will become degraded (Pitman *et al* 2007). Four threatened ecological communities found in Ku-ring-gai 'are all likely to suffer a loss of species if subject to repeated high frequency fires' (Ku-ring-gai Council 2006). Bushfire risk minimisation and biodiversity protection need to be considered in an integrated manner if we are to ensure that ecological integrity is also protected.

While the majority of bushfire related losses occur infrequently, losses are not unprecedented in the Ku-ring-gai region. Based on historical data, major bushfires that result in loss of life and property are 'neither cyclic nor predictable' (Blanchi *et al* in CIE 2010). The majority of losses occur infrequently, but significant losses are experienced.

Following the severity of the 2009 Victorian Bushfires, there appears to be weaknesses in our understanding of bushfire risk, policies and expectations of living in bush fire prone areas. The likely increase in intensity and frequency of bushfires under climate change will further exacerbate current risks (Bushfire CRC 2009). In line with Council's duty of care, relevant legislation and legal precedents, and taking into account the results of the Victorian Bushfire Commission (VBRC, 2010), this background study considers planning for adaptation to climate change as a key aspect of bushfire risk management.

The central role of land use planning and development controls in reducing the risk to people and property from bushfire is recognised both in state bushfire legislation, inquiries into major bushfire events and in federal and state strategies for adaptation to climate change.

The key land use recommendations for the draft Principal LEP are to:

a. Retain the one hectare lot size for existing Residential 2(g) lands, and increase the minimum lot size for all other residential, and school lands within the 10 evacuation risk zones that do not meet the exit criteria outlined in Appendix D;
b. Apply the E3 – Environmental Management Zone to sites that are both:
    - identified as at extreme bushfire risk using the Bushfire Risk Management Plan 2010 (Hornsby and Ku-ring-gai Councils: 2010) as a guide; and
    - within the 10 evacuation risk zones that do not meet the exit criteria outlined in Appendix D;
c. Apply the E4 – Environmental Living zone to all other sites that contain bushfire prone lands category 1 or 2, identified as extreme bushfire risk using the Bushfire Risk Management Plan 2010 as a guide;
d. Apply the recommended minimum lot depth standard to sites that contain lands within 55m of Category 1 or 2 bushfire prone lands, that are located within areas of extreme bushfire risk using the *Bushfire Risk Management Plan 2010* (Hornsby and Ku-ring-gai Councils: 2010) as a guide.

1. Introduction

Ku-ring-gai Council, located in Sydney's North Shore (Figure 1), is responsible for the management of 82km^2 of land which includes 11km^2 of bushland. Much of this bushland is contiguous with larger natural areas to the north, south-west and east of the Local Government Area (LGA) including Ku-ring-gai Chase, Lane Cove and Garigal National Parks. These bushland areas adjoin other green belts of National Park, private bushland and State Forest of the Greater Sydney Metropolitan Area.

The extent of this bushland and the steep, rugged topography of the area results in a significant fire risk for residents, public and private assets and the integrity of natural systems. While fire is an essential element for many Australian bush landscapes to ensure the viability of vegetation communities and native fauna, the frequency, intensity and timing can have adverse ecological consequences.

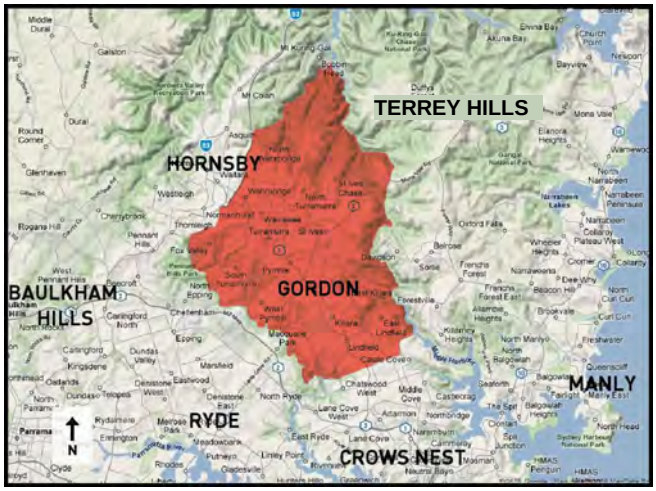
Bushfire events can have major impacts on the community, infrastructure, environment, and economy. Council, along with other agencies, plays a significant role in the management of bushfire risk both on public and private land, through land use planning and assessment, land management, emergency planning and education. The need to prepare Ku-ring-gai's Principal Local Environment Plan (LEP) provides an opportunity to incorporate strategic land management approaches to bushfire management.

Ku-ring-gai Council has researched the regional influence of climate and changing weather patterns, vulnerability related to past, current and future fire events, the level of resilience of today's community and developed adaptations options with draft priorities according to their cost benefit (Ku-ring-gai Council 2007; Taplin *et al* 2010; Ku-ring-gai 2010).

This background study is used to inform the draft Principal LEP, consistent with the objectives and actions of the North Subregional Strategy (NSW Department of Planning 2007 and the Metropolitan Plan for Sydney 2036 (NSW Government 2010b). Accordingly, this report will focus more on planning constraints and opportunities, while recognising that these measures are part of a broader range of responses required for bushfire management.

A common method of dealing with irregular events such as bush fire, is through a risk management approach. *Bushfire Risk Register – A Tool for Bushfire Risk Management Planning* (Zhenxiang Tan et al 2006). This is based on the Australian Standard, AS4360, *Risk Management*, and has become the standard for managing bushfire risk throughout NSW. In response, this planning study adopts a risk management approach to assess the constraints and future planning options for bushfire management in Ku-ring-gai.

Figure 1 Location sketch of Ku-ring-gai local government area



1.1. Aims and Objectives

This background study aims to guide the preparation of the draft Ku-ring-gai Principal LEP through providing a context for the consideration of bushfire within the draft LEP. This will be achieved through:

- An overview of the legislative, governance, biophysical, climatic, land use and socio-economic context of bushfire in Ku-ring-gai;
- A review of past, current and future data on bushfire behaviour and management;
- The identification of the vulnerability of Ku-ring-gai to risk from bushfire events;
- The identification of key resilience factors to bushfire;
- An examination of the adequacy of existing measures to address bushfire risk now and into the future;
- A review of the probability and consequences of major bushfire events for the LGA;
- The identification of actions to reduce bushfire risk now and into the future, with a focus on options for land use planning.
- Balance effective bushfire management and protection of the core ecological values of Ku-ring-gai

2. Legislative and Policy Context

Ku-ring-gai Council with the regional land and fire agencies have an active program to mitigate bushfire risks. This responds to Council's legal obligations to conduct extensive bushfire risk management programs. These include operational activities such as the implementation of landuse planning and to mitigate short, medium and long term risks to property, life and the natural environment. This section outlines the legislative framework within which this planning takes place. The potential legal repercussions to Council if it fails to adequately consider the likely future impacts of climate change are also raised.

2.1. Role of State Agencies and Council

During fire events effective, recognised leadership is required to protect life, property and the environment (Gill, 2005 pp 70). The role of local government in regards to a natural disaster such as a bushfire includes:

- Ensuring that all required local disaster planning and preparedness measures are undertaken
- Supporting an adequate local disaster response capability, including local volunteer resources
- Undertaking actions to mitigate the effects of natural disasters on local communities
- Methodically using risk assessments in land use planning to reduce hazards
- Improving public awareness and ensuring that local disaster warnings are provided
- Ensuring local resources and arrangements exist to provide disaster relief and recovery services
- Representing community interests in disaster management to other levels of government and contributing to decision-making processes
- Contributing to post-disaster assessment and analysis
- Identifying and managing bushfire hazards
- Implementing planning controls to limit development in high-risk areas
- Enforcing building standards in bushfire-prone areas
- Facilitating local fire-prevention committees
- Encouraging and supporting volunteers
- Co-ordinating local recovery after a disaster (Matthews 2002 pp 21).

Section 63 of the *Rural Fires Act 1997* states that it is the duty of a public authority to take steps to prevent the occurrence of bush fires and to minimise the danger of the spread of a bush fire on or from, any land vested in or under its control or management. As part of this requirement, it is the responsibility of Council to keep landowners informed of policies and policy changes, such as Council's Bushfire Management Policy 2008 (Ku-ring-gai Council 2008).

Severe fires experienced in Victoria in 2009 have resulted in a number of planning and development changes for bush fire prone areas at federal and state levels. These have included changes to *Planning for Bush Fire Protection (2006)* (PBP), the new Australian Standard AS3959-2009, provisions for construction of bunkers in bush fire prone areas and new communication systems implemented across Australia.

2.2. Role of private land owner

Responsibility for bushfire prevention falls to the owner, occupier or public authority is outlined in Section 63 (1-3) of the Rural Fires Act 1997.

Section 63 ***Duties of public authorities and owners and occupiers of land to prevent bush fires states*** (in part)

> *(2) It is the duty of the owner or occupier of land to take the notified steps (if any) and any other practicable steps to prevent the occurrence of bush fires on, and to minimise the danger of the spread of bush fires on or from, that land.*

One of the key messages from the NSW Rural Fire Service following NSW response to the Victorian Bushfires Royal Commission is to educate private land owners to take more responsibility for their own bushfire preparations.

2.3. Legislative and Policy Framework

A range of legislative instruments and planning protocols address bushfire protection in Ku-ring-gai. These are detailed below.

Environmental Planning and Assessment Act (1979)

The objects of the *Environmental Planning and Assessment Act (1979)* (EP&A Act) include the encouragement of the management, development and conservation of natural and built resources, the orderly and economic development of land, and ecologically sustainable development. Section 26 outlines in very broad terms the contents of an environmental planning instrument. This study supports the drafting of the Principal LEP for Ku-ring-gai, an environmental planning instrument under the Act.

Section 117(2) of the Act provides that the Minister may make directions regarding inclusions in a Planning Proposal (re-zoning).

Section 117(2) Direction No 4.4 requires compliance with the principles of Planning for Bushfire Protection 2006 or the provision of appropriate justification for non-compliance.

NSW Local Government Act (1993)

The NSW Local Government Act (1993) requires councils, councillors and council employees to have regard to the principles of ecologically sustainable development.

A council's charter includes requirements to exercise leadership, to be open and responsible and to act generally in the public interest. Specific requirements include planning for the needs of children and to have regard to the long term and cumulative effects of its decisions.

The Principles of Ecologically Sustainable Development as expressed in *Local Government Amendment Act, 1997* are used to guide decision makers in determining public interest. Application of the Principles is not negotiable under the requirements of this amendment.

The Local Government Act, 1993 provides protection for Councils in relation to any negligent act or advice concerning the risks arising from climate change and natural hazard risks. S.733 (2A) and (b) states council will not incur any liability for advice or thing done or omitted and furnished in good faith relating to the likelihood of land being subject to the risk of bushfire. Specifically this section relates to the preparation of planning instruments and carrying of hazard reduction works. However while Council enjoys this legislative protection, it remains vulnerable to litigation under other legislation such as the *NSW Civil Liabilities Act (2002)*.

NSW Rural Fires Act (1997)

Bushfire risk planning and management became a compulsory activity for all fire districts within NSW with the introduction of the *NSW Rural Fires Act (1997)*. The Act governs fire fighting, management, prevention and development in relation to bushfire risk.

Requirements are included for actions that assist in the co-ordination of bush fire fighting, prevention, mitigation and suppression of bush and other fires in local government areas and other parts of the State constituted as rural fire districts. The Act serves to protect persons from injury or death, property from damage, and protect the environment

by having regard to the principles of ecologically sustainable development.

A bush fire safety authority is required for residential and rural residential subdivision and for development for special fire protection purposes (i.e. school, childcare, hospital) on bushfire prone land.

Each area in the State that is subject to the risk of bush fire must form a Bush Fire Management Committee (BMFC) as part of the Act. Each BFMC is represented by the many major land management agencies including local government authorities. Ku-ring-gai is part of the Hornsby Ku-ring-gai District Bushfire Management Committee. The other members of this committee include:

- Hornsby Council;
- Fire-fighting authorities (NSW Rural Fire Service and NSW Fire Brigades);
- NSW Land and Property Management Authority;
- NSW Department of Energy, Climate Change and Water (National Parks & Wildlife Service
- division);
- NSW Police;
- Nature Conservation Council;
- Aboriginal Land Council;
- Energy Australia;
- Integral Energy;
- NSW Farmers Association;
- Roads and Traffic Authority;
- Sydney Water; and
- Transgrid.

Bush Fire Environmental Assessment Code (2006)

The Bush Fire Environmental Assessment Code was prepared pursuant to sections 100J to 100N of the *Rural Fires Act 1997*. The Code applies to any form of hazard reduction works and has regard to the principles of ecologically sustainable development and any matter likely to affect the environment that a determining authority would be required to consider under section 111 of the *Environmental Planning and Assessment Act 1979*.

The Code determines the type of hazard reduction works required, the impact of that work on the landscape and community and guides a process to set conditions that will achieve the best social and environmental outcomes. The certifying authority can then issue a certificate before the works can be undertaken.

National Inquiry on Bushfire Mitigation and Management (2004)

The Council of Australian Governments (COAG) National Inquiry on Bushfire Mitigation and Management (Ellis *et al.* 2004) recommends a risk management approach as '*the best framework for making strategic and operational decisions about bushfire mitigation and management.*' It describes three main elements of risk modification for bushfire as:

1. Planning processes that ensure that built assets are not placed in areas of high fire risk and that structures meet standards of construction that reduce their vulnerability
2. Reducing the frequency of ignitions that result from arson and carelessness
3. Managing the landscape so as to minimise the risk of damage to life and assets.

Land use planning, development controls and building standards have a central role in reducing the risk to people and property from bushfire.

In line with the first of these elements, the report states that:

'Land use planning, development controls and building standards have a central role in reducing the risk to people and property from bushfire.'

The Inquiry acknowledged that there are many constraints on achieving fuel reduction on a large scale across the landscape. Specifically it stated:

'Fuel-reduction burning should not be seen as a panacea: it needs to be used to address strategic priorities that respect the range of assets and values in a landscape and minimise the risk to each of them.'

Metropolitan Plan for Sydney 2036 (2010) and the North Subregion: Draft Subregional Strategy (2007)

The NSW Government requires local land use planning to be consistent with the objectives and actions of the Metropolitan Plan for Sydney (NSW Government 2010b). This plan provides a broad framework to facilitate and manage the growth and development of Sydney until 2036.

The *North Subregion: Draft Subregional Strategy* (NSW Department of Planning 2007) covers the Ku-ring-gai and Hornsby LGAs. This regional strategy translates the objectives of the Metropolitan Strategy (NSW Government 2005) and NSW State Plan (NSW Government 2010c) to more specific objectives and actions for the Hornsby-Ku-ring-gai region. It also acts as a broad framework for the long term development of the regions, guiding government investment, and linking local and state planning issues. The strategies provide details to guide the preparation of Principal LEPs.

The North Subregional Strategy (NSW Department of Planning 2007) chapter entitled *Environment, Heritage and Resources* is most relevant to the management of bushfire risk and natural resources with the key directions for the North subregion. The objectives include:

- To protect the natural environment of the subregion
- To protect the cultural and heritage elements of the subregion
- To manage all development sustainably.

Two broad aims relevant to bushfire risk management for the region and specific objectives and are:

1. To avoid/minimise bushfire risks to life property and biodiversity:
   - E5.3.3 Develop bushfire prone land maps and *Bush Fire Risk Management Plans*- with an understanding of climate change implications for bushfire risk and in accordance with *Planning for Bushfire Protection.*
2. To respond to climate change:
   - E5.1.1 Councils should consider latest information when planning for natural hazards including climate change;
   - E5.3 Identify natural hazards and risk management measures related to climate change in Principal LEPs.

The *Metropolitan Plan for Sydney 2036* (NSW Government, 2010b) also specifically recognises that climate change will result in increased frequency and intensity of bushfires for the Sydney region.

Plan for Collaborative Action on Climate Change (2006)

COAG recognised that a national response to climate change must meet the challenges of reducing greenhouse emissions and respond to the environmental, social and economic impacts that may result from climate change (COAG 2006).

The plan states that all jurisdictions need to work to reduce emissions and adapt to unavoidable climate change. Early adaptation planning must be a key focus and policies should be equitable, cost effective and have multiple benefits. The following sectors were identified as those with the most potential to benefit from early adaptation planning:

'buildings, settlements and infrastructure,…emergency services; water supply… and natural ecosystems. There are also significant benefits in early adaptation planning for human health… The land use sector is identified as a sector that can derive particular benefit from further planning and action to reduce emissions'

The plan includes a commitment to work towards a National Adaptation Framework, which includes strategies for managing fire, protecting human health, conserving biodiversity and managing water resources.

NSW Planning for Bushfire Protection (2006)

Planning for Bushfire Protection 2006 (PBP) sets requirements for development in bushfire prone areas. Its major focus is to guide individual development proposals and is called up through section 79BA of the EP&A Act. It also includes a section on the preparation of LEPs and Development Control Plan's (DCPs).

The plan acknowledges that inclusion of bushfire planning provisions in an LEP and DCP is the best way to achieve bushfire protection objectives. It highlights the opportunity to incorporate appropriate principles, to consider appropriate land uses on bushfire prone land and the provision of sufficient space for setbacks and access for fire fighting and evacuation. A number of planning principles for rezoning residential land in bushfire prone areas are set in the Act.

These principles relate to: land uses for special fire protection purposes; the provision of perimeter roads; asset protection zones (APZ); building lines consistent with the incorporation of an APZ; minimising the urban/bushland interface; and the location of hazardous developments and combustible materials.
Following the 2009 Victorian Bushfires, the Council of Standards Australia (Standards Australia 2009) has amended the construction requirements as detailed in AS3959-2009 (for construction on bushfire prone lands) as follows:

- Replaced three construction levels with six Bush Fire Attack Levels (BAL) based on the potential of a building to be exposed to various heat fluxes associated with ember attack, radiant heat and/or direct flame contact.

- Included more details for determining the effective slope influencing the rate of fire spread.
- Included provisions for attached structures (i.e. garages).
- Included provisions for building materials that have been subjected to fire safety test methods.

The plan also recognises that infill development may require a greater degree of performance based assessment. It is noted that significant areas of existing development do not meet bushfire protection requirements currently.

The plan acknowledges that inclusion of bushfire planning provisions in an LEP and DCP is the best way to achieve bushfire protection objectives.

PBP requires councils to consider exempt and complying development provisions. However, this provision has been superseded by State Environmental Planning Policy (Exempt and Complying Codes) 2008, which sets state-wide controls for exempt and complying development. The first instalment of complying development standards for development on bushfire prone was recently incorporated into the SEPP.

Many principles are easier to achieve in greenfield development sites and larger subdivisions. However, infill situations, as occur across Ku-ring-gai provide a challenge particularly within areas of existing extensive urban/bushland interface.

National Climate Change Adaptation Framework (2007)

The *National Climate Change Adaptation Framework (COAG 2007)* was developed in line with the requirements of the Plan for Collaborative Action on Climate Change by the Council of Australian Governments (COAG). The Framework outlines the agenda for collaboration between governments to address the need for targeted information and allow for the development of adaptation strategies to 2012 – 2014. Supporting decision-makers to understand and incorporate climate change into policy and operation decisions is a key focus of the framework. Potential areas of action incorporate the drying region of eastern Australia, of which Ku-ring-gai LGA is a part. Decisions made in this region without the consideration of climate change impacts, could lead to long-term increased bushfire vulnerability and costs..

The framework sets out a number of actions applicable to local government including:

- Analysis and revision of planning systems including standards for buildings, development and subdivisions;
- Review of information used to determine vulnerability of settlements to climate change related hazards, and development of risk management guidance to take into account any projected changes as a result of climate change;
- Identification and prioritisation of infrastructure assets vulnerable to climate change and development of risk management strategies to reduce vulnerability;
- Development of natural disaster risk reduction strategies, assistance with emergency services planning and recovery management.

Councils are required to include operational, emergency, recovery and land-use planning and policy measures in their strategies for adaptation to climate change. This applies to planning for council's own services and property, the natural environment and the community.

Hornsby–Ku-ring-gai Bush Fire Risk Management Plan (2010)

The Hornsby-Ku-ring-gai *Bush Fire Risk Management Plan* (BFRMP) (2010) was prepared by the Hornsby/ Ku-ring-gai Bush Fire Management Committee pursuant to the *Rural Fires Act (1997)* and the Australian/New Zealand Standard *AS/NZS 4360: 2004 Risk Management.* The *Draft North Subregional Strategy* also includes a provision to consider this plan.

The plan identifies community assets that are at risk from bush fire and establishes a 5 year program of co-ordinated multi-agency treatments to reduce risk and will be reviewed after this time.

The BFRMP supports four objectives, including:

1. To reduce the number of human-induced bush fire ignitions that cause damage to life, property and the environment
2. To manage fuel to reduce the rate of spread and intensity of bush fires, while minimising environmental/ ecological impacts
3. To reduce the community's vulnerability to bush fires by improving its preparedness
4. To effectively contain fires with a potential to cause damage to life property and the environment.

The strategies established in the BFRMP address the bushfire hazards, vulnerability of assets to fire, safety of the community and fire-fighters, and protection of the environment from fire. The plan recognises the role LEPs can play in controlling development in bushfire risk areas.

While the plan acknowledges that climate change will increase bushfire risk, the risk assessment process applied in the plan was based on current climatic conditions.

The BFRMP is available at www.hkbfmc.org.au

Ku-ring-gai Bush Fire Prone Land Map (2008)

Council's bushfire prone land map was certified in January 2008. The map is included at Figure 2 and classifies land according to the following fire risk categories:

- Bushfire Prone Vegetation - Category 1
- Bushfire Prone Vegetation - Category 2
- Bushfire Prone Vegetation buffer – 100m buffer to Category 1, and 30 m to Category 2.

Development of this map is a requirement of the *EP&A Act* where a Bush Fire Risk Management Plan applies. Council's are required to prepare these maps after consultation with the Commissioner of the NSW Rural Fire Service (RFS).

Changes to the bush fire prone lands map occur regularly in line with changes to development and bushland structure. These amendments are required to be considered by the NSW RFS.
A high resolution version of the map is available at http://www.kmc.nsw.gov.au/www/html/471-bushfire-prone-areas.asp

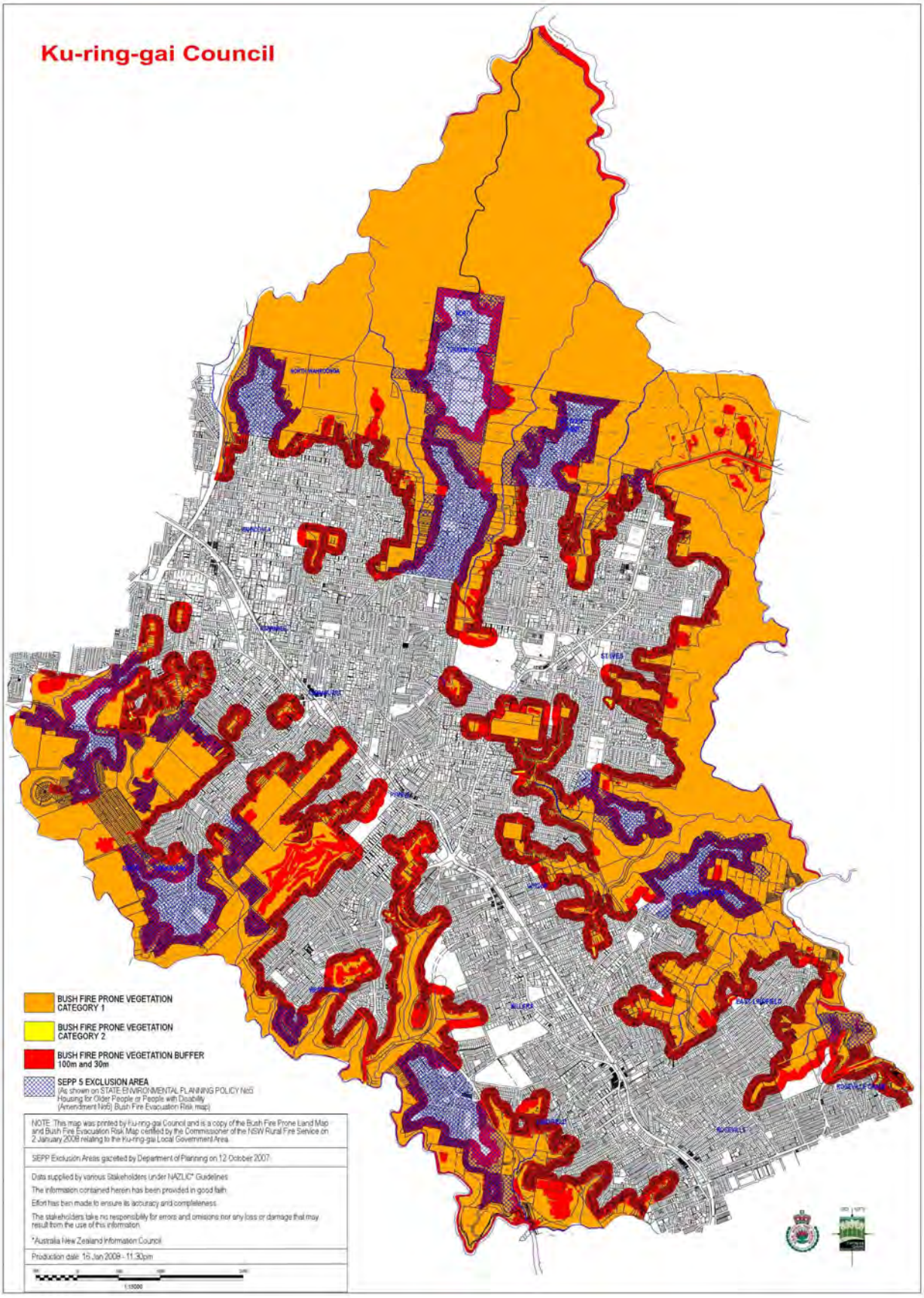
Ku-ring-gai Bush Fire Evacuation Risk Map (2008)

This map identifies areas within the LGA where severe evacuation risks may occur during a bushfire event. The map is identified within *SEPP (Housing for Seniors or People with a Disability) 2004* and *SEPP 53 – Metropolitan Residential Development* and limits development in accordance with these instruments. These instruments limit development for dual occupancy and seniors' developments in these areas.

The bushfire evacuation risk map was updated and certified in January 2008 (Figure 2). New areas included in the update apply to *SEPP (Housing for Seniors or People with a Disability) 2004*. It is unclear whether the new areas apply to dual occupancy permitted under SEPP 53.

Council's bushfire evacuation risk map has the potential to be used further to guide operational strategies and to consider appropriate land uses and density in these high risk areas.

Figure 2: Bushfire Prone Lands and Bushfire Evacuation Risk Map[1]



[1] http://www.kmc.nsw.gov.au/www/html/471-bushfire-prone-areas.asp

2.4. Legislative and civil liability risks to local government

Consideration of risks

Local governments are obliged to determine the short, medium and long term risks to their assets under their care and control. They must also forecast foreseeable changes that influence the level of risk, assess this against its reasonable financial capacity and consider the legislative and civil liability risks arising from its planning and decision-making (NSW Government 1993; NSW Government 2002).

Planning and decision-making in relation to potential future climate change and the probability and consequence of future fire events need to be incorporated within this assessment.

The lack of action to address climate change at all levels is encouraging individuals and environmental groups to explore non-legislative solutions. This includes taking their matters to the court system (Peel 2007). A significant number of successful administrative challenges involving climate change have occurred through the NSW Land and Environment Court (Gray v Minister of Planning & Ors 2006).

The NSW Land and Environment Court appears to have adopted a receptive disposition to climate change issues. In Walker v Minister for Planning (2007) particular relevance was given to planning within local government in relation to flooding in the event of sea level rise. Walker argued that the proposed development at Sandon Point, situated on a coastal plain 14km north of Wollongong City, would be affected by future climate change. Biscoe J held that the Minister for Planning did not adequately consider whether flooding impacts on the project would be compounded by future climate change.

Local government must take into consideration the legislative and civil liability risks arising from its planning and decision making.

There is a significant amount of good quality, detailed and easily accessible information available for local government authorities to use in the development of land use plans. Scientific (IPCC 2007a; Preston and Jones 2006; DECCW 2010 CSIRO 2009), and economic (Stern 2006, Garnaut 2007), evaluations of the risk and consequences of climate change are continually refining knowledge that improves the ability of governments to become more aware of their economic, environmental, social and legal responsibilities..

Local government contributes to the impacts arising from climate change, and risks legal liability if it fails to:

- reduce green house gas emissions
- assist efforts to offset risks
- recognise the potential consequences of climate change
- identify risks and protect infrastructure under their care and control
- implement strategies to maximise resilience to the physical, social and economic impacts of climate change
- demonstrate the application of the precautionary principle.

The *Local Government Act 1993* provides strong support for the argument that councils should attempt to deal with the consequences of climate change. Failure to do so may constitute a breach of its legal obligations under the Act. This is also supported in the *Civil Liability Act 2002* (NSW), ss 42-43;

'Therefore uncertainty relating to climate change is not a valid reason for a failure to respond to its potential impacts however these obligations must be read in light of the recognition of resource availability and the concept of reasonableness .'

Reasonableness in decision making and climate change

Given the detailed advice on the evidence supporting the probability and consequence arising from climate change it is evident that the concept of fact regarding foreseeability is satisfied. This applies at the global level from the International Panel on Climate Change (IPCC) (IPCC 2007b and c), for the Sydney region from CSIRO (2007) modelling, and for Ku-ring-gai specifically in the research by Bond and Macquarie Universities (Taplin *et al* 2010).

Community consultation regarding the risks from extreme weather events combined with historical evidence of the scope and scale of harm arising from past events allow decision makers to estimate the degree of investment warranted in adaptation. A recent survey of Ku-ring-gai residents on climate adaptation found that over 80% of respondents believed climate change was happening and that actions need to be implemented quickly to avoid costly compulsory adaptations in the future.

Ku-ring-gai is ranked 3rd for bushfire risk in the Greater Sydney Metropolitan Region, (behind the Blue Mountains and Shoalhaven). It has the largest number of properties within the bushland urban interface.

Implications for local government

> '*Local governments currently have available to them a number of defences that seem likely to protect them from claims based on a failure to recognise and respond to information about climate change. Nevertheless, just as the science of climate change is gathering momentum, so too the law in this area is evolving rapidly. Local governments should therefore take care to ensure their actions, decisions and policy responses to matters that may either contribute to, or be affected by, climate change remain current and reasonable in what is a rapidly evolving policy context'* (England 2007 pp 14).

Local government may be considered 'easy targets' for litigators who seek to establish a causal connection between a Council decision or plan which allows developments in areas vulnerable to climate change impacts, and associated damage to life or property.

To reduce litigation risks, local councils must account for the effects of climate change in asset management, land use planning, policies and development approvals. This can be achieved by adhering to the principles of Ecologically Sustainable Development, as been applied to climate change matters in NSW courts. Council must also fulfil its primary duty of care to the community.

It is feasible that local government decisions may be subject to increasing litigation and legal challenge on the basis of climate change impacts (England 2007), particularly in relation to policy frameworks such as land use plans, planning policies, construction approval regimes, major construction plans and environmental protection policies. Councils and other levels of government must be aware of and plan for climate change implications in a very demonstrable way in order to meet the test of "reasonableness" in their defence (England 2007). Some legal experts such as Lyster (2010 pers com.) believe Courts may consider awarding significant damages to plaintiffs against public sector agencies. If this occurs, there could be serious financial implications for that sector particularly if climate change is not given due consideration in the decision making process (England 2007).

Councils need to be mindful of whether their policies and strategies demonstrate sufficient precaution or foresight in the investigation and interpretation of the likelihood of a risk occurring. This consideration also links to the magnitude of the consequence arising from the manifestation of the risk.

Impacts such as drought, extreme heat, storms and bush fire have occurred in the past and therefore the detail of the harm is clearly foreseeable.

Figure 3 Under climate change, bushfires are expected to increase in frequency and intensity.

3. Bush Fire Behaviour

Bushfire behaviour is influenced by multiple variables including fuel, topography and weather. These interact in ways that affect the location, season, frequency and intensity of bushfires. The northern suburbs of Sydney experiences minor and major fires at regular intervals. These are expected to be exacerbated by a changing climate, as it will impact on weather and fuel.

Ignition sources

In order for a fire to burn it needs heat, fuel and oxygen. Fire can be started in several ways. Some common ignition sources that start bushfires include:

- Natural:
  - Lightning strike.
- Human:
  - Electricity caused eg. conductors clashing or fallen power lines.
  - Deliberate eg. malicious intent or burning without a permit.
  - Campfires and barbeques eg. unattended or not properly extinguished.
  - Equipment/machinery eg. slashers, grinders, exhaust from vehicles.
  - Industrial hazards eg. chemical spills
  - Cigarettes eg. Butts thrown from a car windows.
  - Hazard reduction/ pile burns/ agricultural burns eg. burns that escape control.

Fuel

The type and arrangement of fuel has more of an effect on fire behaviour than the quantity of fuel (O'Bryan 2005). Forest communities typically have varying vegetation layers that can easily elevate fires from the ground to the crown, making the fire difficult to manage and control. Forest vegetation communities are extensive in the northern Sydney region, particularly in Ku-ring-gai, with crown vegetation extending well into urban areas.

The bushland surrounding Ku-ring-gai is dominated by a number of vegetation communities including Threatened Ecological Communities (TEC's). The main vegetation groups, as defined by Specht *et al* (1995), include:

- Closed scrub/heath which dominates the broad ridge tops with exposures to the north;
- Low woodlands which cover the sheltered easterly facing upper to mid slope;
- Woodlands which cover the upper to mid slopes with exposed westerly aspects;
- Open forests, which run through the creek lines and lower slopes.

All these vegetation communities generate high levels of fuel capable of supporting a bushfire.

Fire is most intense when it burns from the ground layers up into the canopy. For fire to rise up into the canopy it requires a fuel ladder. The first rung of a fuel ladder begins with fine fuels, such as leaf litter and fine twigs. Under extreme bushfire weather, these fine fuels ignite very readily, and can be ignited by wind borne embers from other fires. Fine fuels are usually intermingled with the next rung of the fuel ladder of near surface fuels, such as tufted grasses and low shrubs. This elevates the fire to the next rung of taller shrubs and small trees, then elevating the fire into the canopy. Once in the canopy, fire can spread through the interconnected canopy whilst supported by ground fuel. Fire can move rapidly into the canopy increasing intensity and accelerating spread. Spotting over longer distances is achieved during high wind when the fire reaches the canopy. Such fires are much more difficult to manage, as evidenced by the tragic results of the Victorian bushfires of 2009 (VBRC 2010).

Most of the 1161 ha of surrounding Council managed bushland is contiguous with larger areas of bushland to the north, south-west and east. Ku-ring-gai Chase National Park to the north measures approximately 15,000 ha; Lane Cove National Park, adjoining the south-western boundary is 601 ha and; Garigal National Park to the east is 2,150 ha. These parks are contiguous with other bushland areas that define the character of the Greater Sydney Metropolitan Area. When this land is added to private bushland and that associated with Rail Corp, Roads and Traffic Authority (RTA) and Department of Primary Industries (DPI) (Crown lands), approximately 18,000 ha of bushland can be incorporated within the bushland directly impacting the LGA.

Approximately half of the 54,000 ha of bushland directly impacting[2] the Ku-ring-gai and Hornsby region is composed of vegetation that will support and sustain high intensity fires into the canopy. This presents local and regional risks to private and public assets and the environment.

Topography

Extreme bushfire weather, the type and arrangement of fuel, and the deeply incised nature of the topography surrounding Ku-ring-gai contribute to the high bushfire risk in the area.

Topography influences wind speed and direction, rate of spread of fire, spotting activity and flame length and depth. All of these factors increase commensurate with an increase in slope gradient (O'Bryan 2005).

There are three major catchments that make up the Ku-ring-gai LGA, Cowan, Middle Harbour and Lane Cove River. While each of these contains different biophysical and land use characteristics, the majority of Ku-ring-gai's development is sited atop deeply incised valleys and plateaus, where there is the greatest risk of bushfire.

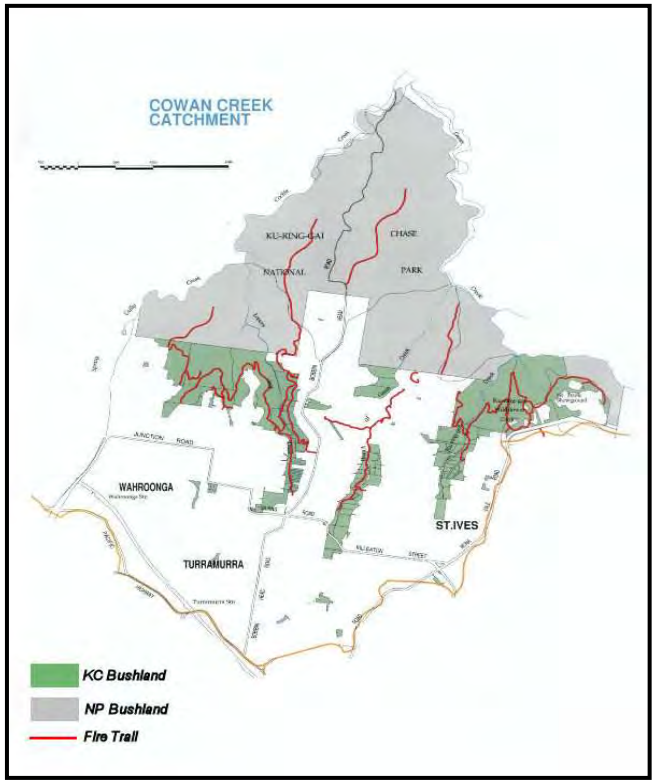
[2] These figures incorporate areas of bushland that adjoin and directly impact the local government areas of the Hornsby Ku-ring-gai NSW RFS district.

Ku-ring-gai has the majority of its development sited atop deeply incised valleys and plateaus, where there is the greatest risk of bushfire.

Cowan catchment

Cowan catchment (Figure 4), comprises 70 per cent bushland most of which is Ku-ring-gai Chase National Park. Two broad ridgelines, running north to south, dominate the area between North Wahroonga and North Turramurra. These are divided by the valleys that carry Fraser and Caleys Brooks and Lovers Jump Creek. Slope angles typically measure between 17 and 30 degrees and are very difficult to traverse. This creates serious issues in regard to preventative and defensive fire management. Porous soil with their poor water retention properties and low nutrient levels foster unique vegetation communities, of which many species tie their life cycles to the passage of fire. Fine fuels build up quickly especially in times of drought when many plants shed their leaves in order to survive.

Figure 4: Bushland within the Cowan catchment



St Ives Chase is a relatively narrow valley running north north-east to south south-west. It dissects two broad ridgelines and supports Branch of Cowan Creek. This narrow valley extends to the north to include Ku-ring-gai Chase National Park. Across the valley, slopes have an average angle of 17 degrees. This makes fire management difficult which is accentuated by sandstone outcrops and boulder-strewn vertical escarpments.

The area between St Ives Chase and the St Ives Showground is a large open area divided by valleys and slopes. There are more ridgelines than in other sub-catchments but they are not as broad. The valleys are generally deeply incised between the broad ridgelines and link to 'fingers' of bushland that extend the bushland/urban interface to over 91 kilometres[3] throughout the LGA. While the valleys provide vectors for the spread of bushfire, there are a number of 'peninsulas' of urban development between these valleys.

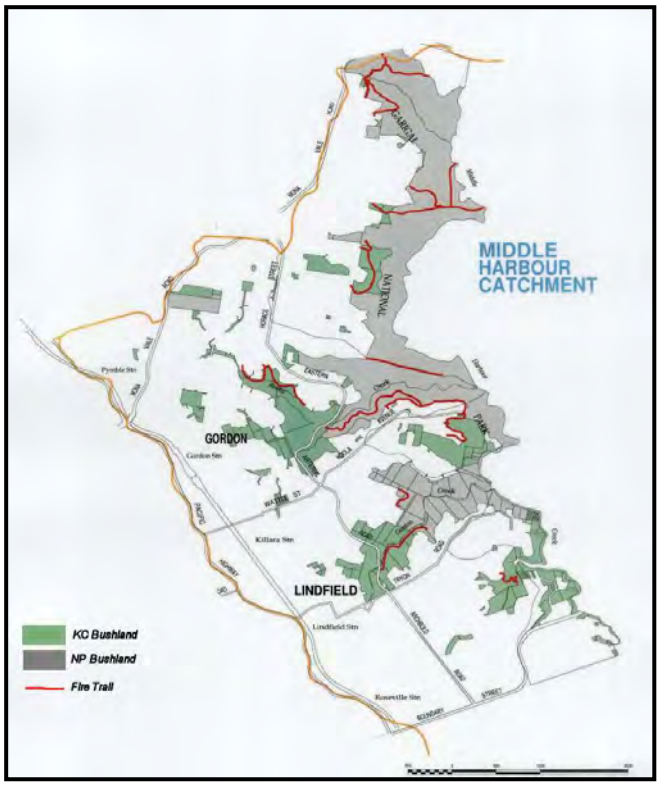
Middle Harbour catchment

Middle Harbour Catchment (Figure 5) is comprised of discontinuous areas of Council managed bushland interspersed between sections of Garigal National Park.

The Middle Harbour catchment is divided into four main sub-catchments of High Ridge Creek, Rocky Creek, Gordon Creek and Moores Creek. The geology of this area reflects typical Hawkesbury Sandstone composition with steep gullies leading up to broad ridge lines which are extensively developed.

For the most part, the area faces the east. The area extends from Mona Vale Road St Ives in the north, to Boundary Road, Roseville in the south. Similar to the Cowan catchment, contains steep, heavily vegetated valleys.

Figure 5: Bushland within the Middle Harbour Catchment



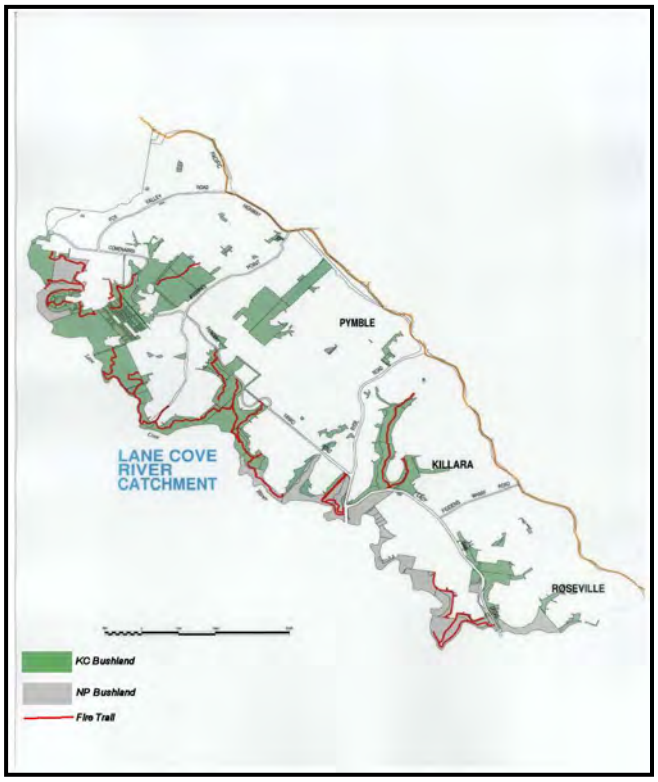
[3] Length of bushland interface has been calculated as that between private housing areas and Council bushland reserves. The length of bushland between developed areas and bushland of all tenures is 160km.

Lane Cove River catchment

Lane Cove River catchment (Figure 6) comprises of six sub catchments including Coupes, Fox Valley, Avondale, Quarry, Blackbutt and Little Blue Gum Creeks. The catchment is composed of 30% bushland, and is generally not as steep as the other catchments.

Rising from the Lane Cove River, which forms the LGA boundary, the soils are based on Hawkesbury sandstone. These are shallow, stony, nutrient poor and porous and often susceptible to severe sheet erosion following bushfires (Atkinson 1989). The catchment has a prevailing westerly aspect.

Figure 6 Bushland in the Lane Cove River catchment



Weather

Weather is the most powerful and immediate influence on fire behaviour.

The Australian climate is typically associated with an eastward-moving sub-tropical high pressure belt associated with Hadley atmospheric circulation. The sub-tropical high pressure belt migrates north in winter and south in summer causing seasonality of rainfall in the north and south of the continent. Hot, dry air descends in the high pressure system, and has resulted in arid conditions over most of the continent (Sturnam and Tapper 2005)

The migrating sub-tropical high pressure belt and the inter-tropical convergence zone (ITCZ) influence the seasonality of rainfall over Australia. Rainfall in the south is mainly associated with the sub-Antarctic trough moving east through the Southern Ocean in winter when the sub-tropical high is further north. The result of this is distinctly different fire seasons across the continent.

These weather conditions are further exacerbated by the El Niño–Southern Oscillation (ENSO) phenomenon. ENSO has three phases, namely above average rainfall (*La Niña*), below average rainfall (El *Niño*) and a neutral phase where conditions oscillate between the two. *La Niña* conditions in Australia typically result in flooding in many areas of the continent. Conditions typically associated with *El Niño* in Australia produce droughts that vary in duration (Sturnam and Tapper 2005)

The median annual rainfall for the Ku-ring-gai area is approximately 1200mm. On average, the highest rainfall occurs in March and lowest in January (DPWS/MHL 1998). Evaporation rates exceed precipitation during the period from October to January in the region.

Extreme bushfire weather that coincides with a Forest Fire Danger Index (FFDI) in excess of 50 is usually associated with long periods of drought and little recent rainfall (Hennessey et al, 2007). Extreme fire danger days coincide with low precipitation, high evaporation rates, strong north-westerly (hot, dry and gusting) winds, high temperatures, low humidity and prolonged periods of drought.

Wind speed can also affect fire travel. Wind direction may vary, with the worst scenario seeing winds from the north-west, typically. hotter winds warmed from the desert which historically occur between August and November. Ku-ring-gai can experience these extreme conditions, particularly during the transition from winter to summer. North-easterly and south-easterly winds prevail during summer, but wind direct can make dramatic changes in the late afternoon or overnight.

These weather patterns have historically resulted in the NSW bushfire danger period being between the beginning of October and the end of March. Prime bushfire conditions reach the Sydney Basin by late December and generally early January.

Traditionally hazard reduction burns are conducted in the cooler months outside the bushfire danger period. Recently hazard reductions burns have been conducted at any time throughout the year due to weather conditions reducing opportunities to undertake prescribed burning within the cooler months.

However, weather patterns including *El Niño* often seriously restrict fuel management programs. In *El Niño* events the usually benign conditions that are good for low intensity controlled burns make hazard reductions dangerous. In *La Niña* years continuous rain events prevent opportunities to reduce the fuel load through hazard reduction burns.

Approximately half of the 58,400 ha of bushland in the Hornsby–Ku-ring-gai region is composed of vegetation that will support and sustain fire into the canopy, resulting in high intensity fires.

3.1. Climate and weather projections

The government agencies of NSW and the University of NSW have been developing climate change forecasts for the NSW regions. Although there are some concerns regarding the validity of the reported downscaling to the regional level, this is the best available information at this time.

There is a range of effects cited in the modelling from relatively minor changes to catastrophic. This variation is dependant on both global and local actions to reduce CO_2 emissions, If CO_2 emissions are controlled to less than 500ppm then there is a stronger possibility that the magnitude of change will be low (DECCW 2010). However if carbon emissions are not reduced then there is strong possibility that the catastrophic effects will arise. Due to the current failure of international cooperation on climate change, it appears that the potential for high emission scenarios will need to be considered in any adaptation strategy.

Even if current weather patterns were to remain stable into the future, severe fire weather conditions as experienced in Canberra 2003 and Victoria 2009 may still occur.

3.2. Key predicted changes resulting from climate change

Under climate change, weather patterns are set to change. It is predicted that temperatures will rise and that rainfall patterns will alter with the wetter period now expected to occur in winter and decline over summer. Relative humidity is also predicted to decline and wind speed and direction will remain relatively unchanged although its frequency and intensity may increase. In short, Australia will become hotter and drier with its rainfall predicted to fall over a shortened period of time.

Even if current weather patterns were to remain stable into the future, severe fire weather conditions as experienced in Canberra 2003 and Victoria 2009 may still occur.

The pattern of the El Niño-Southern Oscillation cycle is projected to continue but with higher temperatures than currently experienced. El Niño years are likely to continue to be drier than average and become hotter. La Niña years are likely to become hotter and wetter than average, and storms with heavy downpours are projected to be more frequent.
In El Niño events, water stress is projected to be more intense due to higher temperatures.

Therefore, while the climate is changing, the unfavourable conditions brought on by ENSO will become more intense. Droughts occurring under El Niño are set to become more prolonged with heat waves and days of extreme temperatures and low relative humidity increasing.

While most climate models predict that rainfall will reduce as a result of climate change a few models predict a modest increase of between 1 and 10%. But even with this potential increase when evapo-transpiration is accounted for, all models predict a net decline in available water. This has ramifications for bushfire fighting and for hazard reduction burning, especially at the urban/bushland interface.

In summary, the downscaling of global predictions to the Sydney region predict: significantly increased spring and summer rainfall; decreases in winter rainfall,, higher maximum temperatures; changing runoff patterns with greater runoff in summer and autumn; Increased heatwaves; prolonged droughts; and reduced water availability. In terms of bushfires, this will result in a longer fire season with increased frequency of very high or extreme fire-risk days and increased fire frequency and intensity.

3.3. Variability and uncertainty of projections

The majority of the climate change data used in this study is based on the CSIRO study (Hennessy et al. 2005).

The smaller scale modelling used by *Hennessy et al* often requires an increase in complexity to reflect actual ground conditions in a specific geographic location. This often results in models having greater degree of error.

Other influences on fire behaviour

Land management, fire suppression and fire ignition, are other factors that play an important role in bushfires Humans have the capacity to influence fire regimes particularly as the majority of fires are ignited by people (including hazard reduction burns). It could be argued that, as population increases, there may be more arson causing bushfires, for the purposes of this report, however, it is assumed that human involvement would remain at constant levels into the future.

3.4. Characteristics of fire

Australian bushfires start with a thin front of flames. These flames are usually as thick as they are high. Typically, forest fires have speeds between 1 to 3 km/h, have flames between 10 and 20 metres high and thick. Severe fires have been known to travel up to 12 km/h, with flames between 100 and 150 metres high and thick (Bureau of Meteorology 2007d).

Ember attack

Loose bark, twigs, leaves and small debris are carried up by air and transported by winds to potentially ignite more combustible fuel. If sustained long enough, this ignition will start new "spot" fires ahead of the main fire front. Stronger winds and convected air columns can result in lit debris (embers) being carried further ahead of the main fire front. Such spotting is a characteristic of bushfire behaviour, particularly forest fires as forests provide the elevated fuel characteristics that encourage spotting.

Ember attack has been identified as the main cause of house ignition during and after a bushfire incident (Leonard et al, 2004). Embers thrown can attack a house for up to 30 minutes prior to the arrival of the bushfire front, when the fire front is 400 to 500 metres from the house. This can continue for many hours after the fire front has passed.

Embers attack houses by lodging in roof cavities, eaves, and gutters, under houses, weep holes in brick work, window sills and entering houses through fractured windows. Any object that interrupts the flow of air will stop embers and cause them to build up potentially forming a source of ignition.

Urban landscaping, street trees parks and urban reserves can be ignited by windborne embers and carry a bushfire into developed areas placing the community at great risk. This can occur regardless of APZs or any other fire mitigation measures adopted.

Ahern *et al* (1999) studied three extreme wildfire events (pre Victoria and Canberra fires) in an endeavour to estimate damage caused to houses at the urban–bushland interface. They found that while the majority of houses destroyed were relatively close to vegetation, some were at distances of up to 684m from the interface. 70% of affected houses were less than 50m from the interface while 5% were more than 180 m from the interface.

Increased risk from bushfire has been identified as the single most serious threat to Ku-ring-gai from climate change. (Ku-ring-gai Council: 2010a)

This example is useful to a point, but is limited by the fact that it only examined distance from the hazard, but did not consider other risk factors such as:

- The construction and design of the house or its vulnerability,
- Whether the house was destroyed during the passage of the fire or at some time later;
- Whether the house and garden were properly maintained and prepared for the onset of a bushfire;
- Whether an able-bodied person was at home at the time;
- Whether those houses that were destroyed at greater distances from the hazard were destroyed by embers emanating from the bushland boundary or some other source.

Smoke

Bushfires generate large amounts of smoke. Fire smoke can produce direct physical effects on people, especially in those with respiratory illnesses such as asthma and emphysema, as well as psychological effects. Stress and anxiety levels in

many people can be raised simply by the smell of smoke in the air. Smoke can also reduce visibility to the extent that roads and even airports need to be closed temporarily (Granger, et al. 2001as frequently occurs on the F3 freeway.

Radiant heat

Bush fires generate extreme heat levels at their active front. As the fire travels forward, the extreme heat lasts for only a few minutes, however, it is sufficient to fracture glass or cause combustible items inside a building such as fabric and paper to burst into flame. Radiant heat is also a significant threat to heat-sensitive power supply and other electronic equipment (Granger, et al. 2001).

Direct flame contact

Flame impingement of the structure can occur through either direct flame contact from the main fire front or by smaller localised flame impingement from localised fuel sources (vegetation, sheds, fences). Either way the external structure elements may ignite or the flames may act on the envelope until an aspect of it opens up to allow ignition of building contents (Wang 2006).
Exposure to flames is typically only a threat where vegetation or other fuel is allowed to accumulate under, against, or on the exposed building, or where the material of the structure is also flammable (ie timber decks).

Wind

Wind speeds in excess of 120kmh can be experienced in fires due to convective forces generated from the fire itself. This is somewhat greater than the wind loading standard applicable to most urban buildings. Such wind can cause direct damage, through unroofing buildings, impact damage from propelling debris, including burning debris (Granger, et al. 2001).

3.5. Historic bush fire events

In the past, bushfires have caused great property damage and loss in Australia, including many deaths[4]. Ku-ring-gai has a history of destructive fires impacting the urban/bushland interface. Catastrophic fires have caused significant loss of life and property and correspond with periods of drought, high temperatures, strong winds, low humidity in spring and summer (Bradstock et al, 1998). Known loss of life in Ku-ring-gai is to date occurred with unexpected wind change during a backburn.

According to the NSW RFS (2008), six major fires were recorded since 1976 that have affected the Ku-ring-gai and/or the surrounding area[5]. However, there have been many smaller fires since this period that have impacted on areas within Ku-ring-gai. Detailed information on losses has only been reported for the major fires, including the fires of 1994, and 2002 to a lesser extent.

[4] Over 400 people have lost their lives in bushfire events over the last 53 years (Blanchi et al, 2010, in CIE, 2010)

[5] Ku-ring-gai Council would like to acknowledge Chris Hunter, Captain of Ku-ring-gai Fire Brigade for additional information provided on the major fire events impacting the LGA.

'76 – '77 Fires

The fires of 1976-77 affected the Hornsby and Blue Mountains areas. Three homes were destroyed in the Hornsby Shire area and one home lost in South Turramurra. In total 9,000 ha of bush was burnt

'79 – '80 Fires

The fires of 1979-80 in the Warringah area were associated with severe drought conditions over much of the state. In the Warringah area alone, 9,000 ha of bush was burnt and 14 houses were lost. According to the data, fires burned over the majority of council areas in the state. One life was lost in this fire season in the Mudgee area.

In December 1979, fire burnt large areas of Ku-ring-gai Chase National Park and adjoining bushland at North Wahroonga, North Turramurra and St Ives.

'90 – '91 Fires

The fires of 1990-91 were noted to have affected many of the council areas in northern Sydney including Ku-ring-gai, where a state of emergency was declared. Fire burnt from North Wahroonga to St Ives Chase. Damage figures for this fire relate to livestock loss in rural NSW.

'91 – '92 Fires

The fires of 1991-92 impacted Kenthurst in the Baulkham Hills shire, where 2 people died. This occurred early in the dangerous period of the fire season, in October. Fires also affected the Central Coast, and a state of emergency was declared in the affected areas. A total of 14 houses were lost in these fires.

'93 – '94 Fires

The fires of 1993-94 had the largest impact on the Ku-ring-gai area, as well as most of the state. Across the state, 206 homes were destroyed and 4 people died. Extensive inquiries into these fires details the losses associated, including losses in the Ku-ring-gai area. The Ku-ring-gai fires occurred in the Lane Cove Valley and large areas of North St Ives and St Ives Chase. No Council properties were damaged or destroyed in this fire.

'01 - '02 Fires

The local impacts of the fires of 2001-02 were centred mainly in the Ku-ring-gai area, mainly in the Lane Cove River valley. No property losses were recorded. Across the state, however hundreds of property losses were incurred. 40,250 ha of bushland burnt in the area from these fires.

Fire trends

From this history, there are usually one or two significant bush fires that impact Ku-ring-gai or the surrounding area every ten years. The Hornsby/Ku-ring-gai Bush Fire Risk Management Plan (BFRMP) documents that large scale and intense wildfires occur once every 10 years. An excerpt from the fire frequency map is included at Figure 7. Large scale

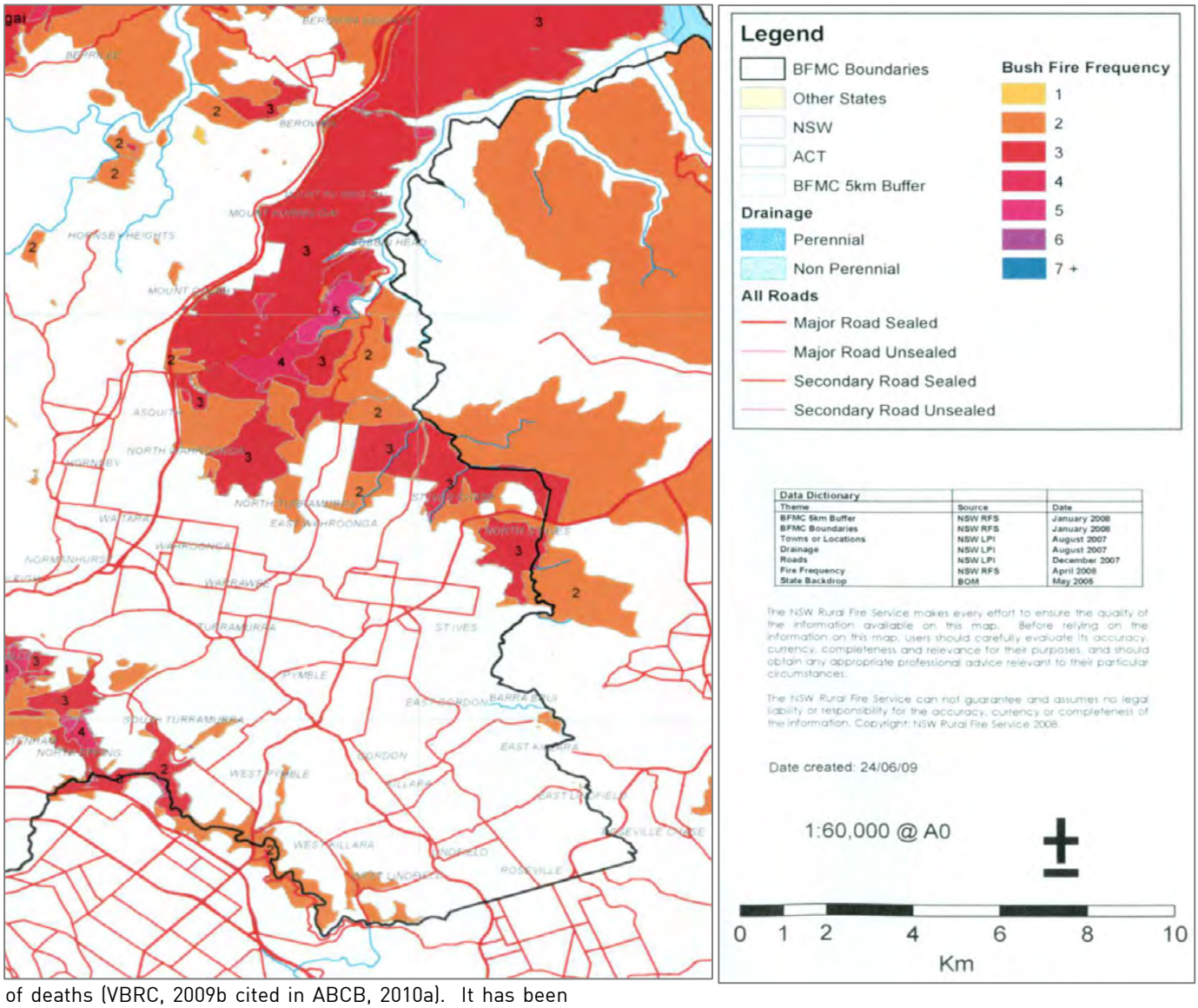
and intense fires are associated mainly with El Niño conditions and post La Niña conditions (Lucas 2005).

The last 70 years has been characterised by unusual and extreme ENSO conditions, where 30% of the extreme ENSO conditions that have occurred since the 1500's have occurred since 1940, with a strong bias towards enhanced El Niño conditions (Gergis and Fowler, 2006). Since fire weather is strongly associated with the ENSO phenomenon, predicting frequency of fire weather in Australia is difficult, especially since little is known about the recent trends in ENSO.

Further, Lucas et al (2007 in Tapner et al. 2010) have found that there has been a general increase in the Forest Fire Danger Index (FFDI) between 1973 and 2007.

Two thirds of the 173 people who died in the Victorian Bushfires were trying to defend well-prepared houses (VBRC, 2010). The Victorian Bushfire Commission's review noted that direct flame attack appeared to be more prevalent than in previous bushfires and that this high incidence is considered to have resulted in the high number of deaths (VBRC, 2009b cited in ABCB, 2010a). It has been noted that the fires exposed weaknesses in our understanding of bushfire risk and in the policies and expectations for bush fire prone areas (Bushfire CRC in Fire Australia 2010).

Figure 7 Bush Fire Frequency Hornsby Ku-ring-gai BFMC Bushfire Risk Management Plan 2009



3.6. Future fire frequency and intensity

As described in the section on climate change, projections for the Sydney region include significantly increased spring and summer rainfall while winter rainfall decreases, higher maximum temperatures and evaporation rates, changing runoff patterns with greater runoff in summer and autumn and increased severity and frequency of heatwaves and droughts.

Such changes are likely to result in significant changes to historical bushfire regimes and will impact on the success of current bushfire management planning and techniques.

Projected changes in bushfire risk and behaviour

A number of studies relating to the impacts of climate change on bushfire risk in Australia have been undertaken.

The historical record for bushfire weather in SE Australia is studied by Lucas *et al* (2007) who note that for the period 1973–2007, there was a general increase in the Forest Fire Danger Index (FFDI) with a statistically significant increasing trend in FFDI for most inland locations. This study is the most geographically and temporally relevant historical study for Ku-ring-gai.

According to Hennessy *et al* (2007) (in Parry *et al. eds* 2007), heatwaves and fires are virtually certain for Australia, and will result in an increase in fire danger associated with increased frequency and intensity, decreased fire extinguishments and faster fire spread. The projected future changes in climate will result in a longer fire season with increased frequency of very high or extreme fire-risk days and increased fire frequency and intensity.

Increased risk is largely due to alterations in temperature and relative humidity. By 2100 the low emissions scenario further increases the fire risk (above 2050) by ~25% while the high emissions case has increases in fire risk of 50–100% along the NSW coast.

Williams and Karoly (1999) looked at how the El Niño-Southern Oscillation (ENSO) can alter bushfire regimes. They concluded that there was a 'coherent' pattern of increased fire risk in south-eastern Australia. It is anticipated the risk would therefore also increase in Ku-ring-gai. Bushfires which have most impact in terms of damage to life and property most often occur in heavy drought years in southern Australia (Beeton et al. 2006).

It is projected that Ku-ring-gai will experience bushfires starting earlier, lasting longer which include more days of extreme fire weather. Hennessy *et al eds*, (2007) have predicted that very high and extreme fire danger days are to increase in south-eastern Australia by 4-25% by 2020 and 15-70% by 2050.

By 2050, Hennessy et al (2007) predict the Sydney area will see the days it experiences over 35ºC rise from two days to four. More recent work by the CRC (2009 in CIE 2010) shows a trend for Melbourne from 1940 to 2009 of 4 more days per decade.

The study by Hennessy *et al*. (2005) using two simulation models (Conformal Cubic Atmosphere Model (CCAM) v2 and CCAM v3) found the following percentage increases in fire danger for the Sydney area applying both models to the Forest Fire Danger Index (FFDI) ratings; shown below in Table 1.

Table 1 Percentage increase from present in days where fire danger is very high or extreme

CCAM v2				
	% increase 2020		% increase 2050	
Scenario	Low	High	Low	High
FFDI	5.75%	12.64%	12.64%	35.63%

CCAM v3				
	% increase 2020		% increase 2050	
Scenario	Low	High	Low	High
FFDI	9.20%	27.59%	29.89%	74.71%

Taplin *et al* (2010) using CCAM3 from Lucas *et al.* (2007) identify the likely increase in the number of days of extreme bushfire risk for Ku-ring-gai (Table 2). Base data is available for a limited range of sites. Richmond Air Force base data is used as a surrogate for Ku-ring-gai because it is almost as close as Sydney Airport data collection site and shares the non-coastal character of Ku-ring-gai more closely than the main airport site located on the coast near Botany Bay. Each column represents an increase in temperature and the likely time line when those figures will be reached under current circumstances.

Canberra 2003

The fires were naturally lit by lightning strikes and were driven by westerly winds into Canberra after burning for approximately 2 weeks in a NSW National Park. El Niño conditions occurred in the lead up to these fires, with below average rainfall experienced in the months prior. Higher than average temperatures in these months prior ranged from an additional 0.9°C in May to 5.0°C in November (Webb et al: 2003).

The events and the level of damage were attributed to the drought conditions drying out vegetation, thunderstorm activity igniting the fires, and extreme fire conditions after ignition that caused the fire to spread.

Table 2 Projected increase in fire risk days

Ku-ring-gai environs projected increases in the number of days/annum with very high, extreme, very extreme and catastrophic fire weather using Lucas et al. (2007) CAM3 simulation models

	Present days/pa	2013 (0.4°C) days/pa	2034 (1.0 °C) days/pa	2067 (2.9 °C) days/pa
Richmond				
Very high	13.3	14.2	16.3	23.6
Extreme	1.5	1.6	1.9	4.0
Very Extreme	0.4	0.4	0.5	0.9
Catastrophic	0.0	0.0	0.0	0.2
Sydney Airport				
Very high	7.6	8.1	9.4	14.2
Extreme	1.2	1.4	1.7	3.5
Very Extreme	0.2	0.2	0.3	1.0
Catastrophic	0.0	0.0	0.0	0.2
Williamtown (N'tle ap)				
Very high	10.3	11.2	12.8	17.8
Extreme	1.4	1.7	2.3	4.1
Very Extreme	0.2	0.3	0.5	1.1
Catastrophic	0.0	0.1	0.1	0.3
Nowra (Jervis Bay)				
Very high	8.8	9.1	10.3	14.7
Extreme	1.1	1.2	1.6	4.0
Very Extreme	0.1	0.1	0.2	0.6
Catastrophic	0.1	0.1	0.1	0.1

As well as climate change altering weather patterns to increase bushfires, the additional CO_2 in the air and higher temperatures may encourage bush growth, increasing fuel for a fire (CSIRO 2006).

Climate change may also adversely impact the amount of suitable days for prescribed burning as a form of adaptation. These impacts then contribute to a loop in increasing the degree of bushfire risk.

Estimating probability and consequence

The evidence strongly suggests that climate change will increase the probability of fire and to a lesser extent, the magnitude and severity of these fires.

Whilst the average probability of a bushfire event endangering a single life or house in Australia is extremely low, there are areas within Australia where individuals and properties are subjected to considerably greater risk such as in Ku-ring-gai. There is the potential for the level of bushfire risk in the future to be greater than the historical trend, as a result of increasing urbanisation and climate change (Hennessy, 2007).

Estimating the probability of a change in fire incidence and magnitude is complex and relies on the accuracy of regional data to determine changes in fire weather. Bushfires are included in Garnaut's (2008a) analysis of the costs of climate change as one of nine types of 'extreme weather events'.[6] It is worth noting that this analysis occurred prior to the Victorian Black Saturday bushfires and as such are likely to underestimate the consequences of wildfire. Garnaut (2008) found that fire risk along the NSW coast would increase by 50 to 100% under a high emissions scenario and that bushfire risk would increase with rising levels of atmospheric CO_2.

There are usually one or two bush fires that impact Ku-ring-gai or the surrounding area every ten years

Trends to date suggest climate effects in the more extreme end of the range of impacts, which will remain unaltered unless rapid and decisive action is taken to reduce CO_2 emissions.

[6] The full list also includes: hot days and nights; hail and thunderstorms; cold days and nights; tropical cyclones; heavy rainfall events; bushfires; droughts; extreme winds; and floods.

4. Vulnerability and Resilience

Vulnerability and resilience are closely related. Vulnerability focuses on the weaknesses in the defence or exposure to extreme weather related impacts. Resilience is the level of robustness of the community, allowing minimisation of the impacts and recovery from a particular extreme weather event.

Understanding vulnerability and resilience requires a thorough understanding of the features of the local community, including the community's values and their vision for the future of their community. This allows for the opportunity to build on strengths and avoid re-inventing solutions that are already in place. In times of emergency many stakeholders look to their Council for assistance and leadership role, as such Council needs to be well prepared to deal with all eventualities.

Critical factors that affect the assessment of vulnerability and resilience are:

- Geographic and land use vulnerability
- Social and economic resilience
- Environmental and ecosystem risks
- Existing response capacity and preparedness

Identification of vulnerability and resilience factors for Ku-ring-gai is based on a literature review, the experience of Council, historical records of extreme events and advice from local and regional community experts. For the purposes of this report, vulnerability and resilience factors are based on current weather conditions and likely trends.

4.1. Geographic and human settlement vulnerability

Geographic and land use vulnerability

Ku-ring-gai, with National Parks on three sides and significant bushland (both in public and private ownership) along creeks and 'fingers' that reach in towards the main ridgeline traversing the local government area between Thornleigh and Chatswood, is extremely vulnerable to bushfire.

Early development in Ku-ring-gai occurred along the plateau surrounding the Pacific Highway and the railway corridor. Subsequent development has spread out to the extremities of the plateau and along ridgelines. In many areas, developments have extended into the valleys. Ku-ring-gai LGA includes 91km of bushland directly adjoining the urban interface, exposing many properties to an extreme level of bush fire risk where a single bushfire can easily devastate an entire locality very quickly.

Clearly, properties at the interface between urban areas and bushland are most at risk. Table 3 outlines the risk rating based on the distance to bushland. With the bushland/urban interface extending over 91 km, Chen (2005) has determined that Ku-ring-gai has 36% of property within the high bushfire risk area, (within 130m of the bushland interface), that is approximately 16,370 properties. Accordingly it is ranked third for fire risk in the Greater Sydney Region behind the Blue Mountains and Shoalhaven. However, within the Sydney Metropolitan Area, Ku-ring-gai has the highest proportion of properties within this interface.

Table 3 Risk of property destruction from fire, distance to bushland (McAneney, et al 2009)

Risk rating	Distance to extensive bushland	Proportion of capital city houses
Very high	Less than 100m	6.0% or 486,000
High	Between 100-200m	3.2% or 259,000
Medium	Between 200-400m	5.0% or 405,000
Low	Between 400-700m	6.1% or 494,000
Negligible	More than 700m	79.7% or 6,456,000

Areas with a high risk rating as shown in Table 3, that is within 100m of bushland are identified as ' Buffer'on the Bushfire Risk Map (Figure 2). There are also properties that include Category 1 or 2 Bushfire Prone Vegetation. Approximately 13,698 existing households are within these bushfire prone areas. These areas contain residences which are typically low to medium density, brick and tile dwellings, but also include schools and aged care facilities located on the interface completely surrounded by bushland with just one road linking the community to safe areas. The intrusion of bushfire risks right into the heart of Ku-ring-gai, can be seen in the range of specific DCP design controls to address these risks, for a mixed use site in Turramurra centre, adjacent to Granny Springs, a bushland reserve.

With deeply incised valleys between urban development situated predominantly on the ridges and with the smaller ridges extending from the central spine into the national parks, adds to this vulnerability. The nature of the vegetation that allow the build up of dry litter exacerbate this vulnerability. Historically, there was inadequate consideration given to bushfires in the development and building control process until the enactment of the *NSW Rural Fires Act in 1997* and *Planning for Bushfire Protection 2001*. Accordingly many properties were developed in bushfire risk areas without consideration of the risks in their design or location.

The deeply incised valleys which separate the broad ridgelines have the capacity to carry a bushfire escaping out of Ku-ring-gai Chase National Park deep into the suburbs of Wahroonga, Turramurra and St Ives.

The Bushfire Risk Management Plan (Hornsby–Ku-ring-gai 2010) (BFRMP) identifies properties with the greatest risk to be those situated atop steep bushland slopes with northerly to westerly aspects. Examples include the residential areas in St Ives, North Wahroonga and North Turramurra.

Bradstock *et al* (1998) identified that properties located on a western aspect are more susceptible to fire in the northern Sydney region, due to the prevalence of fast westerly winds during the fire season. This can be clearly seen in the frequency of fires and the loss of property, particularly as recorded in historical fires in the Lane Cove Valley.

The bushfire risk rating map at Figure 8 is based on the risk map in the BFRMP. The Plan determines priority areas for risk management according to their relative vulnerability by:

- Estimating the level of bushfire risk by using vegetation, slope and likely weather conditions;
- Identifying assets under threat by estimating the location of human settlement, community, economic and ecological and cultural assets relative to bush fire hazards
- Assessing the assets' ability to withstand and recover from expected threats;
- Rating the consequence of bushfire.

Identified areas are rated through 5 categories from extreme risk through to low risk.

There are large areas of development in locations that are highly vulnerable to bushfire.

The Hornsby/Ku-ring-gai Bushfire Risk Management Plan (2010) (BFRMP) classifies approximately 20% of the interface area within the district as having a high bush fire hazard, and 49% having an extreme bush fire hazard. Extreme and High bush fire hazards are predominantly in bushland areas managed by a number of land management agencies, such as the Department of Lands, Department of Environment, Climate Change and Water, Councils, etc. A further 12% of the district is classified as a moderate bush fire hazard, and 8% as low bush fire hazard.

Population pressure and urban consolidation policies are increasing population densities. While the main focus is on areas with access to services, opportunities for increased density in more bushfire exposed areas are still sought, and constructed, albeit at a lower residential density than centres. There is pressure in Ku-ring-gai, from time to time, to further develop areas that are exposed to risk from bushfire. Examples include applications for subdivisions, interest in rezoning larger lots in North Turramurra to standard residential zones, and the recent rezoning for high density residential and hospital expansion, all in evacuation risk areas.

It is noted that, of the four areas which experienced the greatest population growth within the LGA between 2001 and 2006 (SGS 2008), two are within areas subject to bushfire risk (either bushfire prone land, or land within the area of Bushfire Risk Evacuation Map, or both).

Vulnerability by catchment

The following section discusses the relationship between bushfire risk and the biophysical and land use characteristics of the 3 catchments in Ku-ring-gai. Appendix A provides more detail on the zonings by suburbs within bushfire prone lands and bushfire risk evacuation zones.

Cowan Catchment

A number of institutions in this area are vulnerable to bushfire, including childcare centres and a hospital, aged care facilities and schools. Development occurs predominantly at the top of the catchment on the plateau to the south. Development in the north remains sparse due to the topographical constraints of this region.

The steep slopes of the valleys that carry Fraser and Caleys Brooks and Lovers Jump Creeks between North Wahroonga and North Turramurra increase the rate at which fire will spread and also makes access difficult. The build up of fine fuels, especially during drought, also has a powerful influence on fire behaviour.

The slopes in the narrow valley of St Ives Chase (an average angle of 17 degrees) allow fire to spread quickly but are difficult to traverse when fighting a fire. Ku-ring-gai Chase National Park to the north has almost 15,000 hectares of bushland and a bushfire escaping out of the Park would be funnelled down the Branch of Cowan creek thus intensifying and increasing the spread of fire down the valley.

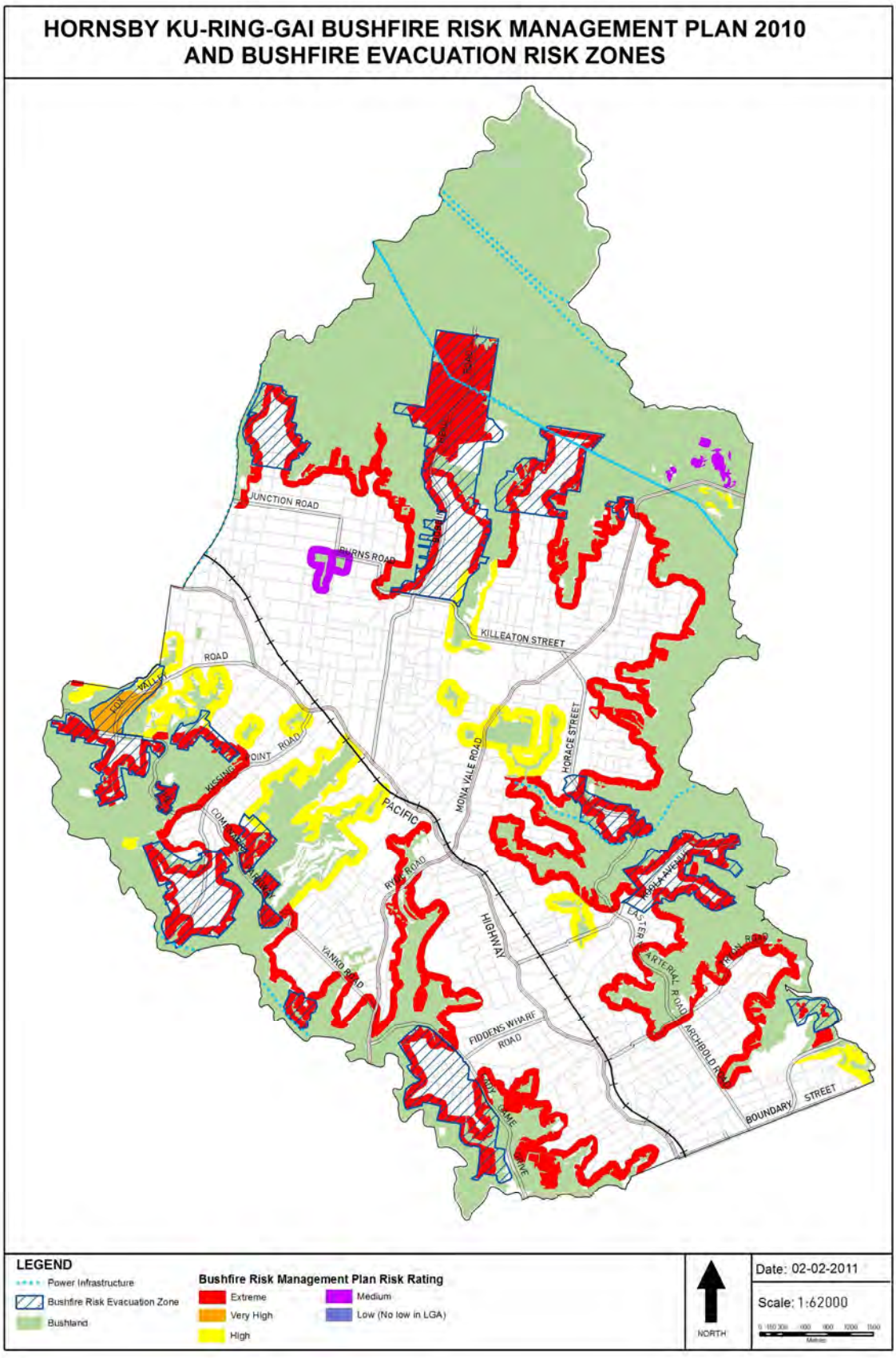
Between St Ives Chase and the St Ives Showground, bushfires under extreme conditions, display behavioural characteristics which see fire spot from ridge top to ridge top with the intervening valleys left to follow. The topography within this catchment facilitates this bushfire characteristic. Council assets such as the Wildflower Garden, Community Nursery and St Ives Showground are vulnerable.

The topography of the Cowan catchment increases risk to residents of the area. The deeply incised valleys which separate the broad ridgelines have the capacity to carry a bushfire escaping out of Ku-ring-gai Chase National Park deep into the suburbs of Wahroonga, Turramurra and St Ives. The long 'fingers' of bushland extend the overall bushland/urban interface.

While *Planning for Bushfire Protection* (both 2001 and 2006) (PBP) provide for setbacks from the bushfire hazard to the dwelling, to allow the setbacks to be used as asset protection zones, the subdivision pattern and most of the development has been established prior to this legislation. The separation distances in PBP are governed by climate, vegetation type and slope angle, and the confluence of these three variables determine the setback distances. The

legislation recognises that such setbacks cannot always be achieved in infill development, so there are large areas of development in locations that are highly vulnerable to bushfire.

Figure 8 Bushfire risk rating for Ku-ring-gai from Hornsby Ku-ring-gai Bushfire Risk Management Plan 2010, and Bushfire Evacuation Risk Zones under SEPP (Housing for Seniors or People with a Disability) 2004.[7]



[7] This map is based on Maps 5 and 6 of the Bush Fire Risk Management Plan (2010) and has been reproduced to clearly show risk ratings. No boundaries have been altered.

Council has estimated the setback line required to provide the asset protection zones (APZs) for a selection of bushfire prone lands within the LGA (see Appendix B). The setback line is calculated using the above variables as required by PBP, as if these areas were not infill development. The resultant maps provide an image of the extent of the vulnerability of the residents and other users in these areas. As can be seen from Figure B1 in Appendix B, in this area of the catchment:

- No development meets the 'ideal' APZ requirements;
- In many cases the APZ setback line is beyond the entire property;
- In some cases the APZ setback line is beyond two or three properties.

While the valleys provide vectors for the spread of bushfire, 'peninsulas' of land containing urban development have been classified by the NSW Rural Fire Service (RFS) as Bushfire Evacuation Risk areas[8]. The first area to be considered was the North Turramurra area. This urban peninsula is the most exposed to large areas of National Park, contains a number of developments for people who extremely vulnerable, including a number of developments under SEPP (Housing for Seniors and People with a Disability), hospitals, child care centre and two schools, with only one road in/out of about 3.8km.

Bushfire risk evacuation areas have also been declared in North Wahroonga and St Ives Chase. In these areas there is likely to be great difficulty in evacuating residents and others to safer areas due to the lack of exit roads.

Middle Harbour Catchment

The steep gullies of Hawkesbury Sandstone lead up to broad ridge lines, which are extensively developed along the bushland/residential interface. Hawkesbury Sandstone vegetation communities include many species that have evolved together with bushfire, burn easily and are dependent on certain fire regimes. Council's *Bush Fire Management Policy* (2008) includes information on fire regimes for the different plant associations within our LGA.

The Middle Harbour Catchment supports a variety of uses besides the predominant single dwelling residential development including sports fields and golf courses which give separation from the bushfire hazard. However, there is still an extensive bushland/residential interface.

The area has quite a broad exposure to the threat of fire along the broad eastern face. The steep, heavily vegetated valleys provide vectors for the spread of fire escaping from Garigal National Park deep into St Ives, Pymble, Gordon, East Killara, Lindfield, as well as Roseville Chase.

As can be seen from the APZ setback line in figure B2 in Appendix B, in this area of the catchment:

- Almost no development meets the ideal APZ requirements;
- In most cases the setback line is in front of the houses, or beyond the property altogether;
- In a couple of cases, the setback line is beyond 2 properties in depth.

Bushfire Evacuation Risk areas have been declared in the Middle Harbour Catchment. They lie between the sub-catchments of High Ridge and Rocky Creeks St Ives and also in East Killara and Roseville Chase.

Lane Cove River Catchment

In this catchment, development along the valley slopes is the most vulnerable. Once again, long broad fingers of vegetation can carry bushfires deep into the suburbs of Wahroonga, South Turramurra, Pymble, West Pymble, Killara and Lindfield.

The Lane Cove River catchment supports a variety of land uses including hospitals, educational institutions with a predominance of single dwelling residential housing and light commercial and retail outlets. Land at the higher parts of the Blue Gum Creek catchment includes land zoned for high density residential development. More than any other of the three catchments, the Lane Cove area has valley slopes that support development down their sides extending, in some cases, into the creek lines themselves. The National Park is a relatively narrow area of bushland along the river.

As can be seen from the APZ setback line in figure B3 in Appendix B, in this area of the catchment:

- A little under half the properties have the house setback along the 'ideal' APZ;
- The setback line is beyond 1 to 4 properties along more than half its length.

The westerly winds drive bushfire through a relatively narrow area of bushland, directly into the path of residential development. Not all of this area is well served by fire trails. A number of houses have been lost to bushfire in this catchment.

A number of Bushfire Evacuation Risk areas have been declared in South Wahroonga and South Turramurra.

Cultural assets

There will be some risk from fire to cultural assets of Aboriginal and European significance. No specific treatments are applied to these sites under the *Hornsby-Ku-ring-gai Bushfire Risk Management Plan*, however, consideration of these items is required during planning for hazard reduction works or fire trail creation and maintenance. Some of these assets are in inaccessible locations, making them difficult to specifically protect during a bushfire event.

There are a number of built heritage assets scattered lightly throughout bushfire prone land, however, the vast majority of these assets are closer to more developed areas. The risks to these are similar to the dwellings adjacent to them, however, the heritage dwellings were not built to modern bushfire construction standards.

[8] For the purposes of SEPP (Housing for Seniors or People with a Disability) 2004 and SEPP 53 – Metropolitan Residential Development

Housing stock

The urban areas on the Ku-ring-gai bushland interface primarily feature aged housing stock of brick and tile construction. Such structures are highly vulnerable to ember attack, which accounted for over 90% of house losses in both the 2003 Canberra and 2009 Victorian bushfires. Many properties have extensive vegetation areas connecting the built area to the bushland increasing the risk.

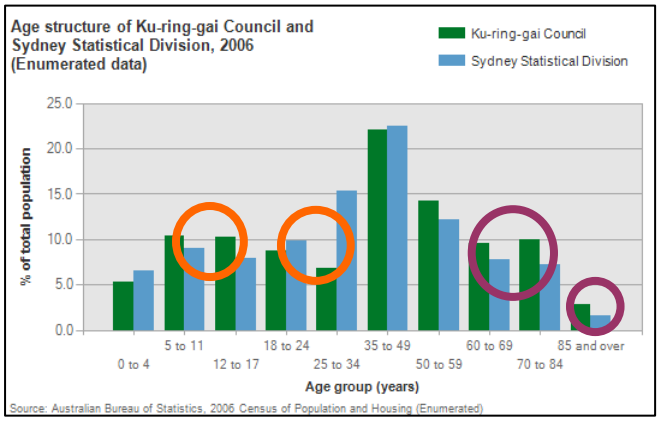
Newer developments in these areas have been constructed since the introduction of PBP. They are more likely to be built to construction standards more appropriate in a bushfire risk area, and to include measures such as Asset Protection Zones, and in some cases, static water supply. More recent subdivisions are also more likely to have considered emergency access. Nevertheless, as PBP allows more leeway for infill developments, recognising that full compliance is not possible in many of these circumstances, these areas will still be vulnerable.

Other infrastructure

Other infrastructure at risk within bushfire prone lands in Ku-ring-gai includes:

- major electricity lines – 3 major lines to the north, and a line to the east, as well as a smaller line within the Lane Cove catchment;
- power lines along the urban streets – these are all overhead lines. Note that not only is this infrastructure vulnerable to bushfire, it can also contribute to fire danger;
- overhead phone lines along the urban streets.

Figure 9: Age structure of Ku-ring-gai Council LGA



4.2. Social and demographic vulnerability and resilience

Social impacts from bushfire risk may occur in a number of ways, while a number of demographic and other factors may influence the degree of vulnerability or resilience of the community.

Societal responses to bushfires will have to operate within a world responding to climate change, which is likely to place an unusual strain on all social systems, the international security system, transport systems and the governmental systems under which we organize ourselves.

Resilience to climate change is also a question of the wider societal support mechanisms offered to communities. State and federal governments in Australia have recognized the need to assist communities to adapt to climate change and a growing number of support provisions and services facilitate such transitions. However, these come at a cost, and do not overcome the need to avoid or minimise the impacts.

Socio-economic characteristics

Ku-ring-gai has a diverse and vibrant society, representing many groups with various interests, goals, beliefs and voices. 32.6% of Ku-ring-gai's population (Ku-ring-gai Council (2010b) are immigrants to Australia. This diversity has helped to shape Ku-ring-gai's prosperity and community spirit. The community is generally well educated, and residents in the LGA have the highest average income in NSW (ABS 2006).

Ku-ring-gai has a higher proportion of people within the LGA who are most vulnerable to the risks of bushfire, and a lower proportion likely to be able to 'stay and defend' their properties.

Nevertheless, this diversity may also pose a variety of challenges in regards to bushfire understanding, preparedness and vulnerability. New migrants in particular may not be fully aware of the risks of extreme bushfire events. In comparison to the Sydney Statistical Division (see Figure 9), Ku-ring-gai has:

- A higher proportion of older people – in all age groups over 50;
- A higher proportion of children in the 5 -17 age groups;
- A lower proportion of people within the 18 – 49 age groups, with a significantly lower proportion in the 25 - 34 age group.

This means that Ku-ring-gai has a higher proportion of people within the LGA who are most vulnerable to the risks of bushfire, and a lower proportion likely to be able to 'stay and defend' their properties.

Like much of Sydney, Ku-ring-gai has an increasing ageing population, making it likely that this divergence will exacerbate over the coming decades. This has implications for the likelihood of people choosing to evacuate, and for the duty of care required in relation to planning for vulnerable (current and future) residents who cannot defend their properties or easily evacuate – eg those in retirement or nursing home accommodation.

Income and insurance

The ability to maintain an income flow impacts the resilience of a community (Handmer 2010). For example, illness from heat and smoke may prevent self employed people maintaining an income, or a fire could burn out cars leaving people with no means to travel to work. A household whose income is not jeopardised by the impact of the extreme weather event is more resilient to the impacts of an extreme event. Ku-ring-gai residents have a higher average income in comparison to most other areas in Australia, increasing the resilience of the community in this respect.

Businesses too are vulnerable to both direct and indirect impacts of bushfire. Locally owned small business may be less able to cope with extreme events than larger national or multinational businesses. Small business plays an important role in Ku-ring-gai's economy and may require assistance following an extreme event.

Insurance also seeks to improve the capacity of a council and residents to deal with financial problems. Insurance levels are therefore a key indicator of income protection, however, the insurance industry is reluctant to share statistics regarding the extent and levels of cover.

After the Victorian bushfires of 2009, the Insurance Council of Australia (Sydney Morning Herald, 5 February 2009, pp3) suggests that Australian building codes fall below international standards, and that this, combined with more severe weather conditions is likely to mean that it will be increasingly expensive and difficult for home owners to insure their homes against bushfire.

Mobility

Residents with poor mobility are more vulnerable to bushfire risk. With nearly 20 per cent of Australians suffering some sort of limitation due to a disability (Australian Human Rights Commission, 2010) their capacity to prepare and respond to extreme events can be compromised. Children are also more vulnerable.

As noted earlier, (see Figure 9) Ku-ring-gai has a greater proportion of older people, (more likely to have mobility problems), and children 5-17 years old than the Sydney area as a whole (ABS: 2006). Appendix C (Figures C1 and C2) shows that there are high proportions of older people 60 and over living in bushfire prone areas. The vulnerability is exacerbated, if one takes into account that the proportion of the 18 to 34 age group is considerably smaller than the Sydney area, reducing the availability of able bodied people to fight fires, either as volunteers or to protect their own properties.

Further, there are pockets containing significant numbers of people whose mobility is compromised because of age, infirmity, illness or a permanent disability. North Turramurra is the most extreme example of this. If a catastrophic event occurs such as a bushfire, moving these people to safety and assisting them to recover could be a major undertaking for Council, community services and local residents.

Transport and energy disruption

Impacts may arise through transport disruption. Within the LGA the rail line, and major road arteries are generally not within bushfire prone land, however, the F3, Pacific Highway and the railway to the north towards the Central Coast have been cut off in the past, stranding residents and workers from the LGA and the northern areas away from home or from work. Similarly, Mona Vale Rd towards Warringah can also be cut by bushfire.

The issue of evacuation risk from congested exit roads in a number of areas within the LGA has already been discussed.

With the prevalence of overhead powerlines in the area, bushfire events often result in a loss of power, not just to those areas that are within bushfire prone lands, but extending beyond to include other residential, business and community facilities.

Psychological effects

Extreme events can have profound psychological effects on society, demonstrated by the words of one witness to the 1991 storm: "I have never felt so horrifically petrified... I began feeling empty, lonely" (Kathy Woodall in Lawson-Hanscombe 1991 pp6).

According to Kiter-Edwards (1998), the level of psychological stress can be linked to ability to cope with disaster. Residents who are well connected to their local community are better able to cope in a crisis as they know how to access the information and services they need

(Handmer 2010). Connectivity in a predominantly dormitory style area is problematic. To some extent the high levels of education in the Ku-ring-gai community may override this disadvantage.

McFarlane *et al* (1997) investigated psychological stress related to natural disasters. This issue was also identified by the attendees at Council's workshop. The literature also indicates that bushfire has a significant psychological impact on people. This literature focussed on the Ash Wednesday fires in Victoria in 1983, and found that communities are affected very differently by natural disasters. The region affected by the Ash Wednesday fires was identified as having a high socioeconomic status, which was found to be a 'protective factor' lowering the prevalence of psychological disorders in the community resulting from the disaster. Wealth, insurance and support housing contribute to the resilience of the community. Ku-ring-gai's community has similar characteristics to the Ash Wednesday communities suggesting that, as a whole,

socially, Ku-ring-gai is more likely than some other LGAs to be able to cope with a natural disaster.

Nevertheless, there may be certain sections of the community less able to cope, such as the elderly, especially where they live alone. These people may require support during and after bushfire events.

It is noted, that the above work was undertaken for a specific fire event. However, with likely increases in fire frequency the potential for increased psychological stress on the community should not be underestimated.

Other impacts

Other impacts that need to be factored in any socio-economic consideration of vulnerability include:

- Access to support services;
- Isolation of elderly and disabled;
- Impact of social dislocation;
- Health impacts from air borne respiratory irritants;
- Injuries sustained either fire fighting or during clean up and repair.

Many of these impacts have economic consequences for Council, as Council provides much of the post-impact support service. However, in the case of disasters, councils are supported financially by state and federal emergency funding provisions. While this funding is currently available, if the frequency and magnitude of extreme weather events occur as predicted, it is likely there will be a significant draw down effect on emergency funding, as the trigger for the declaration of a State of Emergency may become harder to satisfy.

4.3. Environmental and ecosystem services vulnerability

Biodiversity

Ku-ring-gai has a total of approximately 537 vertebrates, 173 invertebrates, 843 floral species, 171 fungi and 26 ecological communities (Ku-ring-gai Council 2006a, Ku-ring-gai 2007). Of these at least 6 ecological communities, 28 fauna species and 15 flora species are threatened (State and / or nationally listed). The habitats of the majority of these animal species are found within bushfire prone land.

Current pressures

Bushfires and extreme storms do occur naturally and in the absence of climate change and human impacts are unlikely to cause significant large scale environmental problems; indeed many ecosystems rely on bushfires. Figure 7 shows that in the last thirty years the major fires have predominately affected the Ku-ring-gai Chase National Park, more so than privately owned bushland or Council reserves. However, current pressures on Ku-ring-gai ecosystems occur from a diverse range of activities and in combination with bushfire events and mitigation measures, cause significant adverse impacts on natural ecosystems and ecological systems.

First and foremost urbanisation and intensification of the urban footprint result in the direct loss of vegetation, habitat and cause habitat fragmentation. Indirect pressures from urbanisation include weed invasion from gardens to bushland, predation from domestic animals and increased stormwater runoff causing erosion and saturating soils rendering them unsuitable for native plants accustomed to dry, low nutrient conditions. Informal recreational activity such as mountain bike riding, expand the impact footprint and disturb areas once isolated from human impacts.

Further, bushfire is more likely to cause permanent damage to small remnants than large intact remnants, as it is more likely that the small remnant will be totally affected by the fire. Urbanisation in Ku-ring-gai has resulted in a number of small or narrow bushland remnants adjoining urban development.

Impacts on ecosystems including threatened ecological communities (TECs) also occur from current bushfire risk abatement practices. Some native species benefit from periodic wildfire, others do not. While Council's controlled burning regimes take into account the required fire regime for various species or communities, hazard reduction burns are lower temperature burns compared to wildfire and the benefits to the natural ecosystem are fewer and negative impacts more substantial. Compounding this problem is the emission of air pollution into the atmosphere. A percentage of CO_2 will be sequestered through vegetation re-growth. However, research suggests that the efficacy of using hazard reduction burns to achieve greenhouse gas emission abatement does not appear plausible in Australian sclerophyll forests (Bradstock and

Williams, 2009). The significance of any sequestration remains undetermined. CO_2 emissions add to the burden already in the atmosphere increasing the likelihood of weather events that lead up to increasingly frequent and intense wildfire conditions.

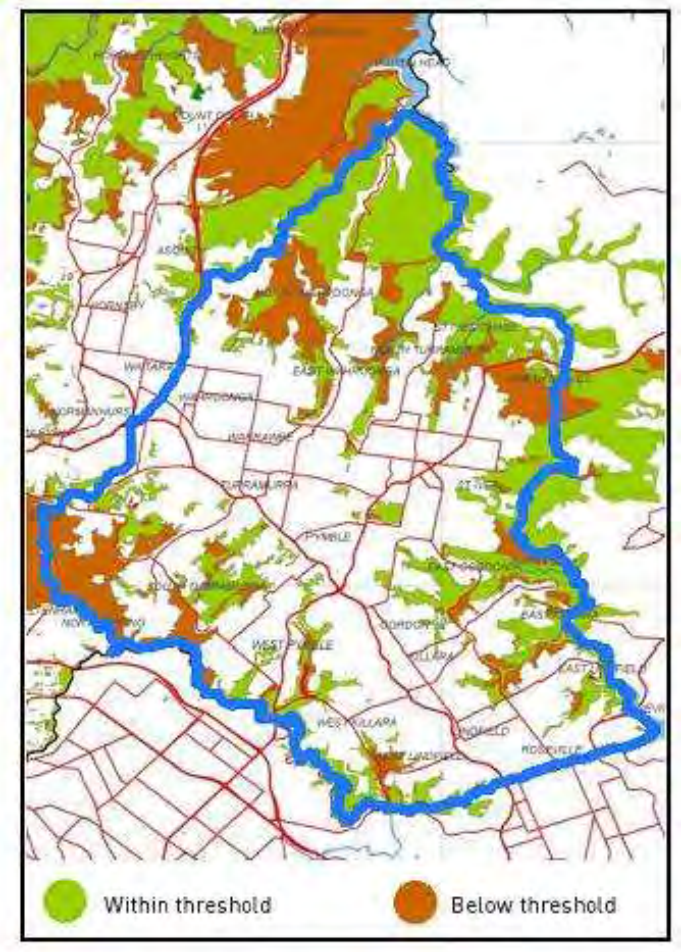
Post fire weed invasion reduces the ability of an ecosystem to recover after a fire. This occurs when weed species rapidly colonise the area cleared by the bushfire. Typically weed species can out-compete native species in the time it takes to colonise an area as they are highly fecund, whereas natives are much slower to establish. Post fire environments are harsh, vulnerable to erosion and lack the protection vegetation provides young plants from elements. Weeds are hardy and withstand a range of environmental conditions and generally do not require specific conditions in which to flourish.

Dependence on specific fire regimes

The environmental outcomes are not based solely on the last fire, but are a 'function of the sequence of previous fires, their timing and their properties' Gill (2005 pp72). This can be exacerbated by the configuration and design of urban areas in proximity to bushfire prone lands.

The NSW Rural Fire Service (1998) found that there may have been a permanent altering of the structure and composition of plant species in the Royal National Park

Figure 10 Fire threshold map, Hornsby-Ku-ring-gai Bush Fire Risk Management Plan 2010



following repeated fires over a number of years. While increasing urbanisation close to bushland also exposes native fauna to domestic predatory animals, the loss of vegetation after a fire can expose small fauna to feral species such as cats and foxes.

Figure 11 Some species have evolved with bushfire.
This young *Banksia serrata* plant was recruited after the fire that burnt the old tree. *B serrata* is a fire sensitive species that recruits seedlings from seed that is stored in the canopy and released after fire.

Ku-ring-gai's landscape is dominated by tall trees, many of which are eucalypts. A number of other species within the ecological communities in the LGA also burn readily. Indeed, many species have evolved with fire, and are dependent on specific fire regimes for their continued survival. From this perspective, many of the local and regional ecological communities appear quite resilient to bushfire.

However, the risk of likely increases in frequency and intensity of bushfires increases the risk to ecosystems that are dependent on specific fire regimes. Council's Biodiversity Strategy identifies high frequency fires as a threat to a number of species and communities (Ku-ring-gai 2006; DECCW 2007). Alterations of the natural fire regime as a result of climate change, fire suppression or hazard reduction burns have altered the species composition of vegetation communities in many forests of Australia, including those of Ku-ring-gai (Morrison, D. A: 1995) While native Australian ecosystems are naturally fire prone, increases in frequency and intensity have a negative impact (Ku-ring-gai 2006), even leading to local extinctions (Beeton *et al.* 2006). Fire events on already pressured ecosystems may cause permanent loss of species. Further

if these species are 'key stone' species (Scott Mills L *et al*. 1993) then whole ecosystems can collapse as a response to the loss of the role it played within that ecosystem. It is unlikely that natural systems can adapt at the same pace as climate changes and the occurrence of altered fire regimes. The higher the increase in temperature, the greater the increased risk.

Fire thresholds are the upper and lower time limits or range of fire intervals recommended for each vegetation type to support ecologically sustainable fire management. Lower thresholds aim to ensure that fire intervals are long enough to let vulnerable species grow to maturity and set seed, while upper thresholds aim to ensure that shorter lived species that rely on fire to regenerate remain in the system. The time between these thresholds (within thresholds) is the time between fire events that a specific plant or vegetation community needs to avoid being at risk from a decline in biodiversity.

High frequency fires are a threat to a number of species and ecological communities.

A decline in biodiversity usually occurs from too infrequent burning (above the threshold) or too frequent burning (below the threshold). Other fire factors that also influence decline in biodiversity are fire intensity, season, extent (patchiness) and type of fire.
Figure 10 shows the fire thresholds for vegetation types in the Ku-ring-gai area. Within Ku-ring-gai vegetated areas are considered either within the threshold or below the threshold. The areas shown below the threshold are those that have been recently burnt and may be adversely impacted by additional hazard reduction burns should these be undertaken before the recommended fire interval. .

Hazard reduction burns and Asset Protection Zones

If increasing hazard reduction burns to approximately five times the current practice were to be chosen as an adaptation option, fire sensitive species could also potentially become locally extinct.

The burning of vegetation will also impact the fauna, as vegetation provides habitat, shelter and food for the fauna. Measures to reduce risk of fire exacerbate these pressures with the clearing of ground storey vegetation for Asset Protection Zones. The lower layers of vegetation are home to a number of small birds and mammals. Removing this vegetation at the interface removes shelter and food that may be critical for survival in times of fire.

Biodiversity corridors

Bushfire to date has not been identified as a causal link in the localized extinction of fauna from the Ku-ring-gai area. It is clear from Figure 8 that the bushland areas of Ku-ring-gai are split north-south by urban development, impeding fauna escaping fires and exacerbating habitat fragmentation (Ku-ring-gai 2004).

Re-colonising after fires requires that sufficient plants or animals survive the fire or flee to adjacent areas to re-populate an area. It therefore requires linked or islands of vegetation which remain intact in the vicinity to provide shelter and food for species to survive while the bushland regenerates. Allowing urban pressures to reduce connectivity or remove or degrade such refuges, may result in an inability of these organisms to re-colonise due to the lack of a linkage with another reserve area, resulting in local extinctions.

Council and private bushland within the fingers of vegetation, reaching in towards the centre of Ku-ring-gai, can act as both a biodiversity corridor and (in times of bushfire in the National Parks) a refuge. The burning of these corridors can escalate the impacts of fragmentation. It is worth considering that only certain flora and fauna are sufficiently mobile to take advantage of the corridors and refuges, while others may have increased vulnerability because of their immobility. Fires may cut biodiversity corridors or destroy populations trapped by surrounding human development as has been the case for koalas (Sydney Morning Herald 11-4-2007).

Erosion

A bushfire followed by heavy rain can result in increases in large amounts of newly exposed soil being washed into streams, rivers and lakes. This can be very harmful to the water ecology. With increased fires, there will also be increased post-fire weed invasion, further adding to the vulnerability of the local ecosystems.

Recoverability from bushfire

Recoverability of ecosystem assets from wildfire events is variable according to the extent of the area burnt and ability of species to recolonise. To re-establish pre-fire conditions may take decades if at all. Fire events on already pressured ecosystems may cause permanent loss of species. A precautionary approach is to protect and enhance the existing ecosystems and ecosystem services to improve their resilience to pressures such as those from altered bushfire regimes. This would need to be achieved in part by limiting the human pressures on these systems, as well as more active rehabilitation measures.

Cumulative impacts

While ecological communities within Ku-ring-gai do form part of a unique system (e.g. Blue Gum High Forest), Ku-ring-gai is not home to any unique species that cannot be found elsewhere and Ku-ring-gai's ecology was not listed in the Australian Greenhouse Office (2005) report on 'priority vulnerable systems' to the impacts of climate change.

As Australian ecosystems are naturally fire prone and the seeds of many Australian shrub and eucalypt species have enhanced germination after fire (Florence 1996). This provides some resilience to bushfire, provided the bushfire events are within the fire thresholds for the ecological community. The rate and extent of climate change (or the success of reining in CO_2 emissions) will be critical to future fire regimes. If altered fire regimes were the only issue for

biodiversity in the LGA, lower emissions may allow these communities, to adapt to some extent.

Of vital importance however, are human impacts in combination with altered fire regimes. Should habitats be further fragmented by housing, roads, etc then the risk of local extinctions will increase. These impacts also need to be considered in conjunction with the increased pressure on biodiversity from additional hazard reduction works resulting from urbanisation.

Due to the complex interactions between all the factors involved, there is a strong potential for *'systems that are apparently in reasonable condition altering suddenly to a point where there is no hope of recovery'* (Beeton *et al*. 2006 p34).

4.4. Current response capacity and preparedness

Brigades

The Ku-ring-gai LGA houses two brigades. One brigade, located at Gordon, is provided by the Fire and Rescue NSW. The other brigade (operated by volunteers) is provided by the NSW RFS and is located at Golden Jubilee Oval in Wahroonga. Figure 12 shows the current brigade locations. These brigades service the Ku-ring-gai area through a cooperative agreement between the two agencies to ensure the community is provided with the best possible response to incidents. Together they cover a total area of over 8000 ha which includes 2813.5 ha of bushland within the Ku-ring-gai LGA (of which 1645.9 ha is National Park estate).

By way of comparison Hornsby LGA has approximately 30,000 hectares of bushland which is made up of 52 percent National Park estate, 17 percent Council managed lands and the other 31 percent being made up of land belonging to the Department of Lands, and private bushland as well as that associated with the RTA and Rail Corp. While this bushland is more than that of the Ku-ring-gai LGA it meets an urban interface of just 47 kilometres. 14,000 houses lie within 130 metres of that bushland (Chen 2005).

The Ku-ring-gai LGA houses just two fire brigades.

Figure 13 displays a comparison of response capability between Hornsby and Ku-ring-gai LGAs. To meet the bushfire response of the Hornsby Ku-ring-gai area 15 NSW Rural Fire Service Brigades and three support brigades are located strategically throughout the LGA with Fire and Rescue NSW units located at Hornsby, Berowra and Beecroft. Hornsby also supports 2 fire towers, 1 training centre and a fire control centre which directs fire operations for both LGAs. The Ku-ring-gai brigade is supported by volunteer brigades in the Warringah/ Pittwater district as well as Fire and Rescue Brigades in surrounding areas.

While Ku-ring-gai has a smaller area of bushland reserves it also shares a large proportion of its interface with National Parks and a higher density of residential development in interface areas.

However, to compare the response capability for the two LGAs is difficult as a number of factors come into play. Ku-ring-gai may have a greater capacity to draw on support from brigades of neighbouring areas due to it's proximity to urban centres, whereas parts of Hornsby are more rural and remote resulting in an increase in response time. In the event of the outbreak of a fire, the first response regardless of what area, will be the best and possibly the most highly attended. Past events have shown that in severe fires it is those properties that come under threat in the hours after

the initial call that can suffer the poorest response as brigades are usually stretched to capacity responding to numerous calls. During large bush fire events brigades within the area or in neighbouring districts may be responded to areas across Sydney, the state or interstate further limiting the ability to determine response capability.

Figure 12 Location of fire agencies within the Ku-ring-gai LGA.

Fire trails

Fire trails play an important access role in fire suppression and mitigation by:

- Providing greater access in order to prevent fire spread
- Allowing fire fighters safer access to more effectively protect properties on the bushland interface.
- Allow for a more rapid response to aid fire suppression.

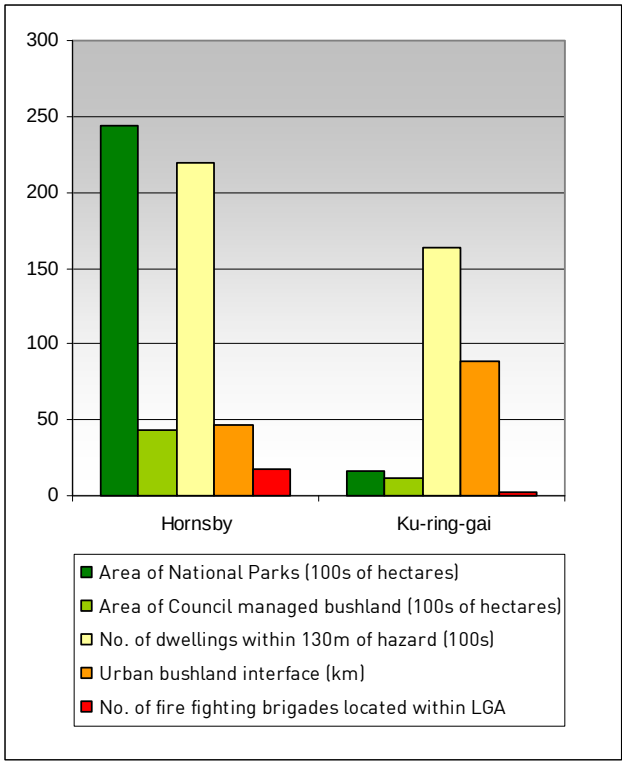
Council's Access Team currently manages a 44km network of fire trails throughout the Ku-ring-gai Council LGA. The maintenance of these trails as well as the vegetation maintenance of 27 km of walking tracks is divided into two yearly rotations. Rotation A - Lane Cove Catchment and one half of Middle Harbour Catchment and Rotation B – Cowan catchment and the remaining half of Middle Harbour.

Council works with the Rural Fire Service volunteers on an annual basis to assess the condition of each trail. This includes accessibility to a range of fire tankers, class (essential, secondary or dormant), land tenure, assets, condition of the trail surface and need for vegetation maintenance.

Council also receives additional funding, usually on an annual basis, through a number of grants[9] made available to each of the fire districts in NSW, which fund additional projects such as fire trail upgrades.

Throughout 2009/10 and 2010/11, in addition to the annual maintenance program, Ku-ring-gai has received additional funding to undertake works on seven (7) fire trails. However, it is noted that these works are dependent on the continuation of available funding.

Figure 13 Comparison of response capability



Water availability

In addition, with climate models predicting an increase in bushfire intensity and frequency and a net decline in available water, access to water for bushfire fighting will also become increasingly problematic.

Mains water supply is often reduced and unreliable during bushfire events due to the extreme increased demand for water by residents and emergency services undertaking property protection. An estimated 95% of households in NSW are connected to mains supply water (ABS: 2006a).

Hydrants are utilised by fire agencies which may also significantly reduce the pressure down the line.

To partially address the need for water for emergency services, within the Ku-ring-gai LGA 56 properties have been registered as having a static water supply available for

[9] These grants are the Bushfire Mitigation Programme, the Fire Mitigation Works Fund and the Rural Fire Fighting Fund.

last resort use by emergency services during a bush fire. Static water supply I.D plates are available from both fire agencies and through Council. Residents display their plate in a prominent position e.g. on the front fence or letterbox. Static water supplies that can be utilised include water tanks, swimming pools, dams or creeks.

At the household level some have an independent water supply or fire fighting reserves in a tank with a petrol or diesel powered pump (unless backup power is available such as a generator), but it expected that this is uncommon in the LGA.

Community fire units

60 community fire units have been established in Ku-ring-gai LGA. These units are made up of resident volunteers who are trained by Fire and Rescue NSW to undertake small scale property protection. The majority of these units are within the southern bushfire risk areas, and in Wahroonga and St Ives.

These units support local communities on a street by street basis and free up formal emergency services for more frontline fire fighting.

Hazard reduction capacity

Bradstock *et al* (1998) investigated bushfire risk at the urban interface in Sydney's northern suburbs, including some areas of Ku-ring-gai. The results indicate that in the region, 27-40% of the urban-bushland interface needs to receive prescribed burning to effectively manage the risks of fire to the properties in any given year. However, as noted in the section entitled 'Current Fuel Management', in a good year 60 hectares are burnt. This is already well beyond the capacity of local resources.

Fragmented vegetation and biodiversity corridors within Ku-ring-gai, necessary for the conservation of biodiversity, increase the potential to quickly spread fire should a crown fire develop. For this reason, Ku-ring-gai requires more attention from the NSW Rural Fire Service to ensure that the 1,100 hectares of bushland managed by Council is done effectively and minimises the impacts to the community, the environment and property.

With a reduced season for hazard reduction burning under climate change, as outlined in the Section entitled 'Fuel Management into the Future', pressure will increase on the already stretched resources of the NSW RFS- Ku-ring-gai Brigade and Ku-ring-gai Council to adequately protect the community and its assets. It is likely that more areas will be left vulnerable to future bushfires.

Response capacity at the household level

The urban bushland interface in Ku-ring-gai is intensively developed with most new development at the interface being infill. People living on the bushland interface need to prepare their properties for wildfire events. Council provides guidance and education for residents who wish to minimize their risk of property loss, however there are a number of constraints, including cost, access, mental and physical capability and availability of resources. All of these can impact on the ability of Councils to operate as an educational body and on the residents' capacity to implement or undertake property protection.

Currently, there are no mechanisms available to encourage the upgrading of buildings when new development is not being sought. Properties that are poorly designed and located in high bushfire risk areas can increase the risk for surrounding properties, even where the surrounding properties have complied with Planning for Bushfire Protection 2006. The current planning protocols provide only limited improvements in terms of property protection.

In the event of a bushfire, residents and visitors can respond in two ways:

- Stay to protect the home (and shelter within the home)
- Evacuate to a safe area usually outside the fire area altogether, or within designated protection sites within the fire area (see Neighbourhood Safer Places below).

Stay and protect

Increasingly this option has been encouraged where the property is designed and adequately prepared for a bushfire event. With increasing recognition that fire fighting resources will sometimes be spread too thinly to be able to help protect every property, significant effort and resources are expended on educating residents in how to prepare the property for the bushfire season, and what to do (and not do) in the event of a bushfire. Many able bodied residents are now more experienced and knowledgeable about how to protect their properties as safely as possible. Others, new to living with bushfire, are still learning.

This is also supported through development control in bushfire prone areas. Applications for development within bushfire prone land are required to address the requirements of *Planning for Bushfire Protection 2006* (PBP). This includes, where possible:

- Designing the building to increase its ability to withstand a bushfire attack;
- Provision of access for fire fighters and equipment;
- The inclusion of Asset Protection Zones with reduced levels of vegetation and a defensible space for fire fighters.

However, PBP recognizes that infill sites often cannot meet the full requirements that would apply to new development on Greenfield sites. In particular the following measures are often compromised on infill sites:

- the design of the existing development in terms of its ability to withstand bushfire attack;
- setbacks to the hazard incorporating adequate asset protection zones;
- adequacy of access, including perimeter roads.

Household level communication and planning

The need to boost household capacity to respond appropriately to bushfire events was identified by the Victorian Bushfire Commission (2010). Following this, a number of actions have already been taken in NSW to improve communication including:

- The introduction of the Emergency Alert system, which can deliver warning messages to mobile and fixed-line telephones;
- A three-fold increase in the call-taking capacity of the RFS Bush Fire Information Line 1800 679 737;
- Establishment of the RFS website as a 'one-stop shop' for bush fire information in NSW;
- The RFS iPhone™ application, Fires Near Me, designed to alert people to bush fire activity in NSW;
- Introducing new fire danger ratings.

The NSW Rural Fire Service has released a range of material and promotional campaigns that include but are not limited to:

- The Prepare. Act. Survive. campaign;
- A revised Bush Fire Survival Plan, including the distribution of about 800,000 copies last bush fire season;
- The rollout of more than 500 Fire Danger Rating signs across NSW, to inform the community about the current fire danger;
- Neighbourhood Safer Places guidelines;
- Development of the Bush Fire Household Risk Assessment Tool, an online resource to help residents identify the level of risk to, and defendability of their property.

All of these initiatives enable an improvement in decision-making and response capacity at the household level.

Ability to evacuate in a bushfire event

Ku-ring-gai contains a number of 'peninsulas' of land containing urban development that are surrounded by bushfire prone lands and have limited access and egress. These areas (Figure 2) have been classified by the NSW Rural Fire Service as Bushfire Evacuation Risk areas giving regard to an analysis of data provided in accordance with Australian Standard AS4360 – Risk Management. Additional to this Standard, the RFS applied criteria relating to bush fire risk factors which included:

- Single access/egress into the area
- Bottle necks
- Potential limited access for emergency services
- Isolated development
- Access ways that pass through or are directly adjacent to the identified hazards
- Ridge top development with steep slopes
- Known fire paths/impact areas
- Existing high density of special fire protection development
- Identified traffic flow problems
- Identified mains water pressure issues

In all, 12 Bushfire Evacuation Risk areas have been declared in the Ku-ring-gai LGA[10]. These areas contain land that is bushfire prone and land that is not.

In total, approximately 5,200 dwellings are located in the Bushfire Evacuation Risk areas.

The encouragement to shelter in place, under the 'stay or go' policy was not in place at the time the first areas were certified as Bushfire Risk Evacuation areas, and therefore did not consider the number of people likely to stay and defend their properties. However, since the unprecedented intensity of the Victorian Black Saturday bushfires, and the resultant recent adoption of a 'catastrophic' warning category for bushfire days in NSW, it is likely that greater numbers of residents will evacuate in 'catastrophic' bushfire events, than would previously have been the case.

The evacuation risk in these areas is recognised by the prohibition of development under SEPP (Housing for Seniors or People with a Disability) 2004 and of dual occupancy development under SEPP 53 – Metropolitan Residential Development. However, state policies are inconsistent in limiting density in these areas with the new 2008 evacuation risk areas not identified under SEPP 53 and none of the evacuation risk areas are exempted under SEPP (Affordable Housing).

Neighbourhood safer places

Neighbourhood Safer Places (NSP) is a new concept developed following the Victorian bush fires in February 2009. A Neighbourhood Safer Place is a place of last resort for people during a bush fire (RFS 2010). In late 2009, the NSW Rural Fire Service (RFS), in conjunction with other NSW emergency service organisations, developed criteria for the identification and assessment of NSPs across NSW. The primary purpose of a NSP is the protection of human life.

An NSP is an identified building or space within the community that can provide a higher level of protection from the immediate life threatening effects of a bush fire. NSPs still involve some level of risk, both in moving to them and while sheltering in them and cannot be considered completely safe. They are a place of last resort in emergencies only.

The NSW Rural Fire Service has designated the Open Space locations in Table 4 to be used as places of last resort during a bush fire emergency.

The following limitations of NSPs need to be considered:

- NSP do not cater for pets;
- Emergency services may not be present;
- NSP do not provide meals, amenity or cater for special needs (e.g. for infants, the elderly, the ill or disabled);
- NSPs may not provide shelter from the elements, particularly flying embers;
- NSPs are not suitable for people who would be required to travel extensively through fire affected areas to get there.

[10] Note that for the purposes of further assessment within this report, these 12 areas are split into 22 areas as shown in figure 16.

Table 4 Neighbourhood Safer Places in Ku-ring-gai

Title	Location
Claude Cameron Grove	Cnr Westbrook Ave & Kintore St, Wahroonga
Gillespie Field	Bangalla St, Warrawee
Turramurra Memorial Park	Karuah Rd, Turramurra
Kent Oval	3 Kent Rd, North Turramurra
Hassell Park	Palm St & Mona Vale Rd, St Ives
Bannockburn Oval	Bannockburn Rd, Pymble
Regimental Park	20 Lorne Ave, Killara
Roseville Park	60A Clanville Rd, Roseville

5. Consequences of Bushfire Events

Bushfires, especially major bushfire events, can result in loss of life and property, damage to the natural environment, loss of biodiversity, impacts on human health and well being, reduced productivity and financial and economic losses. In addition, it may stretch the resources of governments at a variety of levels. These areas have been identified in literature as vulnerable to climate change in many areas of Australia. The magnitude of the risks is relevant to location as evidenced in this report.

These consequences are likely to be more severe under a changed climate. The extent of the consequences will be influenced by:

- the degree to which climate change can be avoided by contributing to a reduction in CO_2 emissions;
- the degree to which fire regimes are altered; and
- the ability of a community to plan for adaptation, and to transform and adapt to external pressures.

Affluent, well educated and secure communities such as Ku-ring-gai are better able to adapt than most.

However it is important to note that no matter how affluent a community might be, it cannot simply buy its way out trouble. Communities must recognize the need to change behaviour and attitudes if they are to avoid the worst potential climate change effects such as bush fire.

Hobart and region fires, 1967

The 1967 Hobart and region fires claimed 62 lives, left 7000 people homeless and caused damage of approximately AUD$101 million (GHD: Dec 2008).

Ash Wednesday fires, 1983

The 1983 Victorian and South Australian Fires of 1983 claimed 75 lives, left 9,000 people homeless and caused damage of approximately $324 m (GHD: Dec 2008).

Canberra fire, 2003

4 people died, 300,000 people were affected and 500 properties were destroyed as a result of the Canberra fires of 2003, with a damage cost of $350 million (Pitman et al, 2007; GHD: 2008).

Victorian Black Saturday fires 2009

173 fatalities, 414 injuries, 450,000 hectares burnt, over 3,500 structures destroyed. $1.5 billion damage.

5.1. Loss of life and property

Despite the improved management of fire over the last two decades, losses associated with major fire events in Australia are large. Based on historical data, major bushfires that result in loss of life and property are 'neither cyclic nor predictable' (Blanchi *et al.* in CIE 2010). The majority of losses occur infrequently, but significant losses are experienced. Over 53 years, over 400 people have perished and more than 8,000 houses have been destroyed (Haynes et al, 2008 and Blanchi *et al.* 2010, in CIE 2010). Housing losses between 1939 and 2009 are shown at Table 5.

While there has been no loss of life from wildfires in Ku-ring-gai to date, loss of life or health are common consequences of major fires.

The incidence of major fire outbreaks in Australia, where at least 488 houses are destroyed is approximately 1 in 15 years (CIE 2010) Additional property has also been lost. Loss values reported are mainly those related to insured losses, with uninsured losses still high. Tables 6 and 7 provide a summary of deaths related to bushfires over the period 1956–2007. A significant portion of deaths reportedly resulted from defending property (over 28 per cent), late evacuation (26 per cent) and passively sheltering or awaiting rescue (13 per cent) (Bushfire CRC, 2009 in CIE, 2010)

Table 5 Housing losses by state -1939-2009

State	House losses No.
Victoria	6 861
New South Wales	1 530
Tasmania	1 376
South Australia	548
Australian Capital Territory	521
Western Australia	212
Queensland	43
Northern Territory	1
Total	**11 092**

Late evacuation is known to present associated risks. However, until the Victorian bushfires of 2009, the 'stay and defend' strategy was understood to have a reasonable chance of success. Preliminary results from a survey of the residents of fire affected regions, conducted by the Bushfire CRC, indicated a range of difficulties experienced by residents leading up to and during the fire (CIE 2010).

'The capacity of those that stayed to defend their homes and properties was inhibited by the severity of conditions, where heat exhaustion, dehydration, breathing difficulties and eye irritation may have diminished the capacity to defend their houses and subsequently their lives' (Bushfire CRC 2009).

Table 6 Bushfire fatalities 1956-2007 — activity at time of death

Activity at time of death	Fatalities #	Fatalities %
Late evacuation	66	26
Defending property from outside		
Suburban location	28	11
Rural location	35	13
Inside defendable property		
Actively defending	1	<1
Meagre and unsuccessful attempts to defend	4	2
Passively sheltering	26	10
Activities unknown	4	2
Other		
Travelling through the area unaware	28	11
Waiting rescue	7	3
Other or unknown	58	22
Total	**257**	**100**

Data source: Haynes, K. et al. (2008) 100 years of Australian civilian bushfire fatalities: exploring trends in relation to the 'stay or go policy'.

Table 7 Housing losses by state and fire event

State	Events	Housing losses
NSW	6 significant bushfires	100-200 each
Victoria	1939	650
	1944	434
	1983	1513
	2009	2131
ACT	2003	500
WA	1961	approx 200
Tasmania	1967	almost 1300
South Australia	1983	283
	2005	90

Source data: CIE: 2010

5.2. Human health and wellbeing

Ku-ring-gai has good access to health services, within and close to the LGA, providing a level of resilience within the community. However, stakeholders have predicted that healthcare and emergency services are likely to be significantly affected by altered fire regimes. In terms of physical health, fires sometimes result in severe injuries and death. Conservative estimates by Emergency Management Australia suggest that bushfire has caused 9,946 injuries (GHD Dec 2008). During fire events local hospitals are likely to have increased admissions for injuries as a result of fire fighting activities, as well as the elderly suffering from respiratory and heat related stress. A study of the admissions into hospitals with asthma and respiratory related illness during the '94 fires in western Sydney hospitals, showed that there was no link between these fires and hospital admissions at the time. This is despite evidence from California that showed that there were more respiratory related illnesses in hospitals in times of wildfire (Smith *et al*, 1995).

While, as a whole Ku-ring-gai's community, is likely to be relatively resilient to the psychological effects of bushfire disasters, certain sections of the community less able to cope, such as the elderly, especially those that live alone, and those that have had major losses are nevertheless likely to require support during and after bushfire events.

There are instances of community disharmony when decisions have to be made over which houses to save (National Museum of Australia & Ryebuck Media 2004).

Bushfires can also cause a decrease in air quality, and is already a common cause of air pollution within Ku-ring-gai (Ku-ring-gai 2004). On a more local level, hazard reduction burns also increase air pollution. Pollutants include particulates which can cause breathing problems to people susceptible to respiratory problems such as asthma.

Loss of natural habitat and threatened ecological communities also impacts economic and social implications. Stakeholders have identified that TEC's and biodiversity generally are of social significance, as well as contributing to the higher property values in many areas of the LGA. If bushland reserves were decimated by poor management or ill-advised climate response strategies, the highly prized natural assets that contribute the area's intrinsic value could be permanently compromised.

5.3. Economic considerations

Historically bushfires have frequently impacted upon Ku-ring-gai and even without climate change this would continue to be the case. However, economic information on bushfires is limited and scattered.

While there may be some positive economic effects of altered fire regimes on the local construction industry, through the need for reconstruction of properties in the area, this positive impact is minor compared to the massive losses associated with fire. Bureau of Transport Economics (BTE) (2001) found that damages generally impact negatively as a whole.

Estimates of costs to Australia from bushfires vary from $2.5 billion for the period 1967-99 (AGO 2005) to more than $1,692,700,000 (1967-2005?) (EMA in GHD Dec 2008) to more than $5 billion for the period 1926 to 2009 (CIE: 2010). These estimates are conservative as they only include damage from more significant fires.

Economic losses associated with bushfire are generally reported across the state as a whole, rather than by region, or LGA. Within Ku-ring-gai, private property damage and the destruction of Council's natural and built assets are the major potential direct economic impact of bushfires. However, the economic costs of damage to natural systems and to health and wellbeing are more difficult to assess.

At a finer scale, the most relevant and detailed economic data is associated with the 1994 fires. This is mainly for private properties, and this data does not reflect the cost of fire to Council.

No properties were affected in the Ku-ring-gai area during the 2001-02 fires. The next most recent fire event with relevant information is the Canberra fires of 2003-04. It is important to note that this information is based upon extreme fire events, and it could be seen that limited losses from fire since 1994 were due to successful management techniques.

Council may need to find additional funds (eg from rates) to cover extra insurance expenses, reducing funds available for other programs. Council contribution to the RFS has increased by 1% since 2000, while funding from the treasury has decreased by 1%. Council may have to ensure that public buildings are suitably adapted against danger and may need to self-insure.

Loss of productivity is a common consequence of fire. Losses related to business and productivity on top of insured losses has also been estimated for the Ash Wednesday fires to have been significant, however the uninsured losses associated with the Canberra fires were less than expected due to a high proportion of insurance coverage (Aon 2003).

Losses to bushfire on the insurance industry rank fifth in Australia, following floods, severe storms, tropical cyclones and earthquakes. Bushfires cost over $2 billion in 1998 figures (BTE 2001). With more frequent and intense fires, insurance premiums are expected to rise in areas of high bushfire danger, which will affect landowners and Council.

The average loss for houses destroyed in major or significant bushfires between 1926 and 2009 is shown at Table 8 (CIE 2010). The estimates for the value of houses destroyed and value of insured losses for property damage are presented in today's prices or present value terms.

Table 8 Major and significant bushfire events and cost

Bushfire event	Year	Present value of insured losses $ million	Average losses per house destroyed $
Black Saturday - Victoria	2009	1,350	630,000
Canberra	2003	414	850,000
Ash Wednesday SA & Vic	1983	856	340,000
Hobart	1967	1,058	820,000
Black Friday Vic	1939	939	720,000
Black Sunday[a]	1926	unknown	unknown
Eyre Peninsula	2005	32	630,000
Sydney	1994	Unknown	430,000
Lara	1969	87	n.a.
Dandenong	1962	270	600,000

Note: A major bushfire event is an event with over 450 houses burned or loss of greater than five lives in a one week period. A significant event is where over 50 houses are destroyed and there is significant loss of life.

Data source: Emergency Management Australia database 2010. Adjustments made for inflation — based on RBA Inflation Calculator. In CIE (2010).

The cost of bushfire varies according to the number of houses destroyed, displaying a direct positive relationship with insured losses. The average insured losses for every house destroyed in 'major' or 'significant' bushfire events,

between 1926 and 2009, has ranged between $340,000 and $850,000.

Set methodologies developed and in current use (BTE 2001) for estimating losses associated with natural disasters generally, are based on an estimation of costs from data on floods, because of the extensive knowledge of floods. Economic and financial losses can be classified as follows:

Direct Tangible:

- Damage to infrastructure, buildings and contents, vehicles,boats, etc;
- Loss of biodiversity and ecosystem services;

Indirect Tangible:

- Loss of production- volunteers are extensively involved in managing bushfire events, resulting in a loss of productivity from their usual employment/activity;
- Emergency responses and relief - NSW already has the world's largest fire service. Funding for the RFS primarily comes from insurance agencies (73.7%), with 13.3% from local government and 13% from the treasury (NSW RFS 2007).
- Clean-up costs (time and resources);
- Fuel management measures;
- Fire trail creation and maintenance;
- Loss of biodiversity and ecosystem services;

Direct Intangible:

- Death and injury – financial impacts on families;
- Loss of items of cultural significance and personal memorabilia;
- Increasing insurance costs as a result of:
  - Additional claims;
  - Increased funding for RFS (Insurance agencies currently provide 73.7% of the funding for RFS);
  - Potential changes to insurance coverage. Council's own insurance classes bushfires as 'Acts of God' and does not pay out on them, shielding Council from the increased premiums but leaving Council uncovered in case of disaster unless the State or Federal government steps in;

Indirect Intangible:

- Inconvenience and disruption, especially to schooling and social life;
- Stress induced ill-health (physical, psychological) – exacerbated by an ageing population;
- Mortality.

Figure 14: Marysville Primary School damaged by in the Victorian Black Saturday Fire, 2009. (Image Source: AFP, William West)

5.4. Natural environment

Increasing frequency and intensity may result in the permanent alteration of the structure and composition of ecological communities within Ku-ring-gai, exacerbated by urban fragmentation and degradation. Flora and fauna species and habitat may be lost, even entire ecological communities, and ecological services degraded (Pitman *et al* 2007).

However, it is the combined impacts of altered fire regimes in a changing climate with human settlement impacts that have the potential for the greatest consequences to ecosystems and ecosystem services. Bushfire management practices may further amplify these consequences. Planning for any urban expansion needs to be mindful of this consequence.

Some particular flora species may be positively affected, while fauna species are likely to be negatively affected, especially those whose habitat lies within fragmented remnants, such as Lane Cove National Park. Some of the common mammals which could become threatened by high frequency fire include:

- *Acrobates pygmaeus* (Feathertail Glider)
- *Antechinus flavipes* (Yellow-footed Antechinus)
- *Antechinus swainsonii* (Dusky Antechinus)
- *Isoodon macrourus* (Northern Brown Bandicoot)
- *Perameles nasuta* (Long-nosed Bandicoot)
- *Pseudocheirus peregrinus* (Common Ringtail Possum)
- *Petaurus breviceps* (Sugar Glider).

Four threatened ecological communities 'are all likely to suffer a loss of species if subject to repeated high frequency fires' (Ku-ring-gai Council 2006a p25), being Blue Gum High Forest, Sydney Turpentine Ironbark Forest, Duffy's Forest and Sydney Coastal River-flat Forest.

Common mammals which could become threatened by high frequency fires

- *Feather tailed glider*
- *Yellow footed antechinus*
- *Dusky antechinus*
- *Northern brown bandicoot*
- *Long nosed bandicoot*
- *Common ringtail possum*
- *Sugar glider*

Ancillary effects of bush fire include:

- Exposure of soils facilitating higher rates of soil erosion and sedimentation in waterways (Beeton et al. 2006) especially when heavy rain follows a bushfire;
- Reduced catchment yield (Lavoral & Steffen 2004);
- Loss of canopy cover;
- Reduced ability for the vegetation to absorb increasing concentrations of CO_2, thereby feeding the climate loop.

The management of fuel between fires, as well as emergency management, can have similar adverse consequences for the natural environment; eg through:

- Direct loss of vegetation and habitat;
- Selective canopy, and understorey clearing for APZs;
- Increasing fire frequencies even further, with resultant impacts on species and habitats as described above.

Ku-ring-gai Council is required to protect biodiversity under Threatened Species legislation. As such any response strategy needs to carefully consider both the intended and unintended consequences of any choice. Well designed and managed responses in the Ku-ring-gai area are likely to become critical to the future conservation of ecological assets. While human life and property will always take precedence where questions of conflict arise between people and the bush, it is nevertheless possible to construct responses that reduce risk while conserving the remaining natural assets for future generations to enjoy.

Figure 15. Some of the threatened species and communities found in Ku-ring-gai that may be further threatened by altered fire regimes. L-R: Grevillea caleyi, Pseudophryne australis, Ninox strenua, Tetratheca glandulosa, Sydney Turpentine Ironbark Forest.

6. Response to Bushfire Risk

Council will have to consider a variety of costs, from emergency services, repairing structures and buildings to the eventual cleanup and possible replanting of vegetation in Ku-ring-gai in response to bush fire events. Adapting and responding to bush fire risk will not be without cost. In order to reduce any risk exposure to an acceptable level, preventative and combative responses will need to be considered.

Recommendations within two key documents have been used to determine Council's response to bush fire risk. These documents include:

Victorian Bush Fire Royal Commission Final Report (2010)
Lessons learnt from the 2009 Victorian bushfires (Victorian Bushfires Royal Commission (VBRC) 2009) include a clear recognition that local government has a significant responsibility to play a preventative role to make communities safer.

The Victorian Bushfire Commission (VBRC, 2010) has also included a number of recommendations in relation to planning as a result of the catastrophic 2009 bushfires, which also have relevance to other bushfire risk areas, such as Ku-ring-gai. The response options considered here take into account the recommendations of the Commission, as well as the NSW Government's response to them.

Ku-ring-gai Council Climate Change Adaptation Strategy (2010)
Council has undertaken extensive consultation with experts and the community regarding potential options for adaptations to bushfire risk from climate change (Ku-ring-gai 2010). A list of options was developed, and then tested against a set of questions designed to rank each adaptation against financial, social and environmental performance, and the ability of the adaptation action to reduce the risk. These options are also considered within this section.

In addition, the *Hornsby/Ku-ring-gai Bush Fire Risk Management Plan (2010),* and the Ku-ring-gai *Bush Fire Prone Land Map and Bush Fire Evacuation Risk Map (2008)* are used to identify and prioritise those areas where responses are required.

Response options
In addition to addressing the current risk from bushfire events, responses to bushfire risk need to include measures to allow for adaptation to increased frequency and intensity of bushfires in Ku-ring-gai. While there is already a high risk from bushfire in some areas that needs to be addressed in a range of ways, climate change raises the priority of implementing measures to address this risk in Ku-ring-gai.

The options for responding to risk from bushfire have been grouped as follows:

- Reducing the hazard
- Improving the resilience of the current community
- Reducing the vulnerability of the future community
- Emergency response
- Research and measurement

However it should be noted that a number of actions would contribute to more than one outcome. For instance, community education would provide benefits for both the existing and future residents; fire trails provide emergency access, but also a line from which to back-burn; undergrounding power poles reduces ignition sources, while also reducing the potential loss of electricity infrastructure during a bushfire.

6.1. Reduce Hazard

Current fuel management

The fuel management committee of the BFMC prepares fuel management plans for the associated land managers and fire agencies. This includes annual works programs for hazard reduction burning, maintenance of asset protection zones and fire trails.

Hazard reduction burning

There is still a common perception that increasing hazard reduction burning can adequately mitigate the risk of bushfire and that therefore other (non-emergency) measures are not required. This perception has been challenged on a number of occasions.

Bradstock (2008) sought to determine if bushfire mitigation strategies were likely to succeed in reducing bushfire risks under climate change. Data from Hennessey *et al* (2005) was used for both the 'high' and 'low' climate change projections for 2050. It was determined that mitigation was possible under the 'low' projection scenario. He found that biodiversity at the broad scale would not be affected adversely by increased fire frequency. However more research is needed at the local level. To meet this mitigation target for the 'low' scenario, up to 5% of the total landscape would need to be burnt annually through fuel management programs. In other words, hazard reduction burns will need to increase by at least five times current practice (Bradstock, 2008) to achieve the same level of protection.

While hazard reduction burning will still play a significant role in bushfire mitigation in Ku-ring-gai, it is clear that it can only be one of a range of measures to minimise the risks.

For the Ku-ring-gai LGA, 5% of the total bushland equates to 141 ha. In a good burn year, 60 ha within the Ku-ring-gai LGA will have received hazard reduction burns. This would mean raising the best efforts of hazard reduction burns a further 81 ha. Achieving this would require a significant increase in resources, funding and commitment from the district land managers and an exponential increase in volunteer numbers. Government financial and resource constraints make this level of management unfeasible.

The situation is even worse under the Hennessey *et al* (2005) 'high' scenario. To reduce risk under this scenario, a 50 to 100% increase in prescribed burning is required. At the broad scale this would adversely impact biodiversity by shortening fire intervals. At a micro scale, this may manifest in local extinctions through to habitat loss.

Even if commitment targets to fuel management outlined in Bradstock *et al* (2008) could be achieved, only half of the risks will be mitigated. Further, research has indicated that hazard reduction burns have limited value.

For the Sydney Basin, increased hot days, more severe storms, and increased wind speeds will reduce the already limited ideal weather days to carry out prescribed burns throughout the area.

While hazard reduction burning will still play a significant role in bushfire mitigation in Ku-ring-gai, it is clear that it can only be one of a range of measures to minimise the risks.

In regards to the recommendations of Bradstock *et al* (2008) and Hennessy *et al* (2005), it is recommended that a more strategic approach to hazard reduction burning be adopted in order to make the most of the available resources. This approach has been introduced by the Hornsby Ku-ring-gai Bush Fire Management Committee.

Ecological burns

In addition to controlled burning for hazard reduction, ecological burning, i.e, burning to maintain vegetation communities within their identified fire thresholds, may be undertaken. While these burns are mainly aimed at biodiversity enhancement, they also reduce the bushfire hazard for nearby development.

To minimise impacts on biodiversity from controlled burning, whether ecological or hazard reduction, significant knowledge, planning and resources are required. Controlled burn regimes need to consider the required fire regimes for the species and communities affected by the burn:

'Creating a mosaic of fire regimes across a landscape—with fire intervals, seasons and intensities in the mosaic appropriate for particular ecosystems—appears to be the best means of sustaining biodiversity and should be a goal of both ecological and fuel-reduction burning. There will still be trade-offs, because fuel-reduction regimes that threaten biodiversity might have to be applied in particular circumstances to achieve adequate risk reduction' (COAG 2004).

Council's ability to undertake pre- and post- fire weeding is dependent on the availability of funding. This is currently provided through the Environmental Levy.

Additionally, these burns are usually the last priority due to resources / available burn days and therefore often do not get undertaken.

It is recommended that Council continue to support the ecological burn program.

Asset Protection Zones on public land

Council manages 44 asset protection zones (APZ) across the LGA on interface areas adjacent to development. These APZs are strategically positioned to provide additional protection to those areas most at risk from radiant heat and to assist access for emergency services. These sites are treated using a variety of mechanical hazard reduction techniques including brush-cutting, trittering, spraying and pile burning. Prescribed burning is rarely used to treat an APZ. Much of the work involves selective hand removal of species to maximise safety and retain ecological values on the site.

In addition to this, private landowners in bushfire prone areas may choose and are encouraged to maintain their property or a portion of their property as a fuel reduced zone or APZ. Many sites where development has been approved under *Planning for Bushfire Protection 2006*, have areas designated as APZs. Landowners are required, by condition of consent, to manage these areas to minimise fire risk. However, it is unknown to what extent this management regime is maintained.

Future fuel management

The management of bushfire risk using a combination of hazard reduction burning, asset protection zone and fire trail maintenance will continue into the future as guided by strategies including future bush fire risk management plans which are completed by the district BFMC every five years.

It is likely that the changing climate will continue to hamper the hazard reduction burn season particularly for the Sydney Basin. Hazard reduction burns require a prescriptive range of conditions within which the burn can happen. Those conditions reflect that which occur in the cooler months of the year; conditions such as moderate temperatures, moderate relative humidity, fuel moisture levels at around 13 to 16% and relative soil moistures. By burning within this prescriptive range, fire remains at low to moderate intensity and control is maintained.

However, with climate changing and climate shift set to exacerbate that change, hazard reduction burning may decline. The traditional burn season for the Sydney Basin may become the wet season and fuel moisture levels may preclude effective burning. Increased hot days, more severe storms, and increased wind speeds will reduce the already limited ideal weather days to carry out prescribed burns throughout the area.

Managing powerlines

The Victorian Bushfire Commission (VBCR 2010) recommended:

- *The progressive replacement of all SWER (single-wire earth return) power lines in Victoria with aerial bundled cable, underground cabling or other technology that delivers greatly reduced bushfire risk. The replacement program should be completed in the areas of highest bushfire risk within 10 years and should continue in areas of lower bushfire risk as the lines reach the end of their engineering lives*
- *The progressive replacement of all 22-kilovolt distribution feeders with aerial bundled cable, underground cabling or other technology that delivers greatly reduced bushfire risk as the feeders reach the end of their engineering lives. Priority should be given to distribution feeders in the areas of highest bushfire risk.*

In response the NSW Government (NSW Government: 2010) states that;

'the bush fire risk management plans required to be completed by each electrical distributor under the provisions of the Electricity Supply (Safety and Network Management) Regulation 2008, are being reviewed in light of the Royal Commission recommendations and to allow for consistency with local bush fire risk management plans.

Much of the network in NSW bush fire prone areas consists of multiple phase lines, which have improved protection equipment compared to the SWER network in Victoria.

At the end of their design life, replacement options for 22kV and other high voltage lines are reviewed with consideration given to appropriate options that contribute to reducing risks in bush fire areas.

RFS has met with electricity providers to carry out a review of risk assessment policies, processes and standards.'

Although the management of powerlines rests largely with energy utilities, Council could consider the inclusion in the Development Control Plan of controls requiring the placement of power lines underground for larger developments and subdivisions on bushfire prone land. This could be included as conditions of consent for these developments.

6.2. Improve resilience of current community

Risk mitigation needs to consider adapting the built environment to fire, ensuring that houses are less vulnerable to the passage of ember attack, radiated heat and direct flame contact.

Structure retrofits

The VBRC (2010) identified the need to provide information on ways in which existing buildings in bushfire-prone areas can be modified to incorporate bushfire safety measures. The RFS is to review PBP to include a section on retrofitting bush fire protection measures for existing homes (NSW Government: 2010).

Increasing the percentage of existing development that is compliant with AS3959-2009 (*Australian Standard for new developments in bushfire lands*), particularly in relation to improving the ability to withstand ember attack, is viewed as a viable and effective way to reduce infrastructure loss (Ku-ring-gai Council, 2010a).

Council could do this through education and incentives such as rate rebates or organising bulk discounts for increasing the fire resilience of dwellings on bushfire prone land. Providing a discount or rebate on fire resilient installations in homes was identified by Council (Ku-ring-gai Council: 2010a).

It is recommended that Council investigate options to encourage retrofitting of existing properties, in consultation with RFS.

Community education

Education and instruction on emergency response procedures prior to a bushfire event can improve the resilience of a community. This applies to local businesses as well as residents. This is the responsibility of the emergency services and Council (Ku-ring-gai Council 2010a).

The Victorian Bushfire Commission recognised that people needed a range of options to increase their safety in the event of bush fire. The commission found that many people who intended on 'staying and defending' appeared to panic when the severity of the fires became apparent and attempted to leave (VBRC cited in ABCB 2010a). Although a 'stay-or-go' policy existed at the time it was established that *'...many people did not have a well thought out plan and were left to make their own decisions without the benefit of assistance from the authorities...'* (VBRC 2010).

The Commonwealth and some states have made progress implementing initiatives to support household level planning for bushfire events, as described in the section on Vulnerability and Resilience. Further work in this area is continuing.

The RFS also leads a Bush Fire Arson Task Force which is developing arson prevention programmes (NSW Government 2010).

Council will also contribute (with RFS and others) to bush fire education, as part of its responsibilities in meeting the BFRMP. It has started the following programmes, however further work is required in these areas:

- Community education sessions for special fire protection purpose groups i.e retirement villages;
- General fire education at Council events;
- Distribution of Firewise kits to residents adjacent to Council bushland reserves.

Community Fire Units

Council (2010a) in consultation with a number of experts, including Fire and Rescue NSW, adopted a strategy identifying an option for risk management into the future to include an increase in the number of community fire units to improve community self-sufficiency and awareness. Fire and Rescue NSW have indicated that NSW RFS will play a greater role in the resourcing and responsibility for CFUs beginning in 2011.

Asset Protection Zones

The Victorian Bushfire Commission (VBRC 2010) recommends that landowners on developed sites should be explicitly enabled to take reasonable steps to reduce bushfire risk to an acceptable level (guidance on 'acceptable level' to be provided), and that councils should be able to identify areas where this should not apply. This can be achieved through creating asset protection zones. It is the responsibility of the landowner or land manager to create and maintain APZs where appropriate.

APZs are intended:
'to provide sufficient space and maintain reduced fuel loads, so as to ensure radiant heat levels at buildings are below critical limits and to prevent direct flame contact with a building' (NSW RFS 2006).

Planning for Bushfire Protection 2006 describes the requirements for APZs, including not only the separation of the building from the hazard, but also fuel reduction measures such as canopy cover and connection and the management of mid and understorey vegetation.

Existing properties have various options for maintaining asset protection zones including hazard reduction burning, mechanical hazard removal and selective landscaping. In NSW the *Bushfire Environmental Assessment Code for NSW* (RFS 2006) is used by the RFS to help landholders meet existing environmental legislation related to hazard reduction. To gain environmental approval, a landholder can apply for a Bush Fire Hazard Reduction Certificate, which is determined by the RFS using the Code. Assessment of bush fire hazard and the necessary vegetation management should be undertaken on a merit basis specifically related to the site.

Mechanical hazard removal such as vegetation removal or pruning may require an application for a hazard reduction permit from the RFS. The permit overrides Council's Tree Preservation Order controls and consent requirements. In such a case an assessment by RFS would establish the level of risk and whether there were other factors eg EECs/ riparian zones, and provide for approval of the relevant tree works.

Selective landscaping can assist in preventing flame impingement on a dwelling, provide defendable space, deflect and filter embers and reduce wind speed. Careful attention must be paid to species selection, their location relative to their flammability, avoidance of continuity of vegetation (horizontally and vertically), and ongoing maintenance to readily remove flammable fuels (leaf litter, twigs and debris) (RFS, 2006). Landscape plans need to address these requirements.

Approvals for development applications and Major Development under Part 3a of the EP& A Act in bushfire prone areas usually include conditions of consent in relation to the provision of APZs.

It is up to the resident to maintain the APZ over the life of the development. The extent to which this occurs is not known. Regular assessment of landowners' compliance with such conditions of consent is required. Certifiers are currently required to assess compliance with bushfire conditions only at or on completion of construction. No follow-up over time (eg of the maintenance of asset protection zones) is required of the certifier. The VBRC (2010) identified the need to improve compliance with hazard reduction measures in development consents. The NSW Government (NSW Government: 2010) has stated that it supports the establishment of a working party comprising relevant NSW government and other agencies to progress regular compliance assessment, however no funding has been provided to support continuing compliance assessment.

For less able-bodied residents of bushfire prone land the NSW Government has introduced the AIDER program. At the time of writing this had treated over 400 properties, helping vulnerable, disabled, infirm and elderly residents to reduce their property's fire risk.

To support residents in hazard reduction on their properties, Council could subsidise bulk green waste removal and chipping services in high risk areas. This could be targeted at the same time as the annual maintenance of APZs is recommended under PBP, i.e. around September.

The issue of enforcing consent conditions that have been applied through the consideration of *Planning for Bushfire Protection 2006* has been discussed in relation to APZ management. The issue of enforcement is also important in ensuring that the approved construction levels and landscaping design are actually implemented. The degree of enforcement is currently heavily dependent on Principal

Certifying Authorities. An education program for certifiers may be needed. Ideally this would be run by the RFS.

Static water supply

With climate models predicting an increase in bushfire intensity and frequency and a net decline in available water, bushfire fighting will become increasingly problematic. Alternative sources of water will be required.

In order to combat the shortfall in water availability, the Victorian Environmental Protection Agency has already approved the use of treated effluent for firefighting purposes. Victoria's Country Fire Authority (CFA) is also looking to store water in rail tankers strategically located throughout the State which can be moved to any location using existing rail infrastructure. This strategy is designed to overcome water shortages wherever they may be encountered (Melbourne Water: December 2002). These measures are beyond the scope of Council.

The Victorian Bushfire Commission (VBRC 2010) recommended that people in areas at risk of bushfire should have a static water supply, because reticulated water supplies may fail in a bushfire event.

In NSW *Planning for Bushfire Protection 2006* (PBP) also recognises that additional sources of water (ie. non mains supply) are essential to providing greater protection for a dwelling and its occupants during bushfires when mains supplied water can be inconsistent, reduced or non-existent.

The amount of water needed is dependent on differing geographical and topological conditions. The determination of available water supply is made by the water supply authority.

PBP specifies non-reticulated water requirements for subdivisions, dual occupancies, and townhouses and units.

PBP also provides conditions for fire hydrant spacing, sizing, pressures and materials and to ensure that they are not compromised by parked cars or traffic.

Where non-reticulated water supplies are required, suitable connections for fire fighting appliances must be provided and be accessible to fire trucks. Above-ground tanks are specified to be made of concrete or metal, with metal fittings and shielded pumps.

Council could consider applying conditions of consent to smaller developments that include water tanks within areas of bushfire risk, to provide appropriate fittings to tanks. Similarly, development conditions could be applied to pools to require registration as a static water supply site, and that the sticker be affixed at the front boundary. This would increase the amount of water available to firefighters in a bushfire event. The area to which such conditions would apply could be either all Category 1 and 2 bushfire prone lands, all bushfire prone lands, or areas identified as extreme risk in the BFRMP. As these conditions would not be overly burdensome, it is recommended that such conditions be applied to development on all bushfire prone lands.

Bunkers

In its second interim report the Commission expressed its concern about the need for a minimum standard to regulate the design, siting and construction of bunkers, the risks of misplaced reliance on bunkers, the demand for bunkers, and the widespread availability of bunker products (VBRC, 2009b).

Complex safety issues such as location relative to the house and fire sources, air management and maintenance surround bunker construction, make them potentially life-threatening. A series of detailed standards are required to address these issues. Currently, interim regulations have been introduced in the form of a Performance Standard for Private Bushfire Shelters, which was released on 30 April 2010. It provides detailed design considerations and acceptance criteria to assist building practitioners and certifiers to achieve compliance (ABCB, 2010b). The standard provides for safe access and egress, appropriate number of occupants, a means of deterring external

environmental conditions, identifying the building for rescue purposes, how other nearby features (both structural and geographical) may affect the integrity of the structure, its ability to withstand fire intensity, provision of sanitary and other facilities and prevention of untenable conditions. The ABCB has also proposed that private bushfire shelters be classified as a class 10c building (class 10 being a non-habitable building or structure) under the Building Code of Australia (BCA) (ABCB 2010a).

A number of agencies have expressed concern that consumers are likely to put too much faith in the ability of a private bushfire shelter to protect their lives. A discussion paper released by the Australasian Fire and Emergency Service Authorities Council (AFAC) considers that bunkers should be a last-resort option and may be worthy only in situations where other protection measures cannot mitigate the effect of bushfires.

Nevertheless, they may provide an option for improving resident safety where the existing development cannot be upgraded satisfactorily, and where residents choose this option for themselves. In these circumstances, residents are more likely to educate themselves about both the limitations and the maintenance requirements.

Vulnerable Communities Unit

Council (2010a) recognised the need to identify and support residents requiring property maintenance assistance in high risk areas.

However, since the report of the Victorian Bushfire Commission (2010), the NSW Government (NSW Government 2010) has stated that it will provide additional funding to establish a Vulnerable Communities Unit within the RFS to better plan for the protection of those people

who are particularly susceptible in a bushfire. The Vulnerable Communities Unit will be involved in:

- *'The development of strategies to protect lives of vulnerable community members, including their identification;*
- *The integration of Neighbourhood Safer Places, safer precincts, evacuation centres and community protection plans;*
- *Providing specialist advice to Local Emergency Management Committees and Bush Fire Management Committees regarding the needs of vulnerable people; and*
- *Identifying the need for further assistance through the existing Assist Infirm, Disabled and Elderly Residents (AIDER) program'.*

Retreat and resettlement

Victorian Bushfire Commission (VBRC, 2010), discussed specific zoning for bushfire prone lands to prohibit uses such as dwellings on existing lots, however this was considered inequitable for landholders. Instead it recommends:

> *'The State develop and implement a retreat and resettlement strategy for existing developments in areas of unacceptably high bushfire risk, including a scheme for non-compulsory acquisition by the State of land in these areas.'*

The Climate Change Adaptation Strategy (Ku-ring-gai Council: 2010a) identified compulsory property acquisition as an option. However, Council's *Acquisition and Divestment of Land Policy* (Ku-ring-gai Council: 2009) does not encourage compulsory acquisition. Based on recent experience, such an option is likely to be unacceptable to the community at this time.

Land swaps and transferable development rights are also suggested by the commission as alternatives to direct land acquisition in extreme circumstances.

The NSW Government (NSW Government: 2010) does not support a retreat and resettlement strategy and states that it relies instead *'on a comprehensive suite of measures to manage the risks of bush fires to communities.'*

It is recognised that the considerable public resources required for such property purchase or land swap are unlikely to be available at this time, either at a state or council level. This option is not recommended.

Wildlife protection and ecological restoration

Council will need to fund many of the activities required to prevent the loss of EEC's and biodiversity. Current mapping of the TECs in Ku-ring-gai is enabling decision-making to consider these assets in the future. Council will need to continue undertaking works on public land to prevent or address erosion and sedimentation and weed invasion in areas where vegetation is lost due to fire. Current mapping of the vegetation and the conservation significance assessment undertaken in the *Draft Biodiversity and Riparian Zones Study* will help to prioritise limited funding and resources for these purposes.

Under the Draft NSW Biodiversity Strategy (NSW Government: 2010a), it is proposed that DECCW and RFS review the standards for the protection of biodiversity within the Model Bushfire Risk Management Plan and the Bushfire Environmental Assessment Code for NSW to incorporate climate change projections and minimise the impact of bushfire management on biodiversity.

Council's Climate Change Adaptation Strategy (Ku-ring-gai Council 2010a) includes an action to clear breaks through some of the key broader fingers of vegetation, both to prevent fire being drawn in close to the centre of the LGA, and to provide refuge areas for wildlife. The best location

(from both bushfire and environmental perspectives) for such breaks would need to be identified prior to the emergency, and could be allowed to regenerate after the emergency is over.

The Strategy (2010a) also identifies the following potential actions:

- Notification of wildlife carers in post burn work;
- Identification of veterinary care capacity;
- Constructing habitat boxes from non-combustible material;
- Utilising water sensitive urban design, to minimise weed impacts (and therefore fuel loads) at the bushland interface;
- Conservation of biodiversity corridors that link with reserves.

Note that the latter two actions will be considered under other aspects of planning for the LGA. Further research is required to ascertain whether wildlife will use non-combustible habitat boxes, and the best materials to use.

Land use planning which takes into account natural hazard risks is the single most important mitigation measure for preventing future disaster losses (including from bushfires) in areas of new development.

6.3. Reduce vulnerability of future community

Introduction

The findings and recommendations of the *National Inquiry on Bushfire Mitigation and Management* (Ellis et al, 2004) includes the following:

> *'The Inquiry supports the view, expressed in Natural Disasters in Australia, land use planning that takes into account natural hazard risks is the single most important mitigation measure for preventing future disaster losses (including from bushfires) in areas of new development. Planning and development controls must be effective to ensure that inappropriate developments do not occur.'* (Finding 6.1)

This is supported by Moritz and Stephens (2007), who state that:

> *'To achieve a more sustainable coexistence with wildfire in future WUI [Wildland Urban Interface] areas, there are two fundamental goals to achieve. The first is to adopt urban planning guidelines that reduce the expansion and exposure of the WUI itself, producing more compact urbanized areas with less convoluted boundaries. While this shift may present a host of political challenges, it is one of the few ways to produce future communities that both minimize their ecological impact and are more easily defensible in a wildfire situation. The difficulty of evacuating people from WUI communities during wildfires is another solid justification for limiting expansion of the WUI.* (Cova 2005).

While the NSW Government (NSW Government 2010) does not support state level strategic land use changes, nevertheless it has been involved in changes to construction standards for bushfire prone lands, and it has also supported strategic exemptions for bushfire risk evacuation zones.[11]

With a projected increase in the frequency and intensity of fires due to climate change, there is a need for land use planning to avoid:

- placing more people and assets at risk from bushfire
- intensifying the risk to existing residents and assets and
- placing more stress on an already stressed environment.

Development restrictions

The Victorian Bushfire Commission (VBRC, 2010) recommended that:

1 Planning objectives should give priority to the protection of human life;
2 As a whole, planning provisions for bush fire prone areas should be strengthened;
3 In some areas where the bush fire risk is extreme, development, including new subdivision of existing areas, should not be permitted;
4 People should be strongly discouraged by the planning system from living in areas where it is not possible to have the minimum defendable space without unacceptable costs for biodiversity. It should be made explicit that a subdivision without defined building envelopes around which minimum defendable space can be created will be approved only if exceptional circumstances can be demonstrated (eg alternative safety measures are applied). A minimum lot size for a dwelling should be provided for in planning instruments (by zone);
5 There is a need to review the currently accepted 100m buffer between houses and vegetation.[12]

In relation to 1) to 4) above, the NSW Government (NSW Government: 2010) responds that:

- The NSW RFS already has sufficient legislative authority to assist in the regulation of developments in bush fire prone areas across the State;
- PBP provides guidance to Councils, developers and builders for planning and building in bushfire prone areas and must be met for development to proceed;
- Primacy of life for new developments is absolute in this process.

In relation to 5) above, it is agreed that the 100m buffer should be reviewed, however this review needs to be undertaken on a broader basis than by LGA.

The Commission (VBCR: 2010) also recommends the strengthening of existing zones to influence the use and development of land for vulnerable groups, such as child care, hospitals and schools. In NSW these types of development are 'Special Fire Protection Purposes' under the *NSW Rural Fires Act 1997*, and are 'integrated development' under the EP&A Act. Such developments are assessed by the RFS in accordance with specific requirements in PBP. Despite this, a need to provide greater strategic limitations on seniors housing has been recognised by the state government, eg. for bushfire risk evacuation areas under SEPP (Housing for Seniors and People with a Disability) 2004.

Council, in considering the need for adaptation to climate change (Ku-ring-gai Council 2010) has also recognised the need to rezone land or otherwise restrict development in high bushfire risk areas.

[11] Through SEPP (Housing for Seniors and People with a Disability) 2004, and SEPP 53 – Metropolitan Residential Development

[12] In the largest sample area over 20% of the houses more than 100m from forest were destroyed.

Construction standards

One way to improve resilience to bushfire risk for new development is by imposing construction standards. PBP and the associated Australian Standard 3959 provide guidance for the construction standards required, dependent on the level required under PBP. PBP will continue to be updated by the state government as the results of further research leads to policy changes. It is expected that resulting construction will provide greater resistance to bushfire, and increased safety to residents in bushfire prone lands.

Bunkers

The issue of bunkers has been discussed above. With the inclusion of a standard for bunkers, Council could consider imposing conditions of consent to require bunkers as part of future development, where other mitigating factors are inadequate. However, the inclusion of a bunker is not a substitute for appropriate location and design of a development and reliance on them to address the risk of bushfire is not appropriate.

There is a danger that requiring bunkers as a condition of consent will lead residents to assume that this will ensure their safety. Further, bunkers require maintenance to continue to meet the required standards, maintenance which cannot be guaranteed for the life of the development.

Accordingly it is recommended that Council avoid requiring bunkers as a condition of consent for new development.

Addressing evacuation risk

Cova (2005) identifies a range of factors that affect the capacity to evacuate from areas with a high risk of bushfire. Factors that increase evacuation risk include the degree of hazard, road length per household and the road capacity, type of land use (eg residential or tourist), the number and location of exits from the danger area, and the presence of a fuel buffer to the exit roads. These characteristics are typical of a number of locations in Ku-ring-gai which can be further exacerbated in times of fire due to poor visibility, congestion, confusion, and fear as people try to escape. Increasing the number of residents in these areas will only make these issues worse in fire events and has potential to end in disaster.

Cova (2005) argues that fire prone communities at the bushland interface should have a maximum occupancy rate, dependent on the above factors. Based on research in a number of US communities that have experienced major bushfires, he proposes a minimum number of exits based on the number of households in the sensitive area, in a similar way to controls in building codes that specify the number of exits required for a building with the capacity to cater for a particular number of people. This is shown in Table 9. Note that the table could also provide guidance to

an appropriate dwelling density within an area with a given number of exits.

Table 9 Minimum Exits for Interface Communities. Source: Cova (August 2005)

Number of households	Minimum number of exiting roads	Maximum number of households per exit
1-50	1	50
51-300	2	150
300-600	3	200
601+	4	

Appendix D summarises the number of exits in relation to the number of households in each evacuation risk zone in the LGA.

The number of exits was also a factor in the considerations in the identification of Bushfire Risk Evacuation Areas (Figure 2) for SEPP 53 and SEPP (Housing for Seniors and People with a Disability). For such evacuation risk areas there is a strong argument for the incorporation of planning measures such as zoning and minimum lot size/depth within the Principal LEP to prevent significant increases in density, or development types that cater to more vulnerable people. The choice of planning measures may be specific to all the bushfire risk evacuation zones, or only those that exceed the maximum number of households per exits recommended by Cova (2005). Figure 16 identifies the number of existing households within each bushfire risk evacuation zone. Of these, ten areas (identified on the map by the numbers 1, 2, 3, 5, 6, 10, 13, 14, 14a and 15a) exceed the maximum number of households per exit.

Planning measures could therefore be applied either to the evacuation risk zones as a whole, or to the higher risk zones only, or a combination of these, dependent on the planning measure.

Figure 16 Number of dwellings in the Bushfire Evacuation Risk Zones under SEPP (Seniors Housing and Housing for People with a Disability) 2004, broken down into 22 zones. Source: Ku-ring-gai Council, January 2011

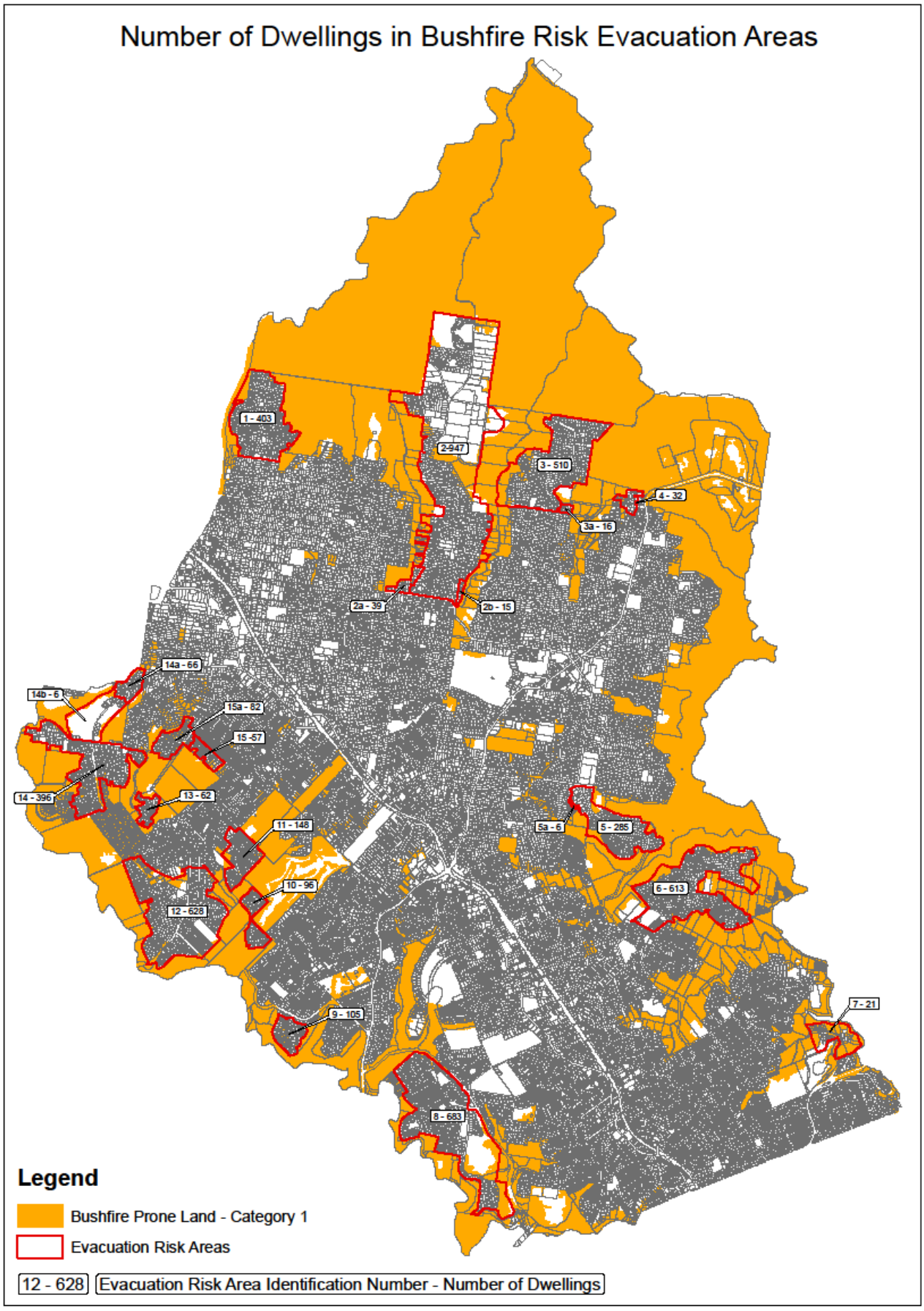


Table 10 Location of evacuation risk areas

Evacuation risk area Number	Key road/s
1	Grosvenor Rd
2	Bobbin Head Rd
2a	McRae Pl/Burns Rd
2b	Bedford Ave
3	Warrimoo Ave
3a	Dalton Rd (cul de sac)
4	Richmond Ave
5	Eastern Arterial Rd
5a	Woodvale Cl
6	Koola Ave
7	Ormonde Ave
8	Bradfield Rd/Fiddens Wharf Rd
9	Boronga Ave/Gloucester Ave
10	Parker Ave/Evans St
11	Ravenhill Rd/CarinaRd
12	Chisolm St, Kissing Pt Rd
13	Howson Ave
14	Browns Rd/Fox Valley/Jordan Rd
14b	San hospital and surrounds
14a	Strone Ave
15	Mitchell Cres
15a	Campbell Dr

Minimum lot size

The use of a minimum lot size for subdivision is a potential planning tool to minimise the number of additional people living in areas of high risk, supported by the Victorian Bushfire Commission (2010) and Council (Ku-ring-gai Council: 2010a). Setting the minimum lot size at a size at least that of existing lots would prevent further subdivision in high risk areas. A minimum lot size of 1,500m^2 for residential zones (as applies to the E4 zone under the *Ku-ring-gai LEP (Town centres) 2010* (KLEP)) and 1 hectare for existing low density Residential 2(g) zones, would prevent subdivision of most low density lots. Such a provision would support the principles outlined in legislative requirements and planning strategies both related to bushfire and to climate change, including *Planning for Bushfire Protection* and Section 117 Direction No 4.4 and is specifically recommended in Council's *Climate Change Adaptation Strategy* (2010a) and the Victorian Bushfire Commission's report. This provision could be applied at a range of scales or locations.

An alternate way of preventing inappropriate subdivision in these areas would be the inclusion of a local clause in the LEP specifying that subdivision is not a permitted development type in relation to these lands.

Minimum lot depth

A standard for minimum lot depth for subdivision could be used to ensure that any future subdivision is designed to provide an adequate setback to development for defendable space and asset protection. It would also have the effect of reducing the potential for increasing the number of people in areas at risk from bushfire. Such a provision would support the principles outlined in legislative requirements and planning strategies both related to bushfire and to climate change.

Appendix E outlines the method used to determine suitable lot depths. The minimum depths recommended would vary dependant on the 'effective slope', that is the slope (measured through 100m) in the direction of the greatest fire hazard, as per *Planning for Bushfire Protection 2006.* The recommended minimum lot depths from the hazard are shown at Table 11. The minimum lot depth would be calculated from Category 1 and 2 vegetation, as identified on the *Ku-ring-gai Bushfire Prone Lands Map* (figure 2). This would allow for changes to the line of the hazard, with the regular updates to the *Bushfire Prone Lands Map*, without the need to amend the LEP.

Table 11 Recommended minimum lot depths

Upslope/flat - 5 ^{o}	>5 ^{o} - 10 ^{o}	>10 ^{o}
55m	65m	90m

This provision could also be applied at a range of scales or locations. For instance, if minimum lot sizes are applied as recommended above, minimum lot depths could be applied to sites within bushfire prone lands that are not covered by an increase in minimum lot size. Minimum lot depth could be applied across sites that contain lands within the lower minimum lot depth calculated based on PBP as outlined above. In most cases this would affect 1 to 2 lots deep from the hazard.

Rezoning

All sites will require zoning consistent with the Standard LEP Instrument. This instrument limits the number of zones that are available to Council. The Standard Instrument includes environmental zones, which permit residential development, but limit the overall number of uses permissible. The following zones could be used where there is high risk during bushfire events:

E3 – Environmental Management

The objectives of this zone under the Standard LEP Instrument relate to the provision of development that will allow the protection, management and restoration of areas with special ecological, scientific, cultural or aesthetic values.

This zone has not previously been used in Ku-ring-gai. According to the Department of Planning (2009) this zone is for land

> '*where there are special ecological, scientific, cultural or aesthetic attributes or environmental hazards/ processes that require careful consideration/*

management and for uses compatible with these values'.

The application of the E3 – Environmental Management zone where land is constrained by hazards is recognised by the Department of Planning (2009). An additional local objective related to bushfire would support the application of this zone.

Mandatory land uses to be included in the zone are restricted to dwelling houses and home occupations, roads and environmental protection works, while there is also a mandatory set of prohibited uses. The land-use table could prohibit uses that would increase the evacuation risk in these areas, (such as secondary dwellings, seniors housing, dual occupancy and bed and breakfast), uses that may result in combustible materials being stored or used on the site, as well as uses that are inappropriate adjacent to areas of significance for their ecological values. Similarly development types that are used by the more vulnerable members of the community should be prohibited.

It is noted however, that there are a number of developments in the highest risk areas that cater for vulnerable people, including schools. The Department of Planning requires that schools be zoned according to the adjoining land use (NSW Department of Planning 2010). This would mean that the E3 zone would be applied to schools in these areas. It is not recommended that schools be a permitted use. To ensure that the existing schools can continue they would need to be listed under Schedule 1- Additional Permitted Uses in the Principal LEP.

This zone could be applied to all Category 1 and 2 bushfire prone lands within the evacuation risk zones or only within those that are assessed as the highest risk using Cova (2005) and/or extreme risk in the BFRMP (Hornsby and Ku-ring-gai Councils: 2010).

E4 – Environmental Living

This zone has been used by Ku-ring-gai in the KLEP. The objectives within the KLEP relate to the provision of low-impact residential development in areas with special ecological, scientific or aesthetic values. Under the KLEP these sites also have increased minimum lot size requirements, to prevent inappropriate subdivision. This zoning would fit well with the urban nature of Ku-ring-gai. An additional local objective related to bushfire would support the application of this zone.

Mandatory land uses to be included in the zone are restricted to dwelling houses, home occupations, roads and environmental protection works, while there is also a mandatory set of prohibited uses. The KLEP also prohibits uses that cater for vulnerable people.

Additional permitted uses in the E4 zone under the KLEP include bed and breakfast accommodation, group homes and secondary dwellings.

This zone could be applied generally within higher risk evacuation risk zones (to land that are not identified as Category 1 or 2 bushfire prone lands), and/or to Category 1 and 2 bushfire prone lands that are not within the highest risk evacuation zones.

E2 – Environment Conservation

The objectives for this zone are primarily related to the protection and restoration of areas of ecological, scenic, cultural or aesthetic values.

Dwelling houses can be prohibited within this zone. It is therefore most appropriate for reserves, or as a split zone on larger private sites. Split zoning is generally discouraged, and other mechanisms, such as lot size/depth will be more appropriate in most cases.

However there are a number of sites that are currently split between residential and open space zones. Where the natural values of these areas are high, the open space zones could be translated into E2 zones. This is discussed in Council's background study on *Biodiversity and Riparian Lands* (Ku-ring-gai Council 2011).

Environment Protection zones generally

Residential zones allow a number of uses through other environmental planning instruments. For instance, SEPP Affordable Housing applies to the bushfire risk evacuation areas at present, allowing applicants to bypass Council's plans, and increase density in these areas. However, development under this SEPP is not permitted in an environment protection zone. It is recommended that Council seek an amendment to SEPP Affordable Housing to exclude its provisions from Bushfire Risk Evacuation Zones.

Zones E2 to E4 will generally need to be supplemented by detailed provisions in the development control plan. These would most likely cover the design, construction and management of uses in these zones, particularly with respect to dwellings (Department of Planning: 2009). It is recommended that such provisions be included in the comprehensive DCP.

Business zones

There are a number of bushfire evacuation risk areas that contain neighbourhood centres. It is recommended that these business areas be retained, and rezoned in accordance with the standard LEP instrument. These areas are not considered to add significantly to the risk, and provide much needed services and facilities for the local areas.

Lands to which planning controls could be applied

The above controls could be applied to different areas within the LGA. Different controls will be more appropriate for some areas than others. For instance, minimum lot sizes would control increases in density in evacuation risk zones, while minimum lot depths would help to ensure that future development can be located to provide an adequate asset protection zone.

The following areas all have the potential (and in some cases have been) to be adversely impacted by bushfire events, and may be considered appropriate lands to which to apply controls. Some of these areas overlap with each other, such as Category 1 and 2 bushfire prone lands, which will be found both inside the evacuation risk zones and outside them.

Some estimates have been prepared of the number of properties that would be affected by proposed zoning and standards (see below). The standard considered most likely to reduce the development potential of a site is the increase in minimum lot size. Accordingly, figures are included in some scenarios, that identify the number of land parcels that currently have at least twice the minimum lot size under the KPSO. This would include, for instance, parcels within the 2c-Residential zone, which have a lot size of at least1858m^2 (ie twice the minimum lot size of 929m^2 under the KPSO). This does not mean that all such sites would actually be affected by an increase in the minimum lot size provision, as other controls under the KPSO and other legislation would come into play, such as a larger minimum lot size for a battleaxe allotment, width of required access handle or the need to protect significant vegetation or riparian zones. Accordingly the estimates provided below are likely to be an overstatement of the number of sites impacted, but is the best available information.

Sites that contain category 1 and 2 bushfire prone lands

These sites contain vegetation that is, and/or links to, a bushfire hazard. Life and property are generally at their most vulnerable in these locations. Further subdivision, or construction close to the hazard, would increase the potential number of residents and assets that may be impacted by radiant heat or direct flame in a bushfire event. Alternatively, significant impacts on the environment are likely to occur from clearing for hazard reduction.

Rezoning and restrictions on land use, minimum lot sizes and/or minimum lot depths could be applied to these sites generally, or where they are located within particular risk areas.

Lands containing a site within 55m of the hazard

Restricted land uses and/or minimum lot depth could be applied across sites that contain lands within 55m of the hazard, identified as Category 1 and 2 vegetation in the *Bushfire Prone Lands Map*.

This could be applied within all bushfire prone lands or only to sites located in certain risk areas.

Bushfire prone lands - buffer

Applying an E3 or E4 zone or controls such as minimum lot depth or size to the buffer areas would reduce the number of people and assets within a significant area likely to be subject to ember attack, as well as smoke, in a bushfire event.

However, many of these areas contain much smaller extents of vulnerable vegetation, and further from the hazard, are more likely to include adequate defendable space, eg including a road. The applicability of the controls could be limited to those areas at extreme risk during a bushfire event.

Areas within extreme risk identified in the Bush Fire Risk Management Plan

These areas are identified in the BFRMP and refer to the degree of risk to assets (figure 8). They include the northern part of the North Turramurra Evacuation Risk Zone and Bushfire Prone Lands Buffer and Category 1 and 2 adjacent to larger bushland parcels and National Parks. A detailed and consistent assessment process was undertaken to determine the risk categories.

It is recommended that at a minimum, Category 1 and 2 lands within these areas should have controls applied to reduce risk to future residents and development during bushfire events. This could include appropriate zoning and land use restrictions, minimum lot depth and/or minimum lot size.

There are 251 residential land parcels (or parts of parcels where there is a split zoning) that are currently twice the minimum lot size permitted under the KPSO that are within either category 1 or 2 bushfire prone land and within the area of Extreme Risk identified in the BFRMP.

Areas within the highest risk evacuation risk zones

Increasing the minimum lot size within the evacuation risk zones that do not meet the criteria for the number of exits would reduce the number of people and assets within a significant area likely to be subject to ember attack and smoke, in a bushfire event. Importantly, it would also reduce the potential for increasing the number of people trying to leave the area where there is a very high risk of not being able to evacuate safely.

It is recommended that at a minimum, these areas should have minimum lot sizes applied to avoid increasing the already high evacuation risk to residents and visitors during bushfire events. Environmental protection zoning within the extreme risk areas identified in the BFRMP (Hornsby and Ku-ring-gai Councils 2010) is also recommended.

There are 3,460 land parcels within these evacuation risk zones, almost 1000 of which are within the North Turramurra area. More than half of the North Turramurra evacuation risk zone is identified in the BFRMP as being at extreme risk in a bushfire event, even where the sites are located well away from the hazard.

Of the total 3,460 residential parcels, 143 parcels are at least twice the minimum lot size. Eleven (11) parcels are currently zoned 2(g) –Residential and developed only with low density development, having a minimum lot size of approximately 1 hectare under the KPSO.

All areas within the bushfire evacuation risk zones

The application of a greater minimum lot size would reduce the number of people and assets within a significant area likely to be subject to ember attack, as well as smoke, in a bushfire event. It would reduce the potential for increasing the number of people trying to leave the areas where the RFS has identified a risk to safety during evacuation in a bushfire event.

There are 5210 properties in evacuation risk zones[13] in Ku-ring-gai LGA.

Of this total, 213 parcels are at least twice the minimum lot size. Again, eleven (11) parcels are currently zoned 2(g) – Residential and developed only with low density development, having a minimum lot size of approximately 1 hectare under the KPSO.

Planning options

There are a number of combinations of the identified lands above, to which zoning and planning controls could be applied. Three options are identified below, which would achieve different levels of risk reduction, dependent on the area. These options are recommended for consideration in the Principal LEP.

Option 1:

a. Retain the one hectare lot size for existing Residential 2(g) lands, and increase the minimum lot size for all other residential, school lands within the 10 evacuation risk zones that do not meet the exit criteria outlined in Appendix D;
b. Apply the recommended minimum lot depth standard to sites which contain or are adjacent to bushfire prone lands category 1 or 2, located within areas at extreme bushfire risk using the Bushfire Risk Management Plan 2010 (Hornsby and Ku-ring-gai Councils: 2010) as a guide.

Option 2:

e. Retain the one hectare lot size for existing Residential 2(g) lands, and increase the minimum lot size for all other residential, and school lands within the 10 evacuation risk zones that do not meet the exit criteria outlined in Appendix D;
f. Apply the E3 – Environmental Management Zone to sites that are both:
   - located within areas at extreme bushfire risk using the Bushfire Risk Management Plan 2010 (Hornsby and Ku-ring-gai Councils: 2010) as a guide: and
   - within the 10 evacuation risk zones that do not meet the exit criteria outlined in Appendix D;
g. Apply the E4 – Environmental Living zone to all other sites that contain bushfire prone lands category 1 or 2, located within areas at extreme bushfire risk using the Bushfire Risk Management Plan 2010 (Hornsby and Ku-ring-gai Councils: 2010) as a guide;
h. Apply the recommended minimum lot depth standard to sites that contain lands within 55m of Category 1 or 2 bushfire prone lands, that are located within areas at extreme bushfire risk using the BFRMP (Hornsby and Ku-ring-gai Councils: 2010) as a guide;
i. Add an objective to the E3 and E4 zones in relation to minimising risk from bushfire events;
j. Prohibit bed and breakfast, group homes, secondary dwellings and schools in the E3 zone;
k. Include existing schools in the Environment Protection zones in Schedule 1 as additional permitted uses.

Option 3:

l. Retain the one hectare lot size for existing Residential 2(g) lands, and increase the minimum lot size for all other residential, and school lands within all the evacuation risk zones;
m. Apply the E3 – Environmental Management zone to sites that contain bushfire prone lands category 1 or 2 within all the evacuation risk zones, and located within areas at extreme bushfire risk using the BFRMP (Hornsby and Ku-ring-gai Councils: 2010) as a guide;
n. As for Option 2, g to k.

Option 1 would impose the minimum number and type of restrictions to the least number of properties, while avoiding increasing the risk to those areas at the most severe risk from bushfire events either because of likely danger during any evacuation, or because bushfire prone vegetation is located on the site.

Option 2 would additionally ensure that future subdivisions in proximity to the hazard in the extreme risk areas allow for adequate setbacks for defence during a fire. While this option would increase the number of sites affected, the additional risk management is reasonable, even more so, given the likely impacts of climate change.

Option 3 extends the restrictions under Option 2 to areas of high risk, and would provide the greatest level of risk reduction for the future. However, it would also affect the greatest number of properties, reducing development potential in these areas.

Option 2 is recommended as the appropriate level of risk management.

[13] This does not take into account the redevelopment of the Seventh Day Adventist site in Wahroonga as approved under Part 3A of the EP&A Act.

Measures to protect biodiversity and ecological processes

Many measures to address bushfire risk involve the removal of vegetation and habitat, with consequences for biodiversity and a number of other ecological processes. The protection of human life and property are always the overriding concerns under the *NSW Rural Fires Act 1997*.

Nevertheless, bushfire and biodiversity protection need to be considered in an integrated manner if we are to ensure that ecological integrity is also protected.

For example, while biodiversity corridors and connections between remnants may be undesirable due to their ability to transfer and spread fire, they are critical for wildlife movement, access to feeding and water resources and as habitat.

In line with the mapping by DECCW for the Sydney Metropolitan Catchment Management Authority (DECCW: 2008a), Council has identified regional fauna habitat and biodiversity corridors within Council's *Draft Biodiversity and Riparian Lands Study 2011.* Fauna habitat within DECCW (2008a) was mapped at a large scale, and does not take into account the need for fuel management on private property. It is important that Council's Conservation Significance Assessment for Ku-ring-gai and the controls for the mapped areas of significance consider the need for bushfire mitigation. The Conservation Significance Assessment has considered this in a number of ways. For instance, where DECCW (2008a) mapping includes bushfire prone vegetation close to private dwellings, Council's Regional and Local Fauna Habitat mapping has been modified to facilitate the creation of an APZ between residential structures and areas to be protected as fauna habitat. It should be noted that no detailed assessment of residential requirements against *Planning for Bushfire Protection* (RFS, 2006) was undertaken and it is acknowledged that creation of fire mitigation measures within Regional and Local Fauna Habitat areas identified may still be required.

It is recommended that detailed controls in the comprehensive DCP support the protection of biodiversity and ecological processes, to improve the resilience and recoverability of these processes to a number of threats including bushfire. Provisions can include matters related to development within areas of conservation significance, tree retention, the utilisation of water sensitive urban design and landscaping, for example. This detail is beyond the scope of this study.

It is noted that Council's *Draft Biodiversity and Riparian Lands Study* also makes recommendations in relation to LEP zoning, and provisions such as minimum lot size. Some areas that are not identified within this report as high priority for the application of LEP rezoning or other restrictions may nevertheless be considered to have high ecological value which would warrant the imposition of such measures. This may also occur in the reverse.

The Victorian Bushfire Commission (VBCR: 2010) recommends the development and administration of:

> *'a collective offset solution for individual landholders who are permitted to remove native vegetation for the purpose of fire protection.'*

This is not supported within the NSW Government: (NSW Government: 2010), which states that it seeks to rely on existing hazard reduction processes which include, in some instances environmental assessment under the Bushfire Environmental Assessment Code for New South Wales (RFS: 2006).

However, where a reasonable development proposal would require the removal of significant vegetation, NSW already has a state-wide offsetting mechanism available under the *NSW Threatened Species Conservation Act 1995*, the Biobanking Scheme. To supplement this, Council is also preparing a biodiversity offset policy for the LGA. It is noted however, that these offsetting schemes only apply to new development, not to hazard reduction for existing developments, where the *NSW Rural Fires Act 1997* overrides other legislation in relation to biodiversity.

6.4. Emergency Response

Evacuation routes

While bushfire evacuation risk areas have been identified which are usually dependent on a single road for access and egress, there are no standards or codes that govern the design or management of these single roads as evacuation routes. In the absence of such a code, there have been occasions where these roads have been altered in ways that may reduce their efficacy as evacuation routes.

Tentatively, the performance criteria for access roads contained in the *Planning for Bushfire Protection 2006* (RFS: 2006) would be a useful tool to ensure that accessibility is maintained on evacuation roads during an emergency response (note that this differs from roadway capacity).

Relevant performance criteria include the intent to provide public road widths and design that allow safe access for firefighters, while residents are evacuating an area.

Acceptable solutions to realise this intent may include:

- 2 way roads (min 8m wide);
- Traffic management devices that facilitate access by emergency vehicles;
- Road curves of appropriate radius to allow for access;
- Appropriate longitudinal grades, crossfall and vertical clearance.

Existing single roads providing access and egress to bushfire evacuation risk areas satisfy the above solutions in that they currently carry 2 way traffic and have been designed for vehicles that regularly use that part of the road network, which typically include waste collection trucks. These roads often are also bus routes and therefore can accommodate vehicles up to large rigid trucks/buses.

Traffic controls (eg traffic signals, roundabouts and priority intersections) would normally affect the capacity of egressing traffic in the event of an evacuation. However, under emergency conditions, (uninterrupted) priority can be given to egressing traffic, which would increase the normal (interrupted) capacity of the access road. Improved guidance systems could also be considered, which could include pavement reflectors on key access roads and signposting.

A study paper from the United States titled Emergency Evacuation (Wolshon and Hicks Meehan, 2003) indicates evacuation operations can be improved by contraflow plans, which can increase roadway capacity by reversing one or more lanes or shoulders on a road for use by egressing traffic, as well as limiting interruptions to evacuating traffic.

Another option for reducing the risk in evacuation risk areas during bushfire events would be the provision of additional exits, to provide alternative evacuation routes (Ku-ring-gai Council: 2010a).

This would require the construction of new roads from the at-risk area, and detailed investigations would need to be undertaken to determine suitable linkages so that new roads do not pass through valleys or through/into other risk areas. However, it is likely that dwellings or land would need to be acquired, resulting in potential impacts to residents and other landholders. Further, the acquisition of land and construction of new roads may be cost prohibitive to Council.

Ku-ring-gai Council (2010a) identified an option to audit key fire evacuation routes and develop a minimum standard or code. To supplement this, evacuation route signage was proposed.

It is recommended that Council:

- Undertake an audit of each of these road access routes to/from evacuation risk zones;
- Investigate whether any standards or codes currently exist for such roads in other jurisdictions;
- Prepare a code for the design and/or management of these roads as evacuation routes, and if necessary, consider preparing a program to implement any required upgrades to these evacuation routes.

Fire trails

The construction of new fire trails was identified in Council's Climate Change Adaptation Strategy (Ku-ring-gai Council 2010a). Fire trails play an important access role in fire suppression and mitigation, but also play a significant role in reducing the hazard.

As noted previously, upgrades and extensions are dependent on grants. It is recommended that Council continue to apply for grants to strategically upgrade and extend the fire trail system.

Communications

Among other recommendations in relation to the emergency phase of bushfire management, the Victorian Bushfire Commission (2010) suggests a number of improvements to communication systems, both between and within the fire management services, and between the fire management services and the public, as well as measures to improve safety for the most vulnerable members of the community.

A number of actions have already been taken in NSW, as outlined in the Section 'Vulnerability and Resilience'.

The NSW Government (NSW Government: 2010) has also promised:

- Funding for the establishment of Rapid Aerial Response Teams, to be strategically located along the NSW coastal slopes and ranges during the bush fire danger period thereby providing an increased aggressive initial attack on fires;
- Upgrade of the RFS's pager and radio network;
- Identification cards for bushfire brigade volunteers;
- Review of Guideline 33, *Guideline for network configuration during high bushfire risk days,* which provides a methodology to NSW Network Operators for making decisions on whether different network configurations should be used during high bush fire risk days.

New brigade

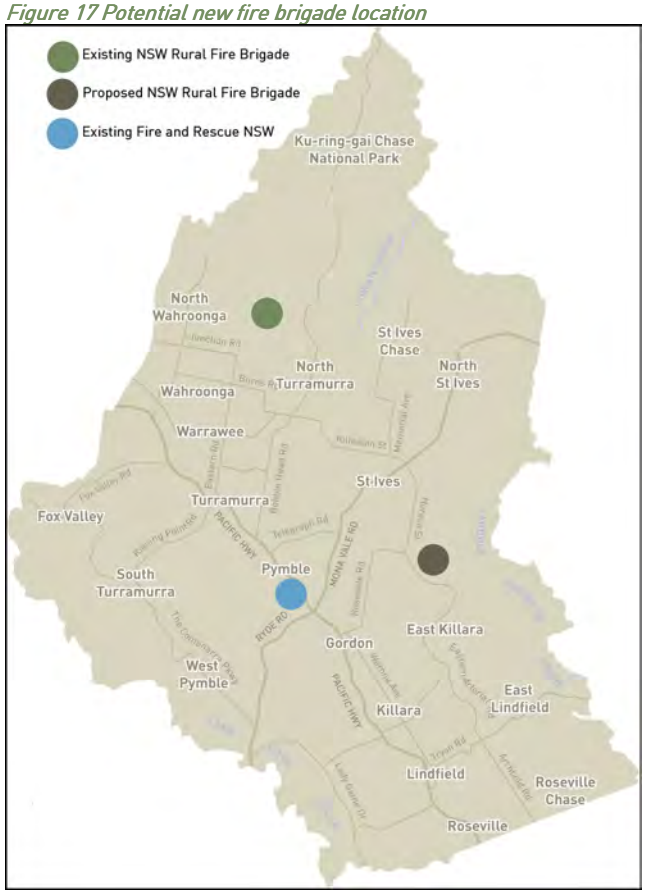
As identified in the section on 'Response Capacity', Ku-ring-gai has only two fire brigades, one being Fire and Rescue NSW and one NSW RFS. Council's Climate Change adaptation Strategy (2010) identified the potential for an additional NSW RFS brigade to be established to boost the capacity to deal with bushfire events in the future. Figure 17 identifies a potential location for a brigade.

A new brigade would involve a large financial cost at a time that volunteer numbers within NSW are dropping (McLennan *et al* 2009). However, locally there is a significant member interest at the existing brigade.[14]

Nevertheless, an appropriate zoning for a new fire brigade should be considered, in case circumstances change in the future. This could be done through one of two mechanisms:

- Zoning appropriate location(s) as one of the 'prescribed zones' that permit 'emergency services facility' under SEPP Infrastructure 2007. These include a number of rural, business, industrial, open space and special zones;
- Permitting 'emergency services facility' as a land use in appropriate location(s) –either as a standard use in the zone, or as and additional permitted use within Schedule 1 of the LEP.

Figure 17 Potential new fire brigade location



[14] Chris Hunter, Captain Ku-ring-gai Fire Brigade in Submission to Council.

6.5. Research/Measurement

The Climate Change Adaptation Strategy (Ku-ring-gai Council: 2010a) for the community has prioritised adaptations, some which will require additional research to accurately determine the Return on Investment, for example:

- Adaptations for strengthening the resilience of housing stock and fire fighting capacity including water sprinklers on roof tops, effect and uptake of storm shutters, fire resistant fire fighting pumps and hoses, fire resistant insect screens, double glazing and solid core doors;
- Selective vegetation removal;
- Identification for safe refuges for people and pets.

These represent just a few of the research and development opportunities available to Council. We may be able to build fire resilience components into Council projects to expand Council's knowledge of the efficacy of these strategies in relation to bushfire risk. Some Council research priorities might include:

- Identification of sections of corridors or 'fingers' of vegetation that can be cleared in an emergency;
- Fast decomposing bacteria to reduce fuel - carbon sequestration, or mechanical removal;
- Introduction of a variety of community education and safety strategies to increase resilience to fire;
- Identification of areas of:
  - non fire tolerant vegetation communities, ,
  - wildlife refuges.

In relation to the mapping components above, it is noted that mapping of key vegetation communities within Ku-ring-gai has been undertaken (Ku-ring-gai Council: 2009a) and broad mapping of non fire tolerant vegetation communities are identified within the *Bushfire Risk Management Plan (2010),* fire threshold map. Wildlife refuges have not been mapped.

In relation to the emergency clearing of corridors, it is important to note that Council's *Draft Biodiversity and Riparian Lands Study* (2011) identifies areas of regional fauna habitat and biodiversity corridors. It is recognised that there are occasions when emergency clearing of vegetation is undertaken in a bushfire event. The identification of sections of biodiversity corridors/ regional fauna habitat that are less sensitive and have greater capacity for regeneration, may allow for more carefully targeted clearing in a bushfire event. It is noted however that decisions to clear fire breaks will be foremost determined by behaviour and location of the individual fire.

Other potential research priorities will rely on participation by other agencies, for example:

- Placing power lines underground to reduce the likelihood of accidental fire ignition, reduce transmission losses, reduce impact on tree canopy, remove unsightly pole and wire infrastructure, and reduce hazards from vehicle / pole crashes.

Each adaptation option investigated as part of the Climate Change Adaptation Strategy has been analysed and prioritised according to their monetary and non-monetary cost benefit. It will be necessary to do a supplementary study on options requiring substantial investment to determine where and when the investment should occur.

A number of issues relating to Council's bushfire management still require investigation and may be the focus of future research. These include:

- The efficacy of hazard reduction burns in risk management and the cost benefit of this strategy in the event of a catastrophic fire;
- The legal situation surrounding adaptation implementation, failure to implement, misalignment of risk and adaptation, under-adaptation, over-adaptation and failure to adequately discharge Council's public interest duty;
- The impact of increasingly frequent and intense wildfires on the biodiversity assets of Ku-ring-gai.

Most future research will require funding from competitive grants. Research funding agencies invariably dictate the priority of research areas. As a result the adaptations selected for nomination in grant applications will be those that best match the priority areas listed by the grant organisation.

More broadly, research resulting from the bushfires experienced in Victoria in 2009 has informed and will continue to inform amendments to the Australian Standard AS3959 – 2009 *Construction of Buildings in Bushfire Prone Areas*, *Planning for Bush Fire Protection 2006 (PBP 2006)* (NSW RFS, 2006), the *Environmental Planning and Assessment Act 1979,* the *Rural Fires Act 1997*, NSW Rural Fire Service policies and various building codes. Further potential research includes:

- The effect of wind on tiled roofs;
- Effectiveness of sarking;
- Appropriate ember protection.

6.6. Summary of recommendations

It is recommended that Council:

Reduce the hazard

1 Adopt a strategic approach to hazard reduction burning, and continue to design the burn regimes to minimise impacts on biodiversity;
2 Consider the inclusion in the Development Control Plan of controls requiring undergrounding of power lines for larger developments and subdivisions on bushfire prone land;
3 Include the undergrounding of power lines as conditions of consent for larger developments and subdivisions on bushfire prone land;

Improve resilience of current community

4 Investigate options to encourage retrofitting of existing properties, in consultation with RFS;
5 Continue its bushfire education and awareness raising programme;
6 Consider subsidising bulk green waste removal and chipping in high risk areas, to support management of APZs;
7 Continue to support the ecological burn program.
8 Apply conditions of consent to developments that include water tanks within all bushfire prone lands to provide appropriate fittings to tanks and that developments that include pools or other static water supply display SWS stickers;
9 Keep a register of wildlife carers and veterinarians to allow them to be notified in post burn work.

Reduce vulnerability of future community

10 In the Principal LEP apply the following zoning and provisions:
   a. Retain the one hectare lot size for existing Residential 2(g) lands, and increase the minimum lot size for all other residential, school lands within the 10 evacuation risk zones that do not meet the exit criteria outlined in Appendix D;
   b. Apply the E3 – Environmental Management Zone to sites that are both:
      - located within areas at extreme bushfire risk using the Bushfire Risk Management Plan 2010 (Hornsby and Ku-ring-gai Councils: 2010) as a guide; and
      - within the 10 evacuation risk zones that do not meet the exit criteria outlined in Appendix D;
   c. Apply the E4 – Environmental Living zone to all other sites that contain bushfire prone lands category 1 or 2, located within areas at extreme bushfire risk using the Bushfire Risk Management Plan 2010 as a guide;
   d. Apply the recommended minimum lot depth standard to sites that contain lands within 55m of Category 1 or 2 bushfire prone lands, that are located within areas of extreme bushfire risk using the *Bushfire Risk Management Plan 2010* (Hornsby and Ku-ring-gai Councils: 2010) as a guide.
   e. Add an objective to the E3 and E4 zones in relation to minimising risk from bushfire events;

f. Prohibit bed and breakfast, group homes, secondary dwellings and schools in the E3 zone;
g. Include schools in the Environment Protection zones in Schedule 1 as additional permitted uses.

11 Avoid relying on bunkers as a condition of consent for new development;
12 Use land use controls and operational measures to improve the resilience to altered fire regimes of vulnerable vegetation and habitat as per Council's Draft Biodiversity and Riparian Lands Study 2011.
13 Include more detailed provisions in the comprehensive DCP to support the Environment Protection Zones.

Emergency response

14 Permit 'emergency services facility' as a land use in appropriate location(s) –either as a standard use in the zone, or as and additional permitted use within Schedule 1 of the LEP;
15 Undertake an audit of each of the road access routes to/from evacuation risk zones;
16 Investigate whether any standards or codes currently exist for such roads in other jurisdictions;
17 Prepare a code for the design and/or management of these roads as evacuation routes, and if necessary, consider preparing a program to implement any required upgrades to these evacuation routes;
18 Continue to apply for grants to upgrade and extend the fire trail system.

Research

19 Consider including research into the following in the work program over the next 2-3 years:
a. Further research into building resilience at the local (street/property) level;
b. Match research prioritise arising from the climate change adaptation funding agencies with the prioritised adaptation options already identified with relevant grants as they occur.
c. Build collaborative research opportunities with tertiary institutions, for example on:
- The efficacy of hazard reduction burns;
- the impact of the frequency and intensity of bushfire on local biodiversity assets.

State agencies

It is also recommended that the following issues be raised with relevant state agencies:

20 The review of the 100m buffer in light of the significant proportion of houses that were destroyed beyond the 100m buffer line in the Victorian bushfires of 2009;
21 Research:
a. Strategic placement of power lines underground;
b. The effect of wind on tiled roofs;
c. Effectiveness of sarking;
d. Appropriate ember protection.

22 Provision of funding to enable the promised establishment of a working party comprising relevant NSW government and other agencies to progress regular assessment of compliance with conditions of consent in relation to bushfire, especially in relation to asset protection zones and defendable space.

23 Establishment of an education program on bushfire construction and landscaping for APZs for private certifiers;
24 The need for an amendment to *SEPP Affordable Housing* to exclude its provisions from Bushfire Risk Evacuation Zones.

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Appendix A

Review of current zoning in bushfire risk areas

Table A1 Current zoning in bushfire prone lands and bushfire risk evacuation zones

Area	Bushfire prone lands Category 1	Bushfire prone lands category 2	Bushfire prone lands buffer	Bushfire risk evacuation zones
LGA generally	The **vast majority** of lands within this bushfire category are open space or National Park. However, there are scattered private sites within this category. Mostly these are parts of low density residential sites, but also includes some larger sites within most suburbs • 2(c), which has a minimum lot size of 929m^2, including some large lots (up to a hectare in Pymble); • 2(b), which has a minimum lot size of 836 m^2 (including 3 hectares -part of Bushranger Reserve- and 2.7 ha of crown land in East Killara) • 2(a), which has a minimum lot size of 790m^2, including large lots (eg up to 1.6 ha in Roseville Chase).	Not very common in LGA Generally Open space land -6(a), sometimes also affecting adjoining low density residential	**Most of the lands** within this bushfire category are low density residential sites • 2(c), which has a minimum lot size of 929m^2, • 2(b), which has a minimum lot size of 836 m^2; • 2(a), which has a minimum lot size of 790m^2.	Mostly zoned for low density development, and some of the other land uses in Categories 1,2 and the buffer. It also includes 5 neighbourhood centres as specified below.
Other zoning and land size by suburbs				
Wahroonga	• SAN: E2 – Environment conservation, R2 – Low density residential • Proposed county road (abandoned) • Special uses (WS&D) • Special uses – school *North Wahroonga:* • Special uses (WS&D) (MLALC)	• 2(c) sites	• SAN: SP1 Health Services Facilities, B1 – Neighbourhood centre, R1-, R2, R3, R4 Residential • Proposed county road (abandoned) • Special uses (WS&D) • Special uses - school	• Fox Valley Neighbourhood Centre *North Wahroonga:* • Neighbourhood centre

Turramurra	*Turramurra town centre:* • E2- Environment conservation	• 2(c) site	*Turramurra town centre:* • E4 –Environmental Living • B2 – Local Centre • R4 High density residential *South Turramurra:* • 2 x Special uses – Church • Business - retail – (3A-A3)	
North Turramurra	Includes some larger 2(c) lots, Special uses, and Residential 2(g) lots with a minimum lot size of approximately 1 hectare.		• Special uses (Seniors living, school, hospital) • Residential 2(g) which currently have a minimum lot size of approximately 1 hectare • One residential 2(h) site which permits residential flat buildings and other more intense development on lots of at least 650m^2 • 3(a) – A3 – Business retail services – the rear of shops in the North Turramurra neighbourhood centre.	• Neighbourhood Centre
St Ives	• A portion of a large R3- Medium density residential land in the town centre • Special uses –Schools • Special uses – Municipal Purposes (Driver training side of Mona Vale Rd) • 6(a) zone -St Ives Showground *St Ives Chase:* • Also affects a few larger 2(c) lots	• Special Uses - Substation *St Ives Chase:* • 2 x 2(c)sites	• Including a large scale Seniors development • A school (on 2(c) land) • Special uses –Schools, substation, Municipal purposes (community centre), Sydney Water • Proposed county road (now abandoned) • Some R3 land in the town centre • Special uses – Municipal Purposes (Driver training side of Mona Vale Rd) • 6(a) zone -St Ives Showground *St Ives Chase:* • Includes a school	
Pymble	*In the town centre* • R2 lands including a school • SP1- Military uses *Outside the town centre* • 6(b) private recreation (Golf course)	• 2(c) sites	*In the town centre* • R2 lands including a school • B7 – business park • SP1- Military uses • Some R3 land • Some R4 – high density residential sites *Outside the town centre*	

			• 6(b) private recreation (Golf course) *West Pymble* • Special uses – school, municipal (Bicentennial park)	
Lindfield	• Part of UTS site zoned under SEPP (Major development) – mostly E1 and E3. • Special uses – Commonwealth purposes (film school & CSIRO) • IDO 29 –Naamaroo Conference Centre	*East Lindfield* • Special use zone – school	• Part of UTS site zoned under SEPP (Major development) – mostly residential, business and open space; • Special uses – Commonwealth purposes (film school & CSIRO) • IDO 29 –Naamaroo Conference Centre • Special use zone -school *East Lindfield* • Special use zone – school • Within the 2(a) zone, a bowling club, and a large scale retirement village	*West Lindfield:* • Neighbourhood Centre
Gordon			• Residential 2h (St John's Wood) • R2 and R4 sites	
Killara			*Killara* • 2 x Special uses – School • Major seniors living development *East Killara* • Minor incursion into 3a commercial land	*East Killara:* Neighbourhood centre
Roseville	*Roseville Town Centre:* • *E4 sites*		*Roseville Chase:* • Special uses –Sydney Water *Roseville Town Centre:* • *E4 sites*	

Appendix B

Vulnerability of existing development

Figure B1 Cowan Catchment example of 'ideal' setback for Asset Protection Zone

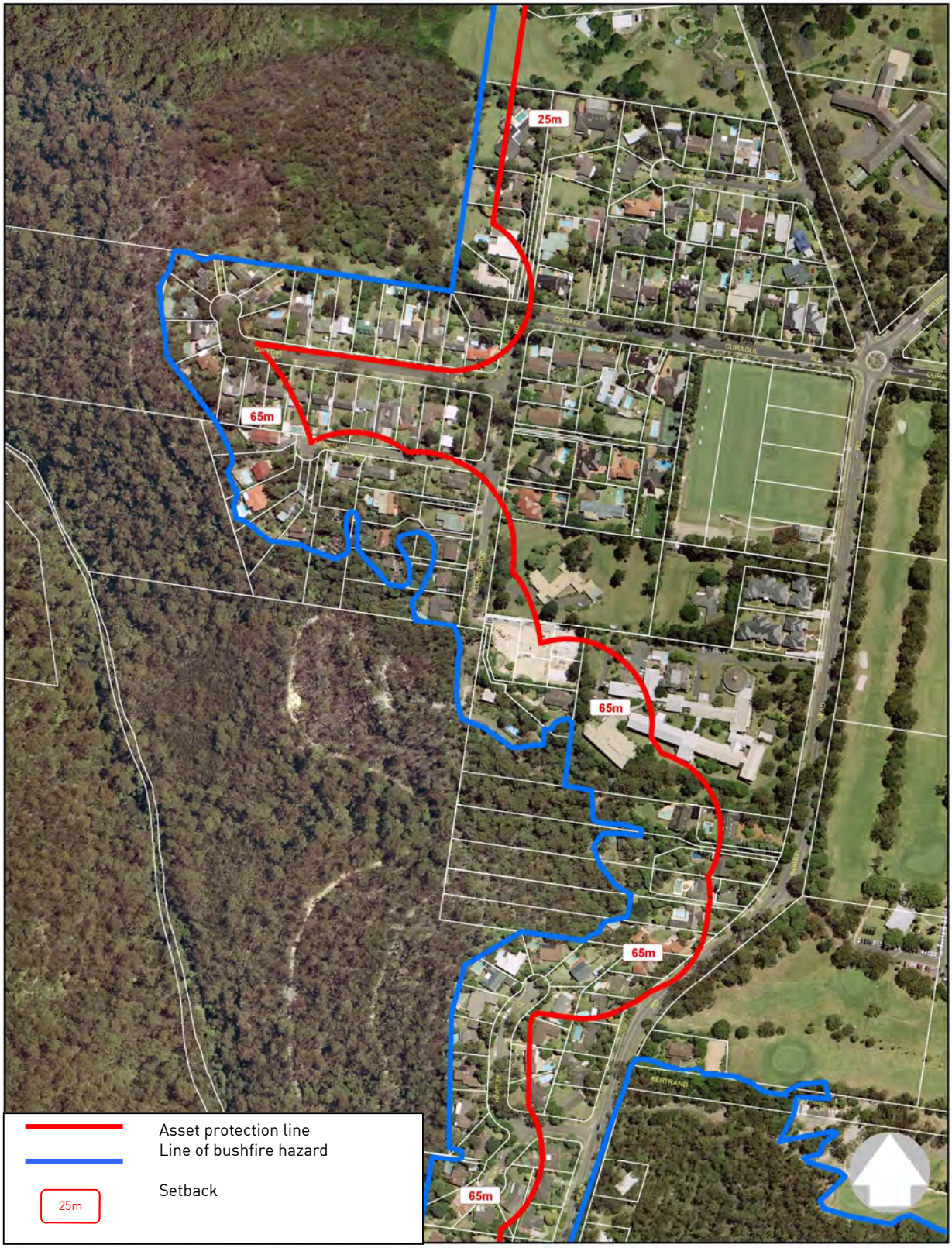
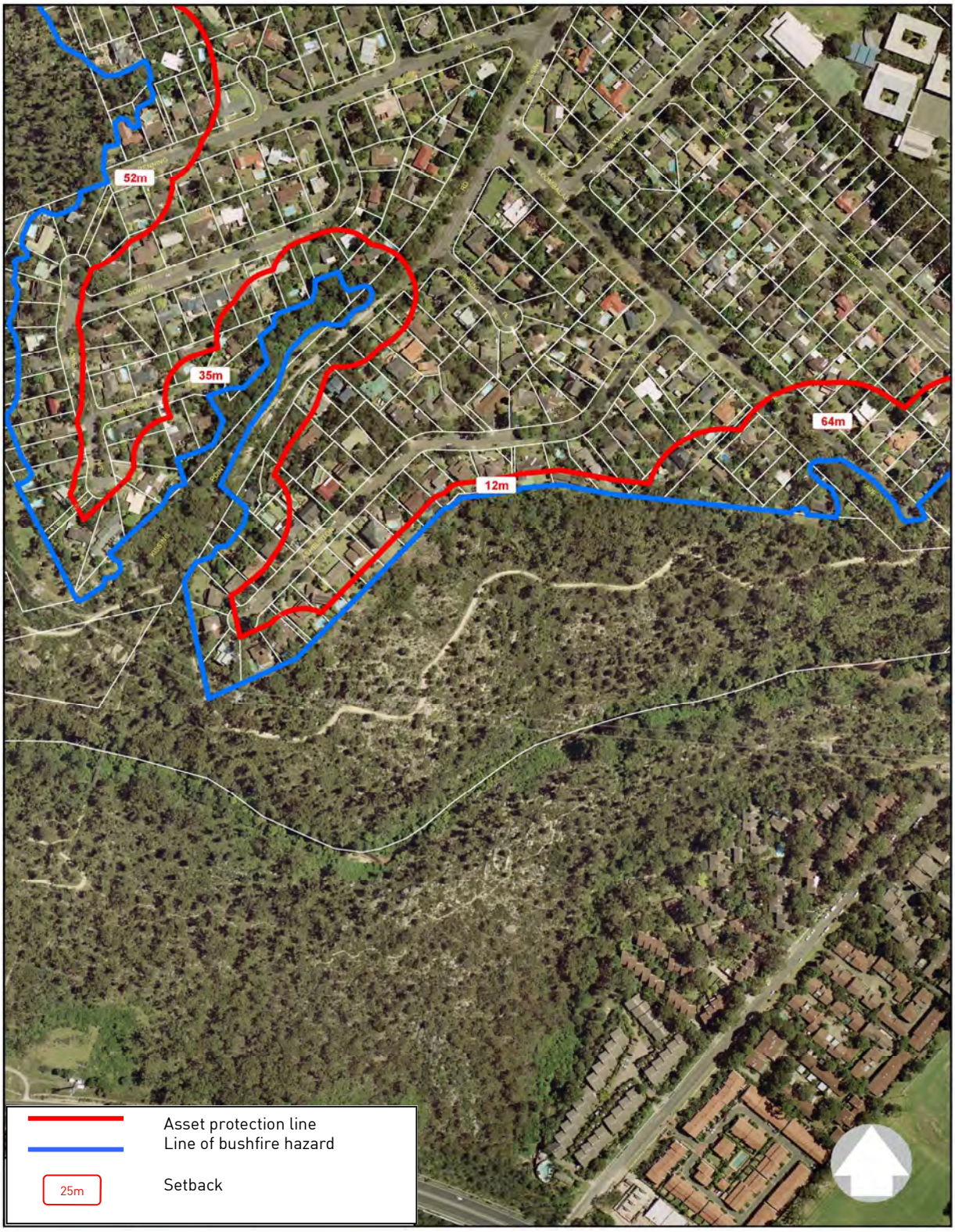


Figure B2. Middle Harbour Catchment example of 'ideal' setback for Asset Protection Zone

Figure B3. Lane Cove River Catchment example of 'ideal' setback for Asset Protection Zone



Appendix C

Proximity of Ku-ring-gai's Older Population to bushfire hazard

Figure C1 Percentage of Ku-ring-gai population 75 years and over in relation to Bushfire Prone Land Category 1 (Vegetation that forms the bushfire hazard)

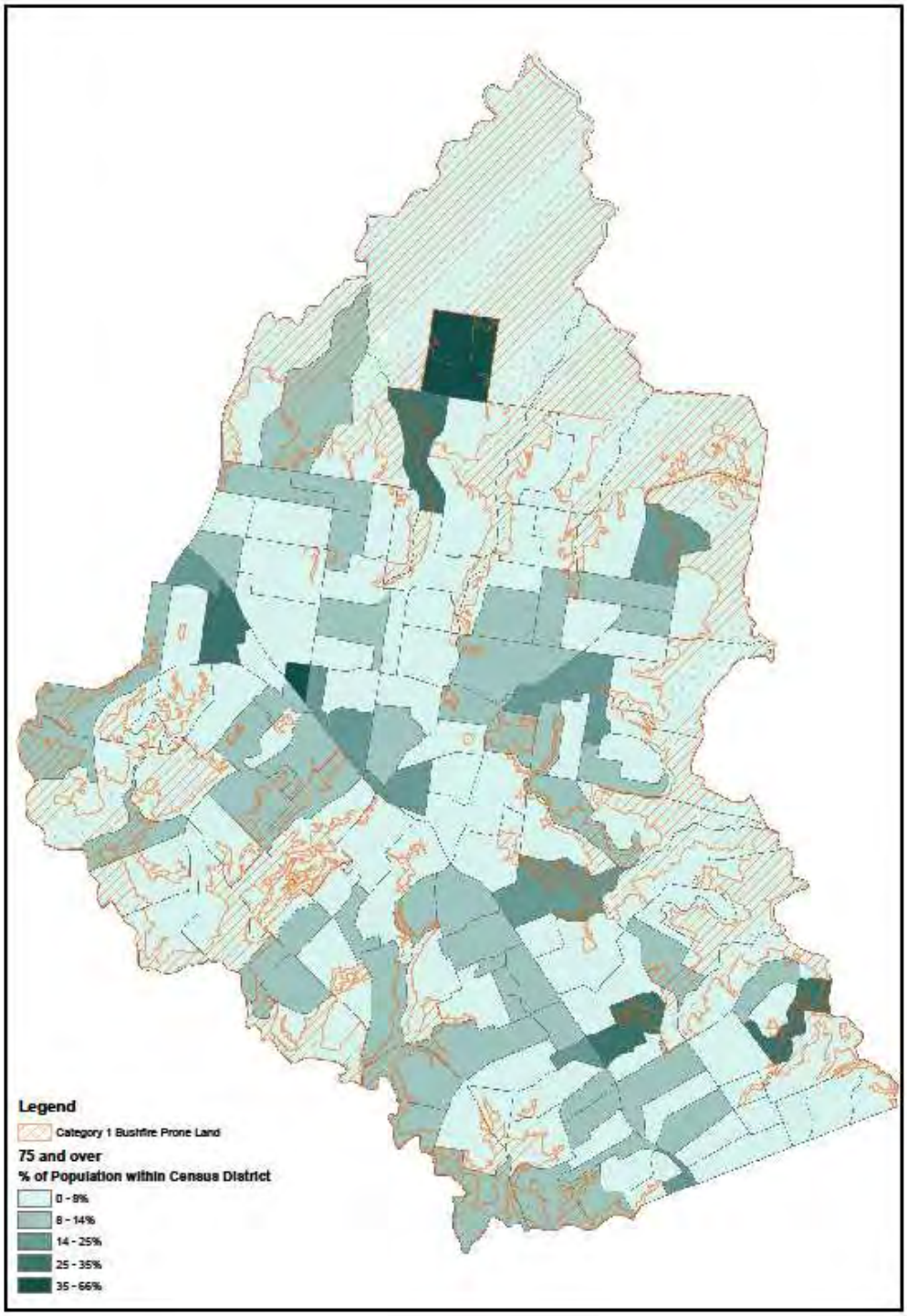
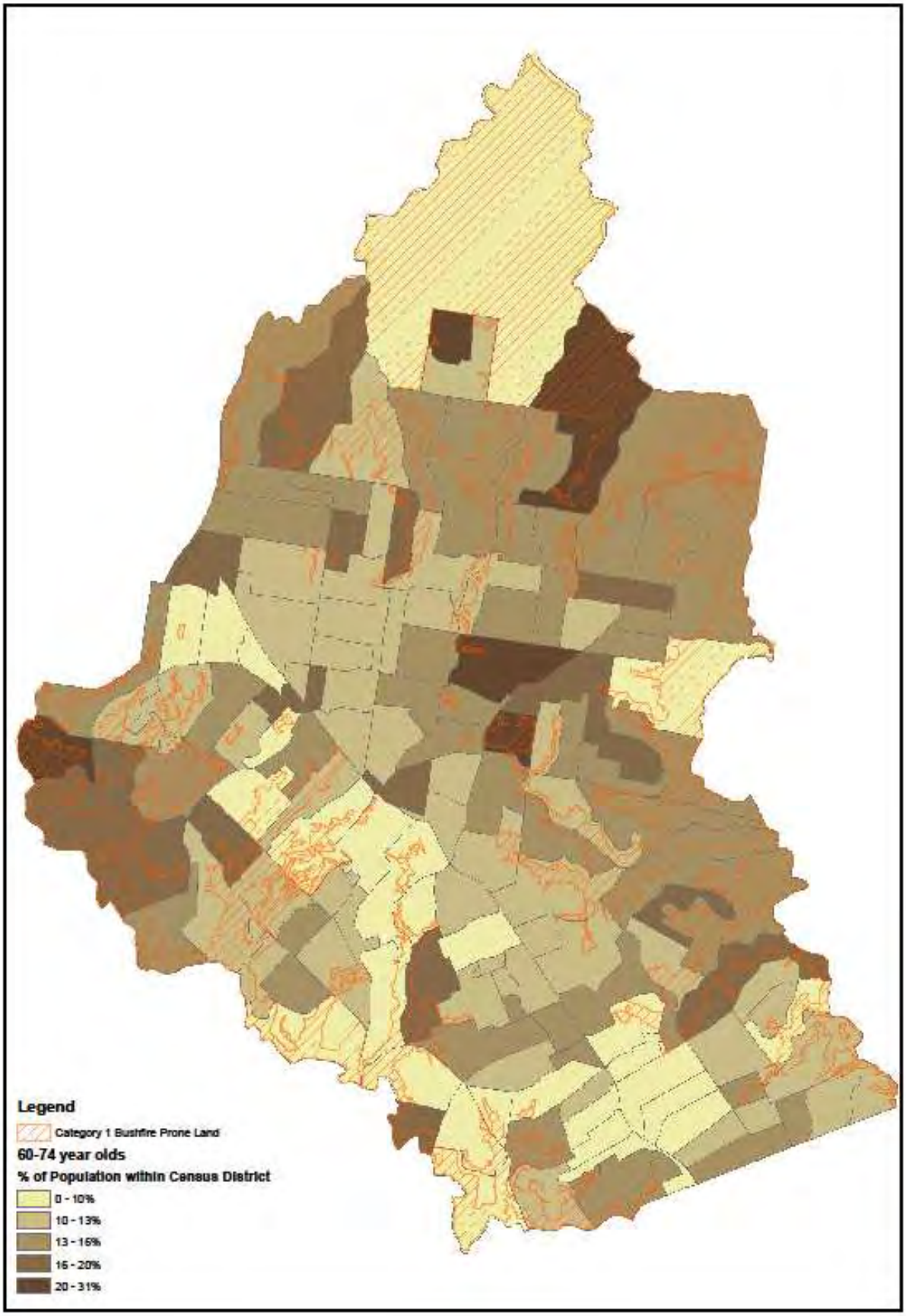


Figure C2 Percentage of Ku-ring-gai population 60 to 75 years and over in relation to Bushfire Prone Land Category 1
(Vegetation that forms the bushfire hazard)



Appendix D

Review of exits from Evacuation Risk Areas

Table D1 Ku-ring-gai's Evacuation Risk Areas, assessed using Cova (2005)
Minimum number of exits per household

Evacuation risk area Number	Key road/s	No of exits	No of dwellings	Recommended max no of dwellings*			Number over recommended
1	Grosvenor Rd	1	403	50			353
2	Bobbin Head Rd	1 to 2	947	50	to	300	897
2a	McRae Pl/Burns Rd	1	39	50			-11
2b	Bedford Ave	1	15	50			-35
3	Warrimoo Ave	2	510	300			210
3a	Dalton Rd (cul de sac)	1	16	50			-34
4	Richmond Ave	1	32	50	to	300	-18
5	Eastern Arterial Rd	1	285	50			235
5a	Woodvale Cl	1	6	50			-44
6	Koola Ave	2 to 3	613	300	to	600	313
7	Ormonde Ave	1	21	50			-29
8	Bradfield Rd/ Fiddens Wharf Rd	4	683	N/A			
9	Boronga Ave/Gloucester Ave	2	105	300			-195
10	Parker Ave/Evans St	1	96	50			46
11	Ravenhill Rd/CarinaRd	2	148	300			-152
12	Chisolm St, Kissing Pt Rd	4	628	N/A			
13	Howson Ave	1	62	50			12
14	Browns Rd/Fox Valley/Jordan Rd	1 to 2	396	50	to	300	346
14b	San hospital and surrounds	N/A	Not assessed				
14a	Strone Ave	1	66	50			16
15	Mitchell Cr	2	57	300			-243
15a	Campbell Dr	1 to 2	82	50	to	300	32
Total			**5210**				Based on bottom of range

Appendix E

Determining a minimum lot depth

Planning for Bushfire Protection 2006 provides for setbacks from residential development to the bushfire hazard. For infill development it is recognised that these setbacks cannot always be achieved, but the available setback is nevertheless required to be managed as an Asset Protection Zone. Where subdivision is proposed, it is reasonable that this setback be met, and accordingly lot depths need to be sufficient to accommodate these setbacks.

Table E1 is an excerpt from Table A2.4 Minimum Specifications for Asset Protection Zones (m) for Residential and Rural Residential Subdivision Purposes (for Class 1 and 2 buildings) in FD_ 100 Fire Areas (<29kW/m2) in PBP.

Table E1 Minimum Specifications for Asset Protection Zones (m)

Vegetation Formation	Effective Slopes: Upslope /Flat	>0° -5°	>5° -10°	>10° -15°	>15° -18°
Rain-forests	10	10	15	20	25
Forests	20	25	35	50	60
Tall heath (Scrub)	15	15	20	20	20
Short heath (Open Scrub)	10	10	10	15	15
Freshwater Wetlands	10	10	10	15	15
Forested Wetlands	15	20	25	35	45

In Ku-ring-gai, almost all vegetation at the urban/bushland interface is classified as forest, for the purposes of *Planning for Bushfire Protection 2006*. From table E1 the following are the recommended APZ setbacks for residential and rural residential subdivision (class 1 and 2 buildings) under PBP for forests in Ku-ring-gai:

A sample of lots adjoining bushland was reviewed. Lots of less depth (eg less than 40m) consistently had dwellings built very close to the hazard. Lots which have their side to the bush are also extremely close to the hazard. Even lots where there is a road between the bushland and the front boundary, have dwellings that are closer to the hazard than the desirable APZ. Deeper lots, unsurprisingly, generally had deeper rear yards and setbacks to the bushland. Nevertheless, these setbacks still do not meet the setbacks for an Asset Protection Zone (APZ) identified under *Planning for Bushfire Protection 2006*, as shown in Appendix 3.

Front setbacks were commonly a minimum of 9m or 12m (consistent with Council's planning controls), while dwelling depths were often from 14m to 20m. House and front yard therefore totalled from 23m to 32m depth. [15]

Given likely increases in frequency and intensity of fires a conservative approach has been taken and the higher APZ setback used for each group of slopes in the scenarios below.

- Using a standard setback to the rear of the dwelling of 25m for slopes from flat to 5° would result in a lot depth to the hazard ranging from 48 to 57m.
- Using a standard setback to the rear of the dwelling of 35m for slopes from greater than 5° to 10° would result in lot depths from the hazard ranging from 58 to 67m.
- Using a standard setback to the rear of the dwelling of 60m for slopes from greater than 10° to 18° would result in lot depths from the hazard ranging from 83 to 92m.

It is noted that some effective slopes are greater than 18° and no standards have been set for APZs for such sites.

Minimum lot depths from the hazard are recommended as in Table x below.

Table E2 Recommended Minimum Lot Depths

Upslope/flat - 5°	>5° - 10°	>10°
55m	65m	90m

The minimum lot depth would be calculated from Category 1 and 2 vegetation, as identified on the *Bushfire Prone Lands Map*. This would allow for changes to the line of the hazard, with the regular updates to the *Bushfire Prone Lands Map*, without the need to amend the LEP.

[15] Two other council areas were found to have used minimum lot depths in this way, estimating the required dwelling and yard as 30-35m deep, eg. Coffs Harbour (2000). Note that Coffs Harbour has a lower FFDI than Sydney.