



FINAL REPORT

Bushfire Risk Assessment for the Ingleside Planned Precinct

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DEPARTMENT OF PLANNING AND ENVIRONMENT
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Bushfire Risk Assessment for the Ingleside Planned Precinct

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1 Executive Summary

This bushfire risk assessment has been commissioned by the Department of Planning and Environment (herein referred to as 'DPE') in relation to the current draft Structure Plan for the Ingleside Planned Precinct, in Sydney's northern beaches region.

This risk assessment adopts a risk-based land use planning approach to critically analyse the extent of bushfire risk exposure in both existing and potential future (based upon the current draft Structure Plan) contexts.

The key observations derived from this risk assessment process include:

Risk identification and evaluation

- The Ingleside Precinct is exposed to potentially extreme existing bushfire risk, noting the Precinct has been previously impacted by fire events and extreme-scale event exposure is likely again based on recorded daily Forest Fire Danger Index (FFDI) captured since 1976.
- The proposed Structure Plan seeks to introduce a nine-fold increase in population, largely occurring via density increases in the Sub-Precincts of North Ingleside and South Ingleside (from approximately 1,080 persons at present to 9,000 persons).
- The proposed Structure Plan identifies important ecological communities which exist within the Precinct. Land use planning measures have thus been identified to maintain and enhance these values within the Precinct. It is the case however, these measures are at odds with the scale of potential risk exposure relevant to the Precinct and introduce strategic planning issues relating to the potential intrusion of landscape-scale fire risk into the Precinct
- Among others there are two primary aspects relevant to the consideration of bushfire risk for the Ingleside Precinct:
 - Risk to property; and
 - Risk to life.
- Risk treatment to property is considered possible through the application of a wide range of mitigation measures, specified in Section 10, consistent with the draft *Planning for Bushfire Protection 2018*. However, such property mitigation measures do not guarantee against property loss having regard to the broad range of factors which contribute to building ignition during bushfire events. Further, the application of any treatment measures is likely to result in substantial impacts on the intended settlement pattern, and subsequently result in issues of overall development feasibility.
- Risk treatment to life is concordantly more complex and based on interlinked relationships between density/settlement pattern, human behaviour, evacuation capability and the potential for urban fire intrusion and house-to-house ignition. The ability to adequately treat life safety risk remains the core criteria which drives development acceptability.

Risk context

- Existing statutory planning and building frameworks either tacitly or explicitly result in acceptance of bushfire risk by government for property – house loss has and can still occur despite the combination of planning, building and other bushfire protection measures and this is acknowledged by the relevant instruments in place. These mitigation approaches seek to balance the trade-off often required between development and risk exposure, acknowledging that development can still occur in risk-exposed locations provided the magnitude of risk is mitigated to a level that is as low as reasonably practicable (i.e. tolerable or acceptable risk).

- From a property risk perspective, amendments to the draft Structure Plan combined with the suite of statutory planning and building (and other) mitigation measures is capable of mitigating, to an extent, property risk issues, acknowledging that despite this combination of measures some considerable loss of property may still occur in higher magnitude events. In the case of Ingleside, almost 2,000 dwellings (5,000 occupants) could be expected to be lost. This represents a significant portion of the proposed housing stock within the Precinct.
- Despite the above, the issue of risk acceptability in relation to the Ingleside Planned Precinct is largely about risk to life, and the identified need to examine the broader consideration of holistic bushfire risk management sought by governments and communities. Thus, the key to risk acceptability in this regard is ensuring from a government perspective that all necessary risk treatment measures are considered and applied to minimise risk.
- Bushfire fatality data for 260 events from 1901 to 2011, analysed by the CSIRO, shows that whilst late evacuation represents the primary activity undertaken at the time of death, there is a rising trend of fatalities occurring within structures (sheltering in place) – particularly in more extreme-scale events.
 - This emerging trend may be symptomatic of:
 - Residents which are reluctant to act upon a 'leave early' warning;
 - Lack of situational awareness (i.e. people caught off-guard);
 - Residents attempting to stay and defend in fire weather conditions which are not conducive to doing so; and/or
 - Residents adopting a 'wait and see' attitude and then leaving it too late to safely evacuate.
- The behavioural response of residents to bushfire emergency and evacuation warnings, studied by the Bushfire and Natural Hazards Cooperative Research Centre, is a necessary input when contemplating evacuation as part of strategic risk-based land use planning.
- There is a strong relationship between built form, density, evacuation and resident behaviour.
- In Australia, 'acceptable' risk in instances of new land release and development is characterised by a general community expectation of zero life loss for design scenario events (which in this case is FFDI 100), thus loss of life represents unacceptable risk (i.e. community expectation is that sufficient information and capability exists today to make risk-informed decisions to avoid exposure where serious potential for life loss exists).
- Following disaster events, public dialogue with regard to the role of land use planning in allowing development to proceed in higher risk locations is common, and growing.
- From a strictly land use planning perspective, whilst evacuation is an emergency management process, risk-based land use planning must deliver route network options and design that facilitate safe and efficient evacuation but acknowledging the scale of unknown and unforeseeable situations which may translate on the day a fire event might occur.
- With regard to the Ingleside Precinct and the issue of risk to life, the topographic context and important ecological values in and surrounding the Precinct constrains the road network. Whilst upgrades to existing roads are proposed, no new roads are proposed and the upgraded network is insufficient to service the proposed population density (up from 1,080 to over 9,000 people) in an emergency, given the serious 'single point of failure' issues which exist. This is acknowledging:
 - Ingleside is completely surrounded by hazard, every evacuation route with the exception of Powderworks Road requires residents and fire services to traverse bushland to enter or evacuate. Powderworks Road is likely to bottleneck in an

- emergency, compounded by evacuees entering the network from Elanora Heights moving south;
- no new road connections from Ingleside to surrounding suburbs is proposed. Notwithstanding, upgrades to four roads (offering five evacuation options) are proposed. 25 per cent of the Mona Vale Road corridor is identified as subject to potential flame contact. The ability for some of these roads to function in a bushfire emergency cannot be guaranteed;
 - the Coronial Inquiry following the 1994 Cottage Point fire identified potential challenges with the road network as it existed at that time, with regard to the facilitation of evacuation and that this should be a core consideration in contemplating new development within Ingleside into the future;
 - evacuation of circa 9,000 people from the Precinct, assuming 12 per cent would leave early, is likely to take hours and require substantially longer warning than that which might be available once an emergency situation is apparent, this is particularly the case if rate of spread/intensity is significant or catastrophic;
 - there are safety issues with the location of 'neighbourhood safer places' or evacuation centres, when coupling these facilities with the nature of the proposed road network and population density; and
 - more generally, there is a broader focus on the ability to evacuate as part of strategic land use planning dialogue in Australia and internationally, in recognising the role of land use planning in disaster risk reduction.
- it is accepted that as a general rule in planning in response to natural hazard, level of exposure can increase, but not the level of risk; and
 - the existing community of Ingleside is exposed to existing bushfire risk (addressed throughout this report). Despite some clearing that would be required as part of development in Ingleside, risk exposure to persons/potential for life loss is increased.

Consideration of key risk issues

Subsequent to the above, the key risk issues were considered, workshopped and deliberated in detail amongst all key stakeholders involving officers from DPE, NSWRFs and Northern Beaches Council across June, July and August 2018.

During stakeholder meetings to workshop and discuss the multitude of risk issues at play, there could be no clear mitigation pathway identified to reduce risk to an acceptable level.

Following extensive exploration of key risk issues, the risk to life as a key criterion/benchmark for risk acceptability is unable to be satisfactorily mitigated either via strategic land use planning and/or other mitigation/management approaches.

This process involved the analysis of:

- the existing risk profile of Ingleside versus the proposed draft Structure Plan;
- changes to development and population densities;
- structure and settlement patterns;
- evacuation networks and alternative evacuation models (i.e. neighbourhood safer places and evacuation centres);
- the ecological values and topography in and surrounding the Precinct;
- the element of human behaviour in preparing for and responding to bushfire emergency;
- the transfer of risk to emergency services and risk to frontline firefighting personnel; and

- the impact of the 1994 bushfires on Ingleside and surrounding areas and the transition of fire which occurred irrespective of low fuel buffer areas.

Overall and having regard to the 'inappropriate' development benchmarks of PBP 2018, the scale and complexity of the competing, compounding and cascading risks to life and property, supported by the evidence base presented by this risk assessment, determines that available mitigation measures are unable to reduce the risk profile to a level which is universally acceptable to DPE, NSWRFs or Northern Beaches Council insofar as the current draft Structure Plan.

Recommendations

Moving forward, several key recommendations are identified:

1. The planning pathway forward for Ingleside should be clearly identified. If appetite for further development or certain types of development is low, appropriate planning instruments should be implemented to avoid potential for ad hoc and incremental risk increase over time via discrete planning proposals.
2. The existing risk profile of Ingleside must be addressed with a combined range of measures to strengthen community resilience to bushfire. This could be undertaken via a resilience workshopping process to identify key mitigation opportunities and built-in to a revised Warringah Pittwater Bush Fire Risk Management Plan and Local Emergency Management Plans.
3. Avoid the introduction of any new Special Fire Protection Purposes within the Ingleside Precinct into the future.
4. Consider the preparation of a Guidance Manual for conducting strategic land use planning risk assessments / bushfire strategic studies as an addendum / appendix to PBP 2018 to ensure consistency in process, approach and evidence-based reporting is conducted moving forward across NSW (similar to the NSW Floodplain Development Manual).

As bushfire protection planning policy has changed since the planning process for Ingleside first commenced, and new methodologies have emerged, it is now expected that new master planning processes would inherently consider the magnitude of potential bushfire risk as a precursor and build-in bushfire resilient land use planning approaches throughout design processes, where appropriate.

2 Core Concepts

This section defines those core terms and concepts which are adopted throughout the body of this report.

Risk – a risk is created when a hazard interacts with an area of social, economic or environmental value. There are a number of direct and indirect losses associated with natural hazards. These losses include:

- loss of life;
- physical suffering;
- emotional suffering;
- damage to property;
- reduced productivity;
- degraded environment;
- loss of species and habitats;
- damaged infrastructure;
- weakened economy;
- destabilised community coherence, political situations; and
- reduced quality of life.

The degree of risk presented by that interaction will depend on the likelihood and consequence of the hazard occurring.

Risk may be defined as the chance of something happening, in a specified period of time that will have an impact on objectives. It is measured in terms of consequences and likelihood.

Risk-based land use planning – the strategic consideration of natural hazard risk and mitigation in informing strategic land use planning activities.

Hazard – a hazard is any source of potential harm or a situation with a potential to cause loss. A hazard is therefore the source of risk.

Risk assessment – a systematic process of evaluating the potential risks that may be involved in a projected activity or undertaking, having regard to factors of likelihood, consequence, vulnerability and tolerability.

Residual risk – the risk that remains after risk treatment (i.e. through risk avoidance, reduction/mitigation, transfer or retention/acceptance) has been applied to reduce the potential consequences.

Likelihood – the chance of an event occurring. Likelihood may be represented as a statistical probability (such as an Annual exceedance probability), or whether this is not possible, it can be represented qualitatively using measures such as 'likely', 'possible' and 'rare'.

Consequence – an impact on the natural, economic, built or social environments as a result of the hazard. The consequences are influenced by the vulnerability of elements at risk, by the exposure of elements at risk to the hazard, and by the characteristics of the hazard.

Vulnerability – the degree of susceptibility and resilience of the community and environment to hazards.

Tolerance - a level of measure of risk acceptability.

Bushfire attack mechanisms – the various ways in which a bushfire can impact upon people and property and cause loss or damage. These mechanisms include flame contact, radiant heat exposure, ember attack, fire winds and smoke.

Acceptable risk – that level of risk that is sufficiently low that society is comfortable with it. Society does not generally consider expenditure in further reducing such risks justifiable.

Unacceptable risk – a level of risk that is so high that requires risk treatment measures whatever their cost, or the elimination of the risk.

Primary loss extent – that extent, measured in distance from a landscape-scale hazard source, which reflects the majority of life and property loss from bushfire events in Australia.

Mitigation – measures taken in advance of a disaster aimed at decreasing or eliminating its impact on society and environment.

As Low as Reasonably Practicable – a risk management concept known as the ALARP Principle, this is applied to define boundaries between risks that are generally intolerable, tolerable or broadly acceptable.

Resilience - the ability of people, property and infrastructure within our communities to adapt over time in a manner that minimises the governance, social, economic and environmental burden in responding to, and recovering from, the changing effects of natural hazard stresses and shocks.

3 Introduction

This bushfire risk assessment has been commissioned by the Department of Planning and Environment (herein referred to as 'DPE') in relation to the current draft Structure Plan for the Ingleside Planned Precinct, in Sydney's northern beaches region.

This risk assessment follows previous bushfire-related assessments undertaken by both Meridian Urban and Eco Logical Australia (ELA) with regard to the bushfire hazard associated with the potential further development of Ingleside. Separately to these bodies of work, this risk assessment seeks to consider the new strategic planning provisions outlined by the revised 2018 Planning for Bushfire Protection guideline released by the New South Wales Rural Fire Service (NSWRFS) in determining:

- a) the overall strategic suitability of the Ingleside Planned Precinct relative to bushfire risk; and
- b) whether development of the Precinct, or part thereof, can be undertaken in a manner which mitigates risk to an 'acceptable' or 'tolerable' level.

This risk assessment is undertaken through a risk-based land use planning lens in order to critically analyse the extent of bushfire risk exposure in both existing and potential future (based upon the current draft Structure Plan) contexts.

This risk assessment acknowledges the identification of Ingleside as a Planned Precinct in response to growth and housing pressures currently facing the Sydney metropolitan area. However, whilst this need has been considered throughout this process, the core objective of this risk assessment is to determine the suitability of the current draft Structure Plan in responding to bushfire risk. This risk assessment process thus remains entirely independent in nature, built upon the evidence base presented within this report.

The risk assessment process adopted for the purposes of this study are based upon that set out by the National Emergency Risk Assessment Guideline (NERAG) and in accordance with ISO 31000 – Risk Management, having regard to the critical elements of likelihood, consequence and vulnerability with consideration of existing and potential future risk exposure framed by an analysis of:

- risk to people;
- risk to property;
- risk to infrastructure;
- economic risk; and
- environmental risk.

3.1 Project Assumptions and Exclusions

It is acknowledged this risk assessment responds to a draft (forward release) version of Planning for Bushfire Protection 2018. This is important having regard to the commencement of land use planning investigations into Ingleside which commenced in 2012/13. Over this period, planning policy expectation regarding strategic planning for bushfire protection has changed across New South Wales (NSW), Australia and across the globe. More generally, the dialogue regarding the role of land use planning in disaster risk reduction is growing, with an increasing emphasis now placed on strategic planning processes to address risk before commitment to development proceeds.

Noting the above, this particular risk assessment process is one of the first of its kind in New South Wales. Whilst the draft Planning for Bushfire Protection 2018 sets the expectation with regard to those matters which should be investigated via risk-based land use planning approaches, it does not provide guidance on how such a process should be conducted. In NSW and across Australia more broadly, limited guidance exists in relation to the critical analysis of land use planning practices in response to bushfire risk. These represents a notable gap in existing policy.

To this end, the contents of the National Emergency Risk Assessment Guideline and Handbook 7 – Managing the Floodplain have been used as a framework approach to conduct this risk assessment. Fit-for-purpose approaches are integrated based upon a wealth of fire-related research.

This is not a process which intersects with the State's disaster arrangements, but does have regard to matters of emergency management such as evacuation, fire suppression, deployment of emergency resources and firefighter safety, etc.

This risk assessment does not represent a Bushfire Strategic Study as required by the draft Planning for Bushfire Protection 2018. This report is prepared in order to understand the appropriateness or otherwise of the current draft Structure Plan for the Ingleside Planned Precinct.

This risk assessment adopts a design fire scenario for fire weather involving a Forest Fire Danger Index (FFDI) of 100 which accords with the current Fire Danger Rating system used across Australia and aligns with existing land use planning and building provisions in place across metropolitan Sydney. Notwithstanding, fire weather higher than FFDI 100 has been recorded on several occasions across the past four decades at local weather stations, with an increase in frequency of higher fire weather danger days occurring over the past 18 years.

The fire runs identified by this assessment rely on the work of third parties, specifically the bushfire behaviour assessment conducted by Eco Logical Australia (2018). The key fire run analysis does not encompass every single possible fire advancement, scenario or situation which may occur or impact upon the Ingleside Precinct.

This risk assessment is informed and underpinned by an extensive evidence-base of contextualised data and information. The accuracy of data and information derived from third party research organisations and other agencies has not been verified, but is adopted as correct on the basis of peer review and the public availability of relevant data sets and information.

Finally, this risk assessment does not seek to resolve or reconcile the full extent of bushfire risk exposure relevant to the existing or proposed communities of Ingleside. This risk-based land use planning assessment deals only with those activities associated with and within the realm of strategic land use planning parameters. Strategic planning, whilst effective, cannot avoid or mitigate the full extent of existing and / or potential risk and the transfer of residual risk must be understood and accepted, for resolution by other processes – statutory planning, building design and construction, infrastructure provision and servicing, emergency and disaster management, land management, community awareness and insurance practices.

The premise of this risk assessment is to identify relevant opportunities to mitigate the extent of risk to a point that is 'as low as reasonably practicable' before risk is considered for transfer to other parties for mitigation and management.

4 Background

4.1 Ingleside Planned Precinct

In 2014 the New South Wales (NSW) government launched the Priority Precinct program which focuses on identifying locations across greater Sydney with good access to existing or planned public transport connections, suitable for rejuvenation with new homes and employment (DPE, 2018). These areas have since evolved into Planned Precincts and have moved forward into the next stage of the planning process which focuses on the provision of priority infrastructure to support new development and redevelopment. The 700ha Ingleside Precinct remains one of these Planned Precincts and is located within the Northern Beaches Council area, refer to **Figure 1** below.

DPE is continuing to work with the Northern Beaches Council, UrbanGrowth NSW, the local community and government agencies to prepare a new plan for Ingleside which is intended to create new homes and coordinate infrastructure. The Ingleside Precinct is seen as a potential opportunity to boost the supply of new homes in the North District of Sydney.

In 2017, DPE released a draft Land Use and Infrastructure Strategy (the draft Strategy) for public comment. It included a draft Structure Plan for the Ingleside Precinct (refer to **Figure 2**), identifying potential future land uses and densities for the Precinct. The draft Strategy is based on detailed technical studies and extensive consultation with the former Pittwater Council (now part of the Northern Beaches Council), UrbanGrowth NSW, government agencies and the local community. This process built upon an initial round of community consultation which occurred in November 2014.

It is understood comments have since been received on the 2017 draft Strategy.

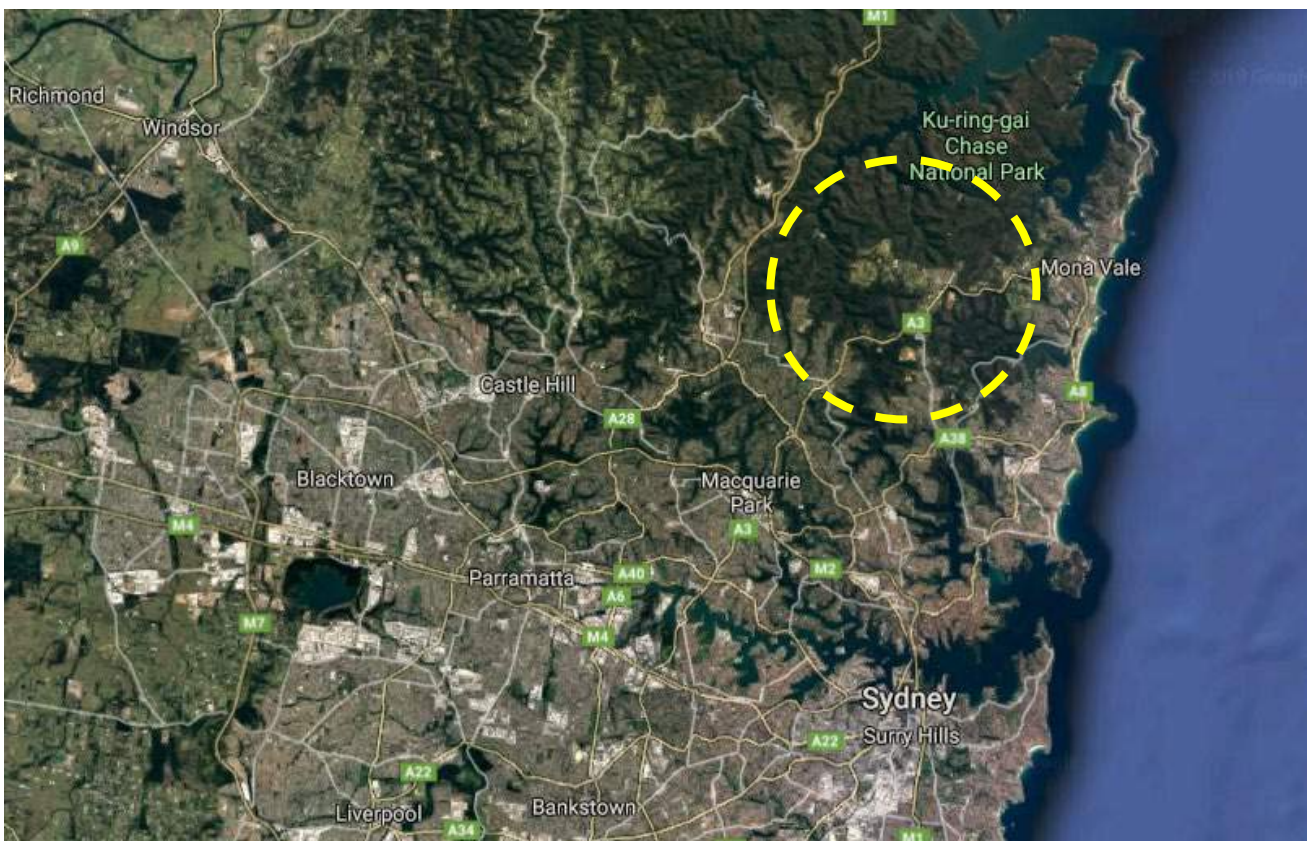


Figure 1 - Landscape and locality context of the Ingleside Precinct (Source: Google Earth, 2018)

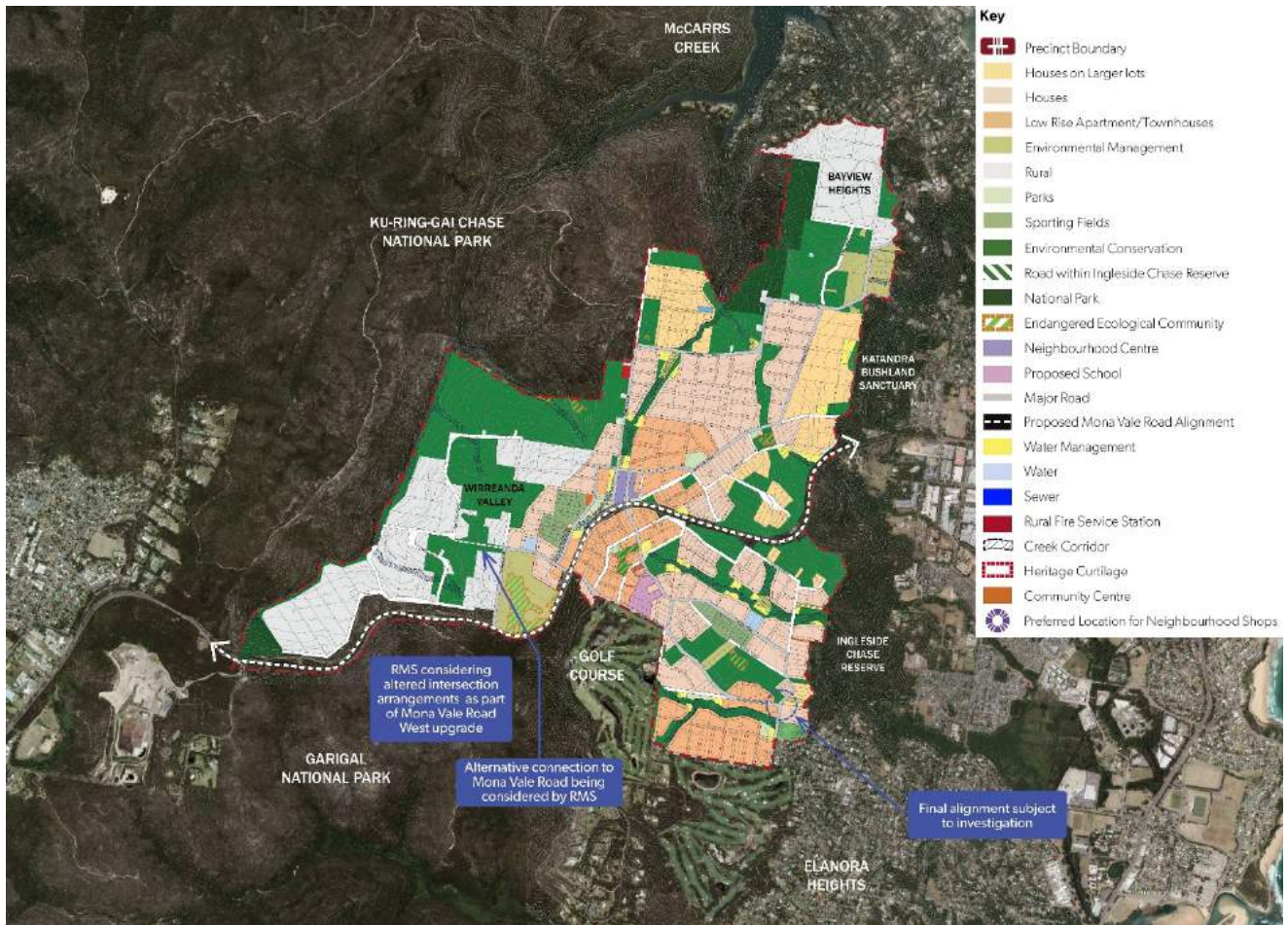


Figure 2 - Ingleside Precinct Draft Structure Plan (Source: DPE, 2016)

4.2 Preliminary Bushfire Constraints Analysis for the Ingleside Release Area 2014

Throughout the development of the draft Structure Plan for the Ingleside Precinct since 2014, bushfire hazard assessment and risk mitigation has formed a core element of the planning process. DPE commissioned Eco Logical Australia Pty Ltd (ELA) to assist with the bushfire protection and risk mitigation assessment for the Ingleside Precinct. To date, ELA has prepared a number of documents and associated mapping outputs, including the 2014 report into preliminary bushfire constraints for the Ingleside release area, undertaken shortly after Ingleside was identified by the NSW government as a priority precinct.

The Preliminary Bushfire Constraints Report analysed the vegetation formations and topographical context of the Precinct and surrounding areas in order to form an understanding of the nature of the extent of hazard. It also had regard to preliminary bushfire mitigation measures which could be considered moving forward. Both the hazard assessment and mitigation measures were revisited by the Bushfire Protection Assessment report prepared by ELA in late 2016.

Following a preliminary review of the Constraints Analysis, NSWRFs provided high-level commentary with respect to the draft Structure Plan as presented at that time – noting NSWRFs had not yet been formally requested by DPE to review or assess the draft Structure Plan or the Constraints Analysis given the early stages of the investigation at that time. The NSWRFs commentary to the (former) Pittwater Council, dated 28 October 2014, included:

- a) 'the Eco Logical Australia map indicating minimum asset protection zones (APZs) width and vegetation formations generally represent the principles of PBP. A more detailed assessment

would be undertaken by the Rural Fire Service once a formal referral was made by Planning NSW;

- b) Below are comments relating to the Eco Logical Australia map indicating minimum APZ width and zoning.
- i. Western side of Chiltern Road adjoining the Ku-ring-gai Chase National Park to the west: This area of National Park and Scout association bushland has been identified through the Warringah Pittwater Bush Fire Risk Management Plan (BFRMP) as an extreme risk and is a natural fire path that has seen several significant bushfire impacts over the past 30 years. The RFS recommend that this area be zoned from 'low density' to 'rural'.
 - ii. North western side of Cicada Glen Road there are two small areas zoned 'rural'. These two areas are identified through the BFRMP as an extreme risk and is a natural fire path that has seen several significant bushfire impacts including property loss over the past 30 years. Due to this risk, consideration should be given to have this land zoned not for development or as a minimum an APZ of up to 60m should be included in the planning document.
 - iii. The proposal to zone the Wirreanda Valley area as rural is supported by the RFS as it minimises isolated development with the large number of environmental corridors that join the National Park to the west.
 - iv. Mona Vale Road upgrade plan for the Wirreanda Valley effectively allows for single access to this area. The RFS recommends consideration be given to establish a second road access to link the Wirreanda Valley to Chiltern Road. This will allow alternative access or escape during bushfire emergencies.
 - v. The current Ingleside Rural Fire Brigade is located in King Road, an area proposed as a mixture of low and medium density. The current strategic direction of the RFS is to retain Ingleside Rural Fire Brigade in the area due to the large bush interface to the west and for strategic purposes. It would be preferred to relocate the Brigade in the future to an area toward the northern end of Walters Road. This would be closer to the rural properties and bushland once the area is redeveloped. The RFS request consideration be given to reserve land (minimum 2,000m²) for this purpose. Once the new Brigade Station is established, existing land could become part of the future development in the King Road area' (NSWRFS, 2014).

The 2014 Constraints Analysis Report does not include a copy of the draft Structure Plan as it existed at that time to enable a comparison against that which was included in the Bushfire Protection Assessment compiled in 2016. Thus, it cannot be determined by this risk assessment the degree to which the feedback from NSWRFS was considered insofar as the current layout concept of draft Structure Plan however it was the topic of several meetings between DPE, Council, NSWRFS and other project consultants in September 2015. To this end, it is identified that some requests (i.e. the Brigade Station location) are reflected via the current draft Structure Plan whilst others remain unclear, on the basis of retrospective assessment and without the benefit of the 2014 version of the draft Structure Plan.

4.3 Bushfire Protection Assessment Report 2016

Building upon preliminary assessments undertaken in 2014, the 2016 Bushfire Protection Assessment Report prepared by ELA sought to underpin the 2016 draft Structure Plan and 2016 draft Land Use and Infrastructure Strategy for the Ingleside Precinct and was released as a supporting document during the public consultation period.

The assessment was prepared having regard to the 2006 Planning for Bushfire Protection (PBP) guideline, being the state-wide regulatory instrument in addressing bushfire hazard for new development. The assessment report incorporated an updated hazard assessment from that

included in the 2014 constraints reporting, incorporating vegetation formation and topographical analysis as key factors in determining hazard extent in the locality.

In addition, the assessment report provided a detailed analysis of the bushfire protection measures required by the 2006 PBP guideline including matters such as asset protection zones, vegetation management, access and road requirements, water supply and building construction provisions.

The assessment report provided a brief assessment of the draft Structure Plan for the Ingleside Precinct noting that generally, the draft Structure Plan is capable of accommodating the required bushfire protection measures set out in the 2006 PBP. However, it did identify two key considerations for future development in the Precinct, including:

1. The area accessed via Laurel Road contains a number of existing residences and is currently accessed by a single road greater than 200 m in length and surrounded by vegetation on both sides. There is no plan to provide alternative access to this area. However, the proposed large lot zoning which specifies a minimum lot size of 2000m² combined with limited developable area outside of the minimum required APZ setbacks will limit any increase in residential density in this area.
2. Due to the nature of the existing zoning, there are a number of single isolated lots containing existing residences adjacent to bushland areas which cannot accommodate the minimum required APZs. These areas will either remain rural or become 'large lot residential' and future intensification of these lots is not anticipated as future subdivision is unlikely to comply with PBP (ELA, 2016).

4.4 Public consultation feedback on draft Ingleside Land Use and Infrastructure Strategy 2017

Subsequent to the public release of the draft Land Use and Infrastructure Strategy for Ingleside in 2016, a period of public consultation followed which resulted in the submission of over 400 community submissions on the draft Strategy and draft Structure Plan. A number of these raised the matter of bushfire risk.

One particular submission was lodged by the Garigal Deep Creek Residents Association (the GDCRA), a group of families that represent 35 properties in a specific pocket of residential properties located adjacent to the southern boundary of the proposed Ingleside Precinct and particularly including the residents of Dendrobium Crescent and Caledonia Crescent to the south of the Ingleside Precinct. This location was particularly impacted by fire in 1994, with numerous houses lost in this pocket (Hiatt et al. 1995, Macleod, 1996).

The GDCRA state it is not entirely opposed to the proposed development of the Ingleside Precinct, but raise serious concerns about the proposed intensity (medium density residential) of a 28ha area between Wilga Street and Powderworks Road in South Ingleside. It is said that medium density residential development would be 'fundamentally unsuitable' and the submission seeks a lower density level of residential development (circa 2,000m²) to be considered.

The primary concern raised by the GDCRA relates to the bushfire threat and particularly to emergency access and evacuation, in light of the 1994 bushfire and the subsequent Coronial Inquiry. As highlighted above, the Inquiry acknowledged concerns about access and the emergency evacuation route network for this area. At page 99, the Inquiry report provides that if future development should occur, there should be 'appropriate access, exit and perimeter roads to and around such new housing estates to accommodate emergency vehicles'. The GDCRA asserts the proposed medium density residential development in the area between Wilga Street and Powderworks Road does not comply with that recommendation. Further, the GDCRA claim it is potentially contrary to parts of PBP 2006 and Ministerial Direction 4.4.

Page 11 of the submission document states that 'insufficient consideration (has been) given to the impacts such a significant increase in population would have on the ability of existing residents to evacuate the bushfire affected land in an emergency'. The submission raises concern regarding

the safety of existing and new residents, and bushfire safety considerations should extend to existing residents in addition to potential new residents.

4.5 Bushfire Peer Review Assessment Report 2018

A Peer Review Assessment was conducted in February 2018 by Meridian Urban to consider the detail, methodologies, bushfire protection measures, recommendations and outputs contained within a Bushfire Protection Assessment report prepared by ELA and dated October 2016 in relation to the Ingleside Precinct. The peer review was undertaken having regard to the suitability and the validity of the bushfire risk mitigation measures recommended by the ELA report. The peer review had regard to a range of supplementary information and documentation from a range of sources, with relevance to the bushfire threat which relates to the Ingleside area, as well as the details informing the current Ingleside Planned Precinct more generally.

The intent of the peer review was to identify any relevant gaps which existed in the bushfire work undertaken to date, and opportunities which may be available to assist all relevant project stakeholders to target bushfire planning activities for the Ingleside precinct moving forward.

Having regard to the content of the Bushfire Protection Assessment prepared by ELA as well as the broader evidence base regarding bushfire hazard and risk which currently exists, data gaps were found to exist which indicated the nature of bushfire consideration to date in informing the development of the Ingleside Precinct was incomplete. Key context identified by the peer review report for this observation included:

- In a disaster management environment, the 2008 Bushfire Risk Management Plan for Warringah and Pittwater identifies the Ingleside area as subject to 'extreme' risk and with some 48 ignitions in the region (on average) per year;
- Correspondence from NSWRFs dated 2014 in response to a 2014 ELA Bushfire Constraints Assessment identifies that the area to the west of the Precinct (incorporating Ku-Ring-Gai Chase National Park) is a '*natural fire path that has seen several significant bushfire impacts over the past 30 years*';
- The FFDI for the area is 100 which demonstrates that Catastrophic fire weather can and does occur in this location (this does not consider the potential effects of climate change);
- The Community Protection Plan prepared by NSWRFs identifies a considerable extent of the current developed area of Ingleside as subject to flame impact as well as radiant heat and ember attack impacts, as per the Bush Fire Survival Maps forming part of the Plan for Ingleside North and Ingleside South; and
- The 1994 Cottage Point fire which resulted property loss in this area (but not life loss).

In consideration of the above, the peer review report noted that:

1. The peer review assessment focused on the accuracy and completeness of bushfire-related reporting prepared for the Ingleside Precinct undertaken to date, relative to existing and draft requirements. It did not assess the suitability of land use planning approaches associated with the current draft Structure Plan.
2. Bushfire-related reporting and assessment completed to date for the Precinct related to the 2006 PBP, noting that a draft 2017 updated version had since been publicly released and provides important principles and context for community-scale bushfire risk management practice that is relevant to the Ingleside precinct.
3. In the absence of any assessment against the updated provisions contained within the draft 2017 PBP (or the finalised version), it could not be determined the currently intended regulatory provisions of PBP, particularly those that relate to community-scale / landscape risk assessments, are satisfied.

On balance, the peer review found it difficult to draw a conclusion as to the potential effectiveness of the bushfire mitigation measures identified by the ELA reporting, noting that further work was considered warranted to advance future development in the Ingleside Precinct in accordance with the intent of the draft PBP 2017 which was released after the ELA report was prepared.

Whilst compliance with the bushfire protection measure requirements contained within PBP 2006 has been assessed by the bushfire work undertaken to date, there remain broader matters for consideration with regard to the creation of a bushfire resilient settlement pattern, structure, road and infrastructure networks, land use and density intentions for the Precinct. It is understood this was not part of the brief to which previous bodies of work were to meet.

The above body of further work was considered necessary by the peer review assessment to satisfy the new provisions regarding strategic land use planning contained within the draft 2017 PBP. Further to such work, it was considered by the peer review assessment that design-based bushfire protection measures in accordance with PBP could then be appropriately determined however, to date this appears to have occurred in the absence of a fully risk-informed view of strategic land use planning approaches to bushfire risk reduction. It must be recognised this was not within the scope of work commissioned and is reflective of the changing nature of risk-based land use planning which is taking place across New South Wales, and which is now inherent to the new Planning for Bushfire Protection Guideline 2018, which now includes the strategic consideration of bushfire risk matters at the outset of new land release/planning proposals.

5 Risk Assessment Methodology

Having regard to the content of the peer review report of bushfire work completed to date in relation to the Ingleside Precinct, a bushfire risk assessment is identified in order to critically examine the magnitude of potential bushfire risk and opportunity for risk-responsive development in the Ingleside Precinct.

5.1 Risk assessment scope and objectives

The scope of this bushfire risk assessment specifically seeks to determine:

- a) the overall strategic suitability of the Ingleside Planned Precinct relative to bushfire risk; and
- b) whether development of the Precinct, or part thereof, can be undertaken in a manner which mitigates risk to an 'acceptable' or 'tolerable' level.

This bushfire risk assessment represents a fit-for-purpose approach with the focus of determining and informing suitable risk-based land use planning approaches for the Ingleside Precinct. As highlighted, the approach to this risk assessment adopts a risk-based land use planning lens in order to critically analyse the extent of bushfire risk exposure in both existing and potential future (based upon the current draft Structure Plan) contexts.

5.1.1 Out of scope

This risk assessment is not a bushfire management plan. This risk assessment seeks to analyse the extent of bushfire risk relevant to the Ingleside Planned Precinct with respect to the existing situation and draft Structure Plan.

This risk assessment acknowledges the identification of Ingleside as a Planned Precinct in response to growth and housing pressures currently facing the Sydney metropolitan area. However, whilst this need has been considered throughout this process, the core objective of this risk assessment is to determine the suitability of the current draft Structure Plan in responding to bushfire risk. This risk assessment process thus remains entirely independent in nature, built upon the evidence base presented within this report.

This process also does not incorporate any additional traffic modelling with regard to bushfire emergency evacuation.

The process does not include the use of any bushfire behaviour modelling such as Phoenix RapidFire, Vesta or Spark.

5.2 Risk assessment process

As established above, this risk assessment process is undertaken through the specific lens of risk-based land use planning and using the processes outlined by the National Emergency Risk Assessment Guidelines (NERAG) published by the Australian Institute for Disaster Resilience (AIDR) as well as AS/NZS ISO 31000:2009 – Risk management: Principles and guidelines (ISO 31000), refer to **Figure 3** below original set out by the Peer Review Assessment Report dated February 2018.

Bushfire Risk Assessment Framework

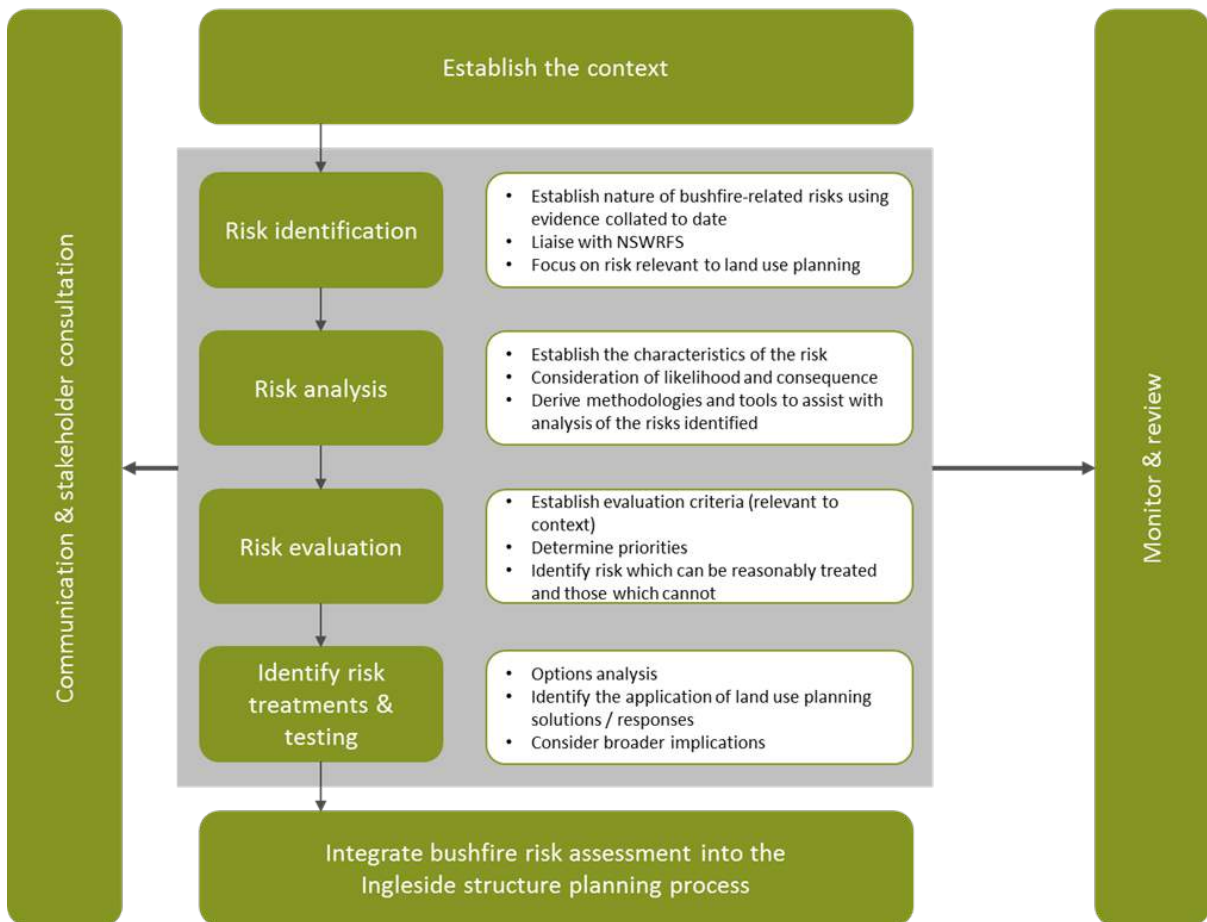


Figure 3 - Bushfire risk assessment framework and process for the Ingleside Precinct

Whilst this process is consistent with that adopted for the purposes of the bushfire risk management plans prepared by NSWRFs across the State, the risk-based land use planning lens adopted for this process differs to the disaster management lens adopted for the purposes of those documents. That is not to say that disaster management is not a consideration of this process, however the primary intent of this risk assessment (as opposed to that of the Warringah Pittwater Bush Fire Risk Management Plan, for example) is to consider the land use rationale of the draft Structure Plan.

In adopting a risk-based land use planning lens, it is necessary to consider the multitude of disciplines and mitigation approaches involved in the development of bushfire resilience. Thus, this risk assessment process maintains strong regard to the traditional aspects of the disaster management cycle and links them to broader social, economic, environmental and settlement systems.



Figure 4 - An integrated approach to community bushfire resilience

5.3 Project stakeholders

This risk assessment process has been conducted to determine and analyse the magnitude of potential bushfire risk relating to the Ingleside Precinct, relative to potential landscape-scale bushfire risk posed by neighbouring national parks and conservation areas. To this end, DPE remains the project sponsor, with key stakeholders including the NSWRFs and Northern Beaches Council. Each of these core stakeholders were engaged at various points of the process and particularly at the inception, risk identification and analysis and risk treatment / project finalisation phases.

The ultimate end-users remain the core priority of this assessment, including both existing and potential future residents within and adjoining the Ingleside Precinct.

A summary of the stakeholder meetings conducted as part of this risk assessment process are outlined below:

Table 1 - Summary of stakeholder engagement

Stakeholder	Date	Description
Department of Planning and Environment	15/16 March 2018	Project inception meeting. Brief overview of proposed project methodology,
Northern Beaches Council and Department of Planning and Environment	27 March 2018	Brief overview of proposed project methodology, Council did not raise any concerns/issues with the methodological process. Council did recommend that consideration of ongoing environmental and biodiversity assessments be had in informing project outcomes.
New South Wales Rural Fire Service and Department of Planning and Environment	27 March 2018	Brief overview of proposed project methodology, NSWRFs confirmed that compliance with PBP 2018 was essential in covering off on its benchmark requirements for landscape-scale assessments. NSWRFs requested further discussion with respect to the benchmarks / definition of risk acceptability to be used to guide the assessment.
Department of Planning and Environment	30 April 2018	A preliminary workshop was held with officers of DPE to discuss the intended risk mapping methodology, ahead of discussion with NSWRFs and Council. Also present was Mr Nathan Kearnes from EcoLogical Australia which prepared the fireline intensity mapping for use by this risk assessment.
New South Wales Rural Fire Service and Northern Beaches Council and Department of Planning and Environment	30 April 2018	A workshop was held with relevant stakeholders regarding the process undertaken to date, initial/preliminary observations and presentation of the intended risk mapping methodology. NSWRFs advice was to adopt an FFDI 100

		<p>for all risk assessment mapping and scenario processes.</p> <p>Some discussion was had regarding the need for strategic approaches to risk assessment, distinct from that of the bushfire protection measures contained within PBP.</p>
Department of Planning and Environment	20 June 2018	A briefing on the methodologies and findings of the risk assessment were presented to DPE, culminating in a discussion regarding risk treatment.
New South Wales Rural Fire Service and Department of Planning and Environment	28 June 2018	A briefing on the methodologies and findings of the risk assessment were presented to DPE, culminating in a discussion regarding risk treatment.
Northern Beaches Council and Department of Planning and Environment	10 July 2018	A briefing on the methodologies and findings of the risk assessment were presented to Northern Beaches Council. Meridian Urban was not present at this meeting.
New South Wales Rural Fire Service and Department of Planning and Environment	23 July 2018	A detailed overview of the various underpinning methodologies and detailed findings arising from the bushfire risk assessment.
Northern Beaches Council and Department of Planning and Environment	24 July 2018	A detailed overview of the various underpinning methodologies and detailed findings arising from the bushfire risk assessment.
Northern Beaches Council and Department of Planning and Environment	3 August 2018	A policy-based discussion between DPE and Northern Beaches Council. Meridian Urban was not present at this meeting.
New South Wales Rural Fire Service and Northern Beaches Council and Department of Planning and Environment	13 August 2018	Full day workshop involving key project stakeholders with a focus on determining key criteria for risk acceptability and risk tolerance.

6 Bushfire Risk Context

6.1 Overview

Pursuant to NERAG and ISO 31000, the essential first stage of any natural hazard risk assessment process is establishing the context to understand the physical and environment and event history (AIDR, 2017). This section articulates:

- the current regulatory environment in place regarding both natural hazard risk assessments and bushfire protection planning in NSW;
- the existing settlement pattern of the Ingleside area and surrounds;
- the draft Structure Plan and draft Land Use and Infrastructure Strategy for the Ingleside Precinct;
- the relevant environmental, built environment and social factors which are relevant to consideration of bushfire risk within the Ingleside locality and surrounding landscape; and
- the nature of the bushfire hazard landscape and fire history relevant to Ingleside, both within and surrounding.

6.2 Current Ingleside locality and landscape context

The community of Ingleside is located within the North Beaches local government area (LGA) approximately 30 kilometres north of the Sydney CBD. It is situated between the developed urban areas of Bayview, Mona Vale and Elenora Heights to the east, and Ku-ring-gai Chase National Park and Garigal National Park to the north-west and south-west respectively (DPE, 2017). The urban areas of Terrey Hills and Duffys Forest lie to the west, between the two national parks. Ingleside is quite elevated in nature, with sweeping views of the ocean to the east. Throughout the area, topographical changes are almost constant with the steepest areas occurring at either end of Mona Vale Road within the Precinct, and the north on approach to Bayview Heights.

The area is subject to a range of environmental and topographical features which have to date and will continue to dictate the urban form of the area, including complex water catchment, drainage and biodiversity values. The Precinct is geographically divided by Mona Vale Road which transitions west to east through the centre of Ingleside. The area to the south, known as South Ingleside, is slightly more developed/more urbanised at present than the area to the north which remains largely rural and rural residential in nature dispersed with a range of non-residential land uses. These include activities such as places of worship, home-based businesses (mechanical, earthmoving, construction, golf courses, equine services and facilities, etc.), nurseries, animal boarding and rescue facilities, etc. A Christian retreat and conference facility which accommodates school groups is also located with the far north-western area of the Precinct, in a densely vegetated area which bounds Ku-ring-gai Chase National Park. A recycling centre and landfill is located to the south of Mona Vale Road, towards Terrey Hills. Generally, the density of the Ingleside as it currently stands is very low density, with detached dwellings on larger 'lifestyle' or rural residential sized allotments and maintains a generally 'semi-rural' nature.

Mona Vale Road varies in width from Terrey Hills through to Mona Vale from four lanes to two lane (one lane in either direction). The two lane portions lie to the immediate east and west of Ingleside as Mona Vale Road traverses through national park and conservation areas. It is understood that investigation studies and approvals to widen these stretches of Mona Vale Road have been sought by Road and Maritime Services (RMS), refer to the Ingleside Draft Land Use and Infrastructure Strategy for further detail.

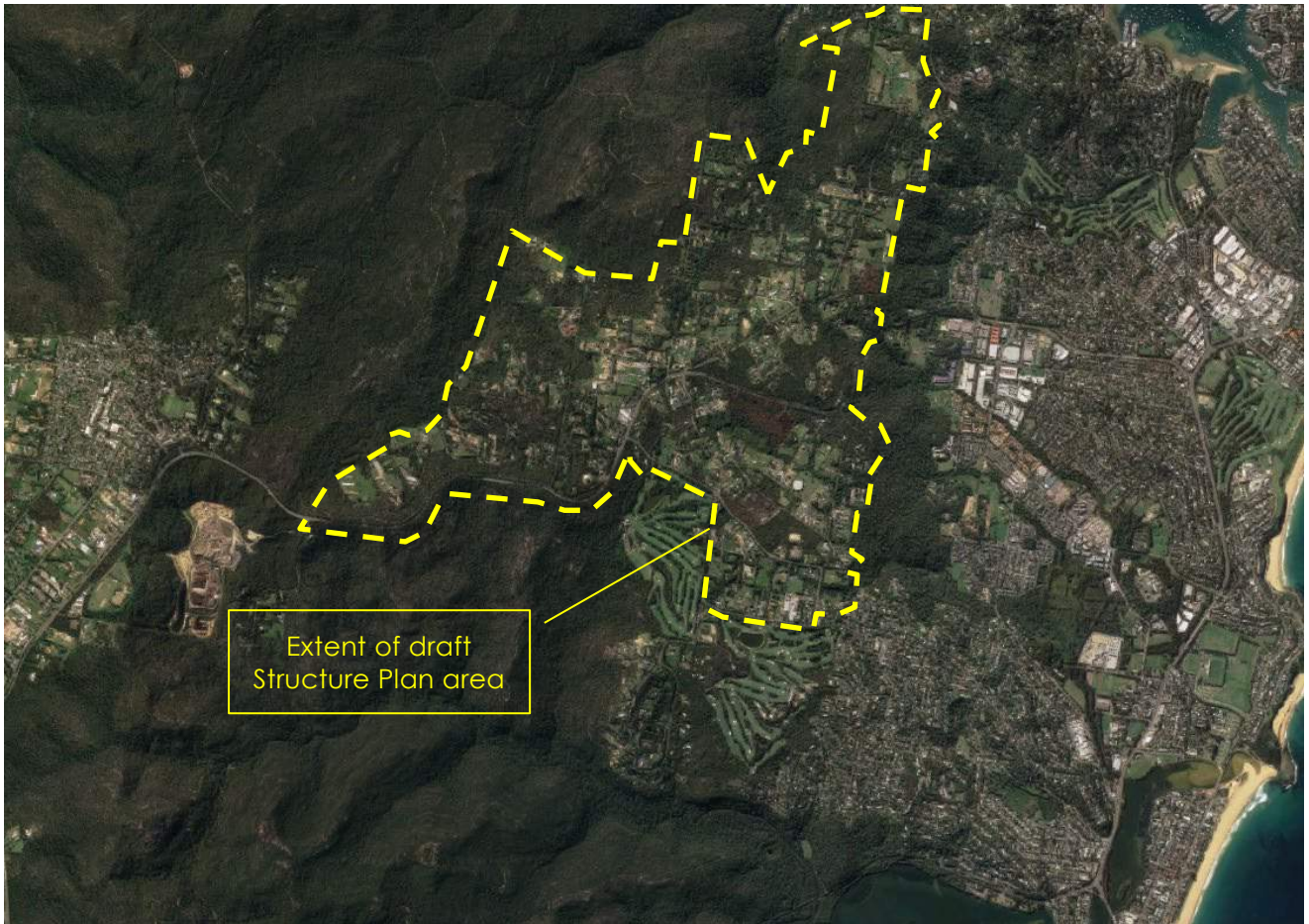


Figure 5 – Current locality and landscape context of Ingleside (Source: Google Earth, 2017)

6.3 Proposed settlement intent under the draft Structure Plan for the Ingleside Precinct

In 2013 Pittwater Council (now part of Northern Beaches Council) and the Minister for Planning agreed to undertake a Precinct planning approach for Ingleside. The planning process establishes new planning controls and infrastructure delivery arrangements to enable urban development by:

- examining the existing context of the Precinct;
- identifying environmental constraints and opportunities for enhancing connectivity and places;
- exploring development opportunities and infrastructure requirements;
- responding to the legislative requirements and best practice guidelines of state and local government;
- addressing feedback received through community consultation; and
- confirming consistency of the draft planning package with relevant planning documents.

The Structure Plan is a response to the strategic planning context and inputs from the specialist studies, landowner and stakeholder consultation (DPE, 2017).

The vision for the Precinct is to create a sustainable development that meets the needs of a well-connected and diverse community, supported by local facilities and infrastructure.

The proposed Structure Plan was informed by six objectives:

1. integrate planning measures and enable environmentally, economically and socially sustainable development;
2. link vegetation communities/fauna habitat with adjoining national parks and reserves;
3. create a diverse housing mix that caters to a range of household types;
4. improve connections to services, facilities, amenities and open space;
5. create an urban identity that respects and capitalises on the natural features of the Precinct;
and
6. create a new neighbourhood centre (DPE, 2017).

A mix of housing types and sizes is sought by the planning intent. Housing density and form is intended to respond to environmental constraints, including topography, riparian corridors and vistas to heritage elements.

A variety of housing choices is intended to be provided within the low density residential areas. Small lot, attached and semi-detached housing is to be located around activity nodes and public transport routes. Larger lots will adjoin areas of heritage and environmental importance.

Low rise apartments/townhouses are proposed close to the neighbourhood centre on Manor Road, Lane Cove Road and Powderworks Road close to a public transport hub. Low rise apartments/townhouses are also proposed at the less visually prominent location of Wilga Wilson, close to local shops at Elanora Heights and transport routes.

The proposed neighbourhood centre is intended to provide local shops and services for future residents.

The Structure Plan also proposes a number of open space areas and environmental conservation areas to protect wildlife corridors. Some of these areas are intended to be acquired by the Council (DPE, 2017). Refer to the draft Structure Plan at **Appendix A** for further detail.

6.4 Policy and regulatory context

The following section provides a discussion on the policy and regulatory context of the regulatory framework of bushfire regulation in New South Wales insofar as it is relevant to the Ingleside Planned Precinct.

These key instruments (and those that follow as part of Section 6.4) demonstrate a 'line of sight' with respect to the cascading relevance from legislation and regulation, to national best practices instruments, previous inquiries, risk assessments and studies as well as leading Australian and international fire and risk research.

6.4.1 Environmental Planning and Assessment Act 1979 (No. 203)

The Environmental Planning and Assessment Act 1979 (NSW) (EP&A Act) regulates planning in NSW. It deals with planning for bushfire risk, to a limited extent.

For example, section 10.3 of the EP&A Act relates to mapping/designation of bushfire prone land. Subject to some exceptions, section 4.14 restricts development on certain bushfire prone land, triggering a need to comply with Planning for Bush Fire Protection. The EP&A Act also deals with the regulation of integrated development, triggered by land being bushfire prone land (see also s100B of the RF Act).

Further, section 9.1 of the EP&A Act gives the Minister the power to direct a local government to exercise its functions of preparing a Local Environmental Plan (LEP) in accordance with principles in a direction. It also gives the Minister the power to direct a local government to include in a planning proposal provisions to give effect to the principles, aims, objectives or policies of a direction. As discussed next, the Minister has issued a direction about planning for bushfire protection.

6.4.1.1 Direction 4.4 – Planning for Bushfire Protection

Direction 4.4, Planning for Bushfire Protection (Direction 4.4), was issued under the former section 117 of the EP&A Act in 2009. Since then, the EP&A Act has been amended/renumbered and section 9.1 of the Act now deals with the planning directions.

Direction 4.4 deals with planning for bushfire protection and applies where a planning authority prepares a planning proposal that will affect or is close to bushfire prone land. The direction aims to (a) protect life, property and the environment from bush fire hazards, by discouraging the establishment of incompatible land uses in bush fire prone areas, and (b) encourage sound management of bush fire prone areas.

Amongst other things, the direction requires that a planning proposal must have regard to Planning for Bushfire Protection 2006 and it must introduce controls that avoid placing inappropriate developments in hazardous areas.

6.4.2 Rural Fires Act 1997

The Rural Fires Act 1997 (NSW) creates the Bushfire Coordinating Committee (BFCC). The BFCC is a statutory body representing the Crown and is responsible for planning in relation to bush fire prevention and co-ordinated bush firefighting. The BFCC is also responsible for advising the Commissioner on bush fire prevention, mitigation and coordinated bush fire suppression (Part 3, Division 2).

The BFCC must constitute various Bushfire Management Committees (BFMC) (Part 3, Division 3). BFMCs are required to prepare Bushfire Risk Management Plans for submission to the BFCC (Part 3, Division 4). If a Bushfire Management Plan applies to land, the land must be identified/mapped as prone to bushfire under the EP&A Act (see section 10.3 EP&A Act).

Beyond the above, the Act sets in place the regulatory environment which guides bushfire response across NSW including command structures and coordinated bush firefighting, hazard reduction processes, fire danger periods and total fire ban provisions. Division 8 of the Act deals with development of bushfire prone land and for bushfire hazard reduction.

6.4.3 Planning for Bushfire Protection Guideline

Broadly, the Planning for Bushfire Protection 2006 (PBP) aims to 'use the NSW development assessment system to provide for the protection of human life (including firefighters) and to minimise impacts on property from the threat of bush fire, while having due regard to development potential, onsite amenity and protection of the environment'.

The current PBP includes a description of the legal framework, bushfire protection measures and performance-based bushfire protection controls.

In April 2017, a draft revised version of the PBP was released for a (now closed) public consultation period. One of the key changes under the draft PBP is the addition of a new chapter on strategic planning, which aims to ensure that bushfire risk is properly considered at the rezoning phase of development.

At the time of writing, the forward release version of PBP 2018 has been released and is anticipated for take statutory effect in 2019. The document articulates the regulatory framework the guideline (which is to be statutory in effect) is to operate within, along with an overview of the relevant bushfire protection measures to be contemplated in the delivery of bushfire-resilient development design. The document provides detailed provisions for various types of development, including new provisions regarding strategic planning (noted above). The final 2018 draft has continued to build upon the strategic planning guidance released as part of the 2017 draft version.

Critically, the 2018 version provides the following:

'Strategic planning should provide for the exclusion of inappropriate development in bush fire prone areas as follows:

- a. when the bush fire risk makes it inappropriate for new development to occur
- b. for development that is likely to be difficult to evacuate during a bush fire when the siting in the landscape, fire history, size and scale of a development is likely to be difficult to evacuate and/or protect during a bush fire.
- c. Some specific locations have significant fire history and are recognised as known fire paths, these areas may require more strategic assessment. Understanding the fire history of an area is important during early planning and may require the provision of more stringent protection measures for development that will adversely affect other bush fire protection strategies or place existing development at increased risk
- d. for development that will adversely affect other bush fire protection strategies or place existing development at increased risk
- e. for development that is within an area of high bush fire risk where density of existing development may cause evacuation issues for both existing and new occupants.
- f. where environmental constraints to the site cannot be overcome' (NSWRFS, 2018).

The 2018 version of PBP further states that in order to address the items above, the preparation of a Strategic Bushfire Study is required. This study is intended to provide 'the opportunity to assess whether new development is appropriate in the bush fire hazard context. It also provides the ability to assess the strategic implications of future development for bush fire mitigation and management (NSWRFS, 2018).

This risk assessment may be considered to constitute a precursor to the preparation of a 'Strategic Bushfire Study' as per Part 4.2 of the final draft of the 2018 Planning for Bushfire Protection guideline, prepared by New South Wales Rural Fire Service (NSWRFS). However the intent of this document does remain somewhat distinct from the above, its overarching intent being to identify and analyse the magnitude of potential risk relevant to the Ingleside Precinct, with respect to both the current and draft Structure Plan contexts. Notwithstanding this, the table below articulates how the elements of PBP 2018 are addressed within this risk assessment report.

Table 2 - PBP Strategic Bushfire Study assessment requirements

PBP Issue	Detail	PBP Assessment Considerations	Risk Assessment Reference
Bush fire landscape assessment	A bush fire landscape study considers the likelihood of a bush fire, its potential severity and intensity and the potential impact on life and property in the context of the broader surrounding landscape.	The bush fire hazard in the surrounding area, including: <ul style="list-style-type: none"> • Vegetation • Topography • Weather • The potential fire behaviour that might be generated based on the above. • Any history of bush fire in the area. • Potential fire runs into the site and the intensity of such fire runs. 	Sections 6, 8 & 9
Land use assessment	The land use assessment will identify the most appropriate locations within the masterplan area or site layout for the proposed land uses.	<ul style="list-style-type: none"> • The risk profile of different areas of the development layout based on the above landscape study. • The proposed land use zones and the resultant permitted land uses. 	Sections 6, 8, 9 & 11

		<ul style="list-style-type: none"> The most appropriate siting of different land uses based on risk profiles within the site i.e. not locating development on ridge tops, SFPP development to be located in lower risk areas of the site. The impact of the siting of these uses on APZ provision. 	
Access and egress	A study of the existing and proposed road networks both within and external to the masterplan area or site layout.	<ul style="list-style-type: none"> The capacity for the existing road network to deal with evacuating residents and responding emergency services, based on the existing community profile. The capacity for the proposed road network to deal with evacuating residents and responding emergency services, based on the existing and proposed community profile. The location of key access routes and direction of travel. The potential for development to be isolated in the event of a bush fire. 	Sections 7, 8, 9, 10, 11 & 12
Emergency services	An assessment of the future impact of new development on emergency services provision.	<ul style="list-style-type: none"> Consideration of the increase in demand for emergency services responding to a bush fire emergency (including the need for new stations/ bridges) Impact on the ability of emergency services to carry out fire suppression in a bush fire emergency. 	Section 9
Infrastructure	An assessment of the issues associated with infrastructure provision.	<ul style="list-style-type: none"> The ability of the reticulated water system to deal with a major bush fire event (particularly in terms of water pressure. Life safety issues associated with fire and proximity to high voltage power lines, natural gas supply lines etc. 	Sections 7 and 9
Adjoining land	The impact of new development on adjoining landowners and their ability to undertake bush fire management.	<ul style="list-style-type: none"> Consideration of the implications of a change in land use on adjoining land including; 	Sections 6, 7, 8, 9 & 10

		<ul style="list-style-type: none"> oThe ability of adjoining and nearby land to carry a bush fire. oConsideration of increased pressure on adjoining landowners to bush fire protection measures through the implementation of Bush Fire Management Plans as a result of the changes in land use. 	
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The 2018 PBP remains one of the key benchmarks against which this risk assessment is evaluated.

6.4.4 Pittwater Local Environmental Plan 2014

The Pittwater Local Environmental Plan 2014 (LEP) is a legislative instrument that makes local planning provisions for land in Pittwater. Amongst other things, clause 1.2 of the LEP says that the plan aims to 'minimise risks to the community in areas subject to environmental hazards'.

The LEP sets out land use zones, types of development (e.g. permitted prohibited, exempt and complying), as well as development standards and release of urban areas. In Part 7, the LEP also has local provisions that specifically deal with issues such as flood, coastal and geotechnical hazards.

The LEP refers to the RF Act in terms of provisions relating to developing bushfire prone land.

6.4.4.1 Pittwater 21 Development Control Plan 2014

The Pittwater 21 Development Control Plan 2014 (DCP) operates in addition to legislative requirements including the LEP. The DCP includes specific provisions for Ingleside and at control A4.6, it is noted that 'the natural features of the locality result in a high risk of bushfire'.

The DCP includes various general controls, including controls about bushfire hazard for land identified on the certified Pittwater LGA bushfire prone land map. The control aims to protect people, the natural environment, infrastructure and assets. It provides that 'all development is to be designed and constructed so as to manage risk due to the effects of bushfire throughout the life of the development' and that 'development of land to which this control applies must comply with the requirements of Planning for Bushfire Protection (2006) (and) Australian Standard AS 3959:2009 - Construction of a building in a bushfire-prone area'.

6.4.4.2 Pittwater bushfire prone land map 2013

The Ingleside Precinct is largely mapped as bushfire prone land. Section 10.3 (previously section 146) of the EP&A Act deals with mapping of bushfire prone land.

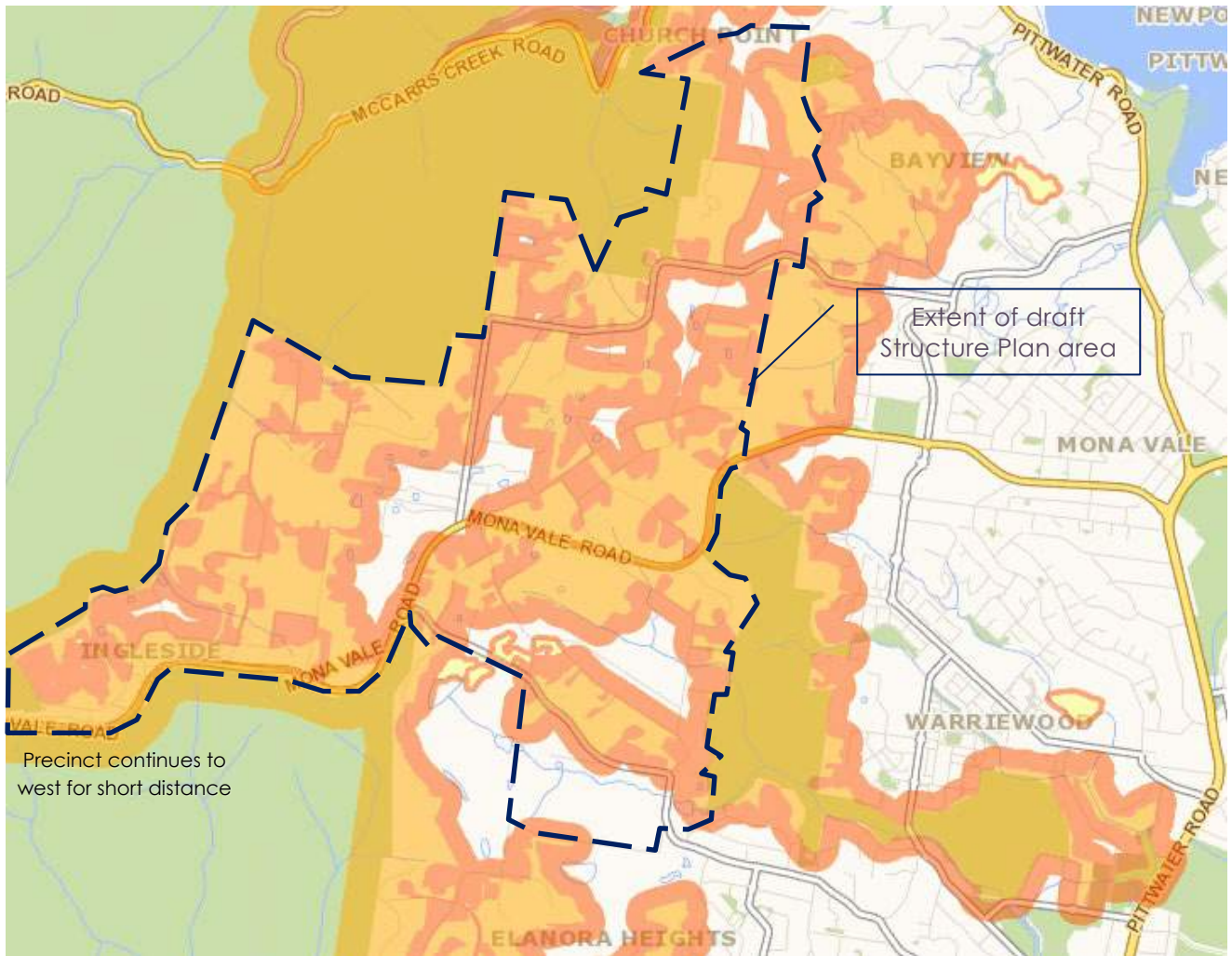


Figure 6 - Pittwater bushfire prone land map 2013 (Northern Beaches Council, 2018)

6.5 International-level guidance material

6.5.1 Sendai Framework for Disaster Risk Reduction

The Sendai Framework is a 15-year, voluntary, non-binding agreement to which Australia is a party, which recognises that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders. It aims for the following outcome:

‘The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries’ (United Nations Office for Disaster Risk Reduction, 2015).

The Framework includes seven global targets which are underpinned by four priorities for action, these include:

Priority 1 – Understanding disaster risk

Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and response.

Priority 2 – Strengthening disaster risk governance to manage disaster risk

Disaster risk governance at the national, regional and global levels is very important for prevention, mitigation, preparedness, response, recovery, and rehabilitation. It fosters collaboration and partnership.

Priority 3 – Investing in disaster risk reduction for resilience

Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.

Priority 4 – Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction

The growth of disaster risk means there is a need to strengthen disaster preparedness for response, take action in anticipation of events, and ensure capacities are in place for effective response and recovery at all levels. The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating disaster risk reduction into development measures (United Nations Office for Disaster Risk Reduction, 2015).

6.6 National-level guidance material

The following section provides an overview of relevant national level strategies and guidelines which are relevant to the consideration of bushfire risk within the Ingleside Precinct.

6.6.1 National Strategy for Disaster Resilience

The NSDR focuses on the shared responsibility of governments, business and communities in preparing for, and responding to, disasters. It recommends that state agencies and municipal councils adopt increased or improved protective, emergency management and advisory roles. In turn, communities, individuals and households need to take greater responsibility for their own safety and to act on advice and other cues given to them.

Other actions include steps to support improved risk-based planning decisions, the take-up of insurance and the provision and construction of resilient infrastructure.

6.6.2 National Land Use Planning Guidelines for Disaster Resilient Communities

Prepared by the Planning Institute of Australia on behalf of the Commonwealth Government Attorney-General's Department, the National Land Use Planning Guidelines for Disaster Resilient Communities were released in 2016 to provide a guide on best practice approaches. Focusing largely on policy and strategic land use planning, the Guidelines provide a toolbox of methodologies for various activities typically associated with land use planning and the integration of natural hazard, risk, climate change and community resilience considerations into everyday planning practice (PIA, 2016).

It incorporates elements such as policy making and strategic (planning scheme) plan making, hazard identification and risk assessment, risk mitigation and community consultation. The Guidelines incorporate risk assessment guidance, centred upon the 'ALARP' principle – ensuring identified risk is mitigated via urban planning processes 'as low as reasonably practicable'. The Guidelines seek to better equip planning (and other) professionals with the knowledge and information required to effectively integrate resilience-based practices into all-manner of land use planning activities, including catchment-based approaches to flood resilience (PIA, 2016).

6.6.3 Australian Disaster Resilience Handbook Collection

6.6.3.1 Handbook 4: Evacuation Planning Handbook

This handbook incorporates guidelines and considerations for developing community evacuation plans underpinned by an all-hazards approach. It uses the nationally recognised five stages of the

evacuation process as a framework for planning an evacuation. This handbook should be used to guide pre-event community evacuation planning, which will in turn maximise the efficiency and effectiveness of any evacuation that may be required. It is recognised that any generic plan will need to be adaptable for accommodating differences in the time, place and circumstance of a specific emergency (AIDR, 2017).

One of the key challenges in community evacuation is the need for shared responsibility. This does not necessarily infer equal responsibility, but it does acknowledge the multi-agency effort involved in safe community evacuation and value of community involvement throughout evacuation planning processes (Teague et al. 2010; AIDR, 2017).

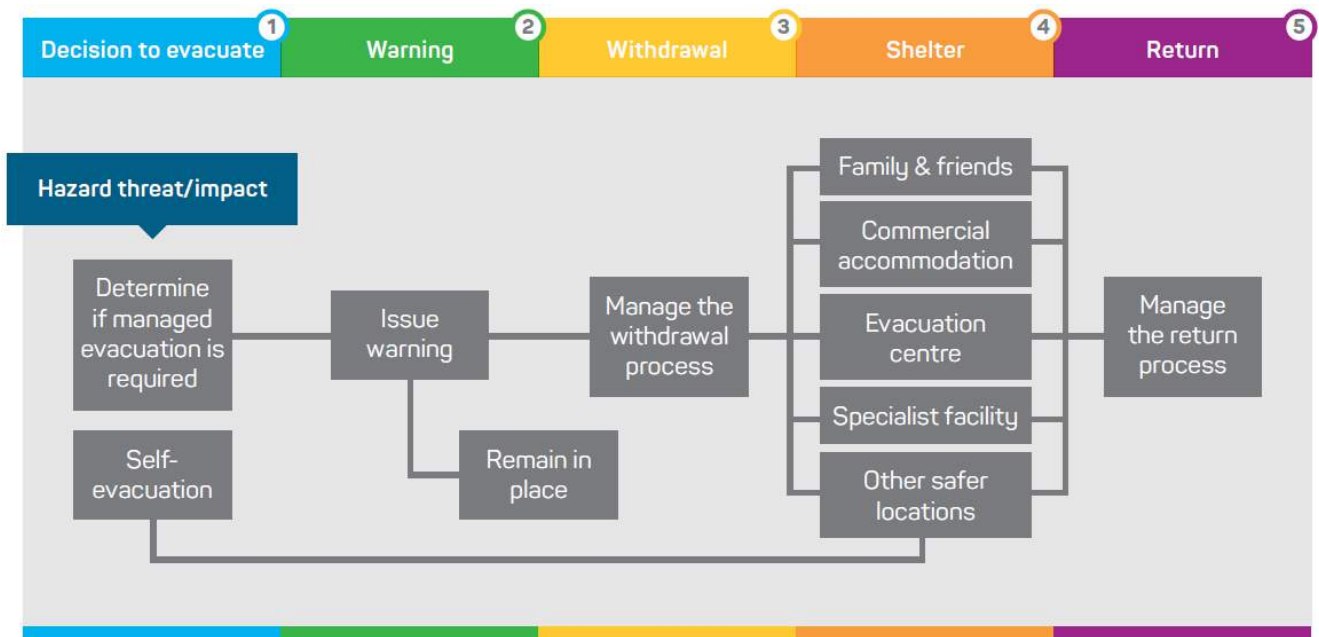


Figure 7 - The fire stage evacuation process (AIDR, 2017)

6.6.3.2 Handbook 10: National Emergency Risk Assessment Guidelines

The National Emergency Risk Assessment Guidelines (NERAG) were published in 2015. NERAG is aimed at improving the quality and comparability of emergency risk assessments and their evidence-base. The handbook is intended to align with the National Strategy for Disaster Resilience.

Section 1.1 of the NERAG states that 'NERAG provides a contextualised, emergency-related risk assessment method consistent with the Australian Standard AS/NZS ISO 31000:2009 Risk management – principles and guidelines'. For example, NERAG aligns with the structure of risk management principles, framework and process described in AS/NZS ISO 31000:2009. It also adopts the same definitions of terms including risk management, risk framework and risk assessment.

NERAG provides a method for risk assessment, focussing on risk assessment in relation to emergency events. The method is consistent with the Australian Standard AS/NZS ISO 31000:2009 Risk management – principles and guidelines. Section 1.2 of the NERAG explains that it reflects AS/NZS ISO 31000:2009, in that it sets out the importance of:

- integrating with an established risk management framework or creating a new one;
- describing the context for the risk assessment, including the risk criteria;
- communicating and consulting both during and after the risk assessment process; and
- treating risks, which involves developing and selecting risk reduction options.

6.7 Bushfire risk and land use planning research

6.7.1 Community Preparedness and Responses to the 2017 New South Wales Bushfires

This research paper has reviewed the reactions of the NSW community when faced with an immediate threat from a bushfire. It has been found that great value is placed upon measures to notify the community of impending bushfire threats and severity, largely via smartphone applications and online warnings. These notification services are found to be easy to understand, accessible and successfully orientated to at-risk communities during an impending bushfire threat. While these measures are appreciated by the community, issues continue to remain with regard to appropriate community response (Whittaker & Taylor, 2018).

The research revealed that even when notified, the at-risk community tends to remain where they are to observe the bushfire for themselves, adopting a 'wait and see' approach. Despite a change in focus on warning messaging since the 2009 Black Saturday fires for catastrophic events, most people still do not intend to leave before there is a fire on such days (Whittaker & Taylor, 2018). This impedes the communities decision-making process in preparation to defend themselves or evacuate even after receiving notification of the bushfire threat. Even after warning, community members continue to seek further verification of the threat from neighbours or other sources. To avoid injury, loss of life and poor preparation, the NSWRFSS has proceeded to explore additional measures to improve community education, risk realisation and notification of impending fire threats on the basis of this recent research (Whittaker & Taylor, 2018).

6.7.2 Planning and Bushfire Risk in a Changing Climate

Planning and bushfire risk in a changing climate examines the role of urban and regional planning in relation to managing bushfire risk in Australia. The research approach has included a significant literature review including the major fire inquiries within Australia, the undertaking of focus groups in four jurisdictions (ACT, NSW, Victoria and NT) and a review of education and training in this field. The research spans a significant part of Australia with focus group discussions in Canberra, the south coast of NSW, the Mornington Peninsula and Darwin (Norman et al. 2014).

The outcome of the research is a deeper understanding on the contribution of urban and regional planning to managing fire risk throughout Australia. Differing perceptions of fire and various planning responses by States and Territories provide a rich policy environment for the emergency management sector to work with. Added to this complexity are expanding urban areas from Darwin to Melbourne and the challenges of continuing urban development in Australian coastal regions that are already experiencing environmental change and predictions of an even hotter environment and an increased potential for fire risk (Norman et al. 2014).

A key finding that emerges is the need for a more integrated approach to planning for fire risk that better connects planners with emergency management and those involved in assessing risk (Norman et al. 2014).

6.7.3 Urban Planning for Natural Hazard Mitigation

The integration of natural hazard risk management into urban planning is faced with a range of fundamental challenges (March, 2018). To identify these challenges and address them, this research undertaken under the auspices of the Bushfire and Natural Hazards Cooperative Research Centre is currently exploring innovative and new means of integrating these two spheres of practice (March, 2018). The research outputs will aim to increase the understanding of the current limitations of planning and emergency management to work coherently and separately (March, 2018). Upon completion, this analysis will potentially assist planning systems to develop new insights into applying the available tools and methods to enable planning styles to design and management the continual change of communities (March, 2018).

6.7.4 Australian Business Roundtable for Disaster Resilience and Safer Communities

In 2017, the Australian Business Roundtable for Disaster Resilience and Safer Communities and Deloitte Access Economics released its latest report 'Building Resilience to Natural Disasters in our States and Territories'. The report identifies State and territory governments are at the forefront of disasters when they occur, alongside local government – and they manage most public infrastructure and deliver the services that are most vulnerable, such as transport and hospitals – and they are responsible for land use planning (Deloitte Access Economics, 2017).

At 2017, the total cost of disasters across NSW was \$3.6bn per year. This is forecast to escalate to \$10.6bn per year by 2015 having regard to direct and indirect tangible costs as well as intangible costs (Deloitte Access Economics, 2017). NSW also receives the second-highest allocation of Commonwealth resilience funding (2013/14 – 2016/17) at \$31m, including \$2.3m from the national bushfire mitigation fund and \$1.5m from the mechanical fuel load reduction trials program (Deloitte Access Economics, 2017). Funding from the national bushfire mitigation fund is matched by the NSW Government.

From a social perspective, bushfire life loss, injury, homelessness and persons affected registers as the second highest type of disaster cause, after heatwave, and higher than flood (Deloitte Access Economics, 2017). However, as at 2017, the economic cost of bushfire equated to only 4 per cent of total disaster-related economic costs in NSW, with 49 per cent relating to severe storm (hail).

The report offers four recommendations, including:

1. Embed resilience across all aspects of policy and decision-making
2. Prioritise resilience investments by considering the broader economic and social benefits that result
3. Improve understanding of disaster risks and costs to society
4. Collaborate and coordinate to build resilience and address the long-term costs of natural disasters (Deloitte Access Economics, 2017).

Mainstreaming resilience into planning, land use and building requirements is identified as a key strategy in embedding resilience in decision-making but noting also that land use planning systems are yet to fully embrace their role in mitigating the risks to loss of life, property damage and destruction of vital infrastructure arising from natural hazards (Deloitte Access Economics, 2017; Harwood et al. 2014). Moving into the future, the report identified three key instruments within the State government toolkit for driving disaster resilience. These include:

1. Governance and policy – a focus on streamlining resilience considerations into governance and policy activities and decision-making
2. Funding and direct investment – investing in the resilience of communities and the networks and infrastructure upon which they rely
3. Collaboration with business and community – working together to build resilience to disaster impacts (Deloitte Access Economics, 2017).

6.7.5 Productivity Commission Inquiry Report into Natural Disaster Funding Arrangements

In 2015, the Productivity Commission released its inquiry report into natural disaster funding, looking at the efficacy of current national natural disaster funding arrangements and having regard to the priority of effective natural disaster mitigation and reduction in impact of disasters on communities (Productivity Commission, 2015). The Black Saturday bushfires in Victoria is Australia's costliest disaster event on record, both in terms of life loss (173) and economic cost (estimated between \$1.4bn and \$4.4bn (Productivity Commission, 2015).

The salient points made by the inquiry report include:

- Australia is exposed to natural disasters on a recurring basis. Effective planning and mitigation of risks is an essential task for governments, businesses and households
- Governments overinvest in post-disaster reconstruction and underinvest in mitigation that would limit the impact of natural disasters in the first place. As such, natural disaster costs have become a growing, unfunded liability for governments
- Regulations affecting the built environment have a significant influence on the exposure and vulnerability of communities to natural hazards. While building regulations have generally been effective, there is a need to transparently incorporate natural disaster risk management into land use planning
- Effective natural disaster risk management in land use planning does not necessarily imply that there should be no development in high-risk areas. Land use planning systems need to be transparent and sufficiently flexible to incorporate community preferences (Productivity Commission, 2015).

As per above, the concept of residual risk consideration and reducing risk to a level that is 'as low as reasonably practical' (the ALARP principle) is identified in order to consider development in higher risk locations, accounting for the balance of competing interests land use planning processes must respond to, only one of which is natural hazard management.

6.7.6 Resilient Sydney – A Strategy for City Resilience 2018

Resilient Sydney is the first resilience strategy for metropolitan Sydney. Developed with the help of the Rockefeller Foundation, it was launched in July 2018. It is a call to action for collaboration and working beyond boundaries. The strategy was developed with the help of 100 organisations with various responsibilities for managing Sydney and is endorsed by the 33 Councils of Sydney. The strategy nominates the fragmented governance arrangements across Sydney as something that needs to be countered through more collaboration, collective leadership and sharing knowledge (City of Sydney, 2018).

It highlights key risks to Sydney's resilience, including the top three risks being heat, severe storm and bushfire. 35 Actions are listed to address acute shocks (such as floods and terrorism) and longer term chronic stresses (such as drought, climate change and lack of access to public transportation) (City of Sydney, 2018).

The strategy promotes a people centred city, where place-based planning considers vulnerability and resilience as a first step when planning for (and with) local communities. It reminds us that place based disaster planning of critical infrastructure is common in other countries, and of the need to look at places through a resilience lens, informed by an understanding of all hazards along with vulnerabilities. Implementation of the strategy will be undertaken by the many partner organisations (City of Sydney, 2018).

6.8 Existing bushfire hazard and risk studies

6.8.1 Warringah Pittwater Bush Fire Risk Management Plan

The Warringah Pittwater Bush Fire Risk Management Plan (BFRMP) was prepared by the Bushfire Management Committee (BFMC) pursuant to Part 3, Division 4 of the RF Act. The draft plan was endorsed by the BFMC in 2010.

The BFRMP identifies bushfire risks (including assets), assesses bushfire risk and discusses risk treatment, including the identification of risk management zones that identify the fire management intent for specified areas. Treatments also include things such as hazard reduction and community education.

In terms of land tenure throughout the BFRMP area (which remains larger in extent than just the Ingleside Precinct, land management responsibility is varied and includes:

Table 3 - Land tenure of the Warringah Pittwater BFRMP Area (Source: NSWRF, 2010)

Land Manager	% of BFRMP Area
National Parks & Wildlife Service	40
Department of Lands	5
Local government	16
Private	35
All other	4

The BFRMP provides that ‘the Warringah Pittwater BFMC area has on average 48 bush fires per year, of which fires occurring every 5 to 7 years on average can be considered to be major fires’. These are largely generated on strong north-westerly winds between October and March, annually.

In correspondence from NSWRF to the (former) Pittwater Council dated 28 October 2014 in response to the initial bushfire constraints analysis conducted for the Ingleside Precinct, NSWRF stated that with regard to the ‘western side of Chiltern Road adjoining the Ku-ring-gai Chase National Park to the west: This area of National Park and Scout association bushland has been identified through the Warringah Pittwater Bush Fire Risk Management Plan as an extreme risk and is a natural fire path that has seen several significant bushfire impacts over the past 30 years. The RFS recommend that this area be zoned from ‘low density’ to ‘rural’ (NSWRF, 2014). This NSWRF commentary (as highlighted previously in this report) made a number of recommendations with regard to the 2014 draft Structure Plan, some of which were reflected by the 2016 (current) draft Structure Plan and other items which do not appear to have been reflected, despite risk evidence established by the BFRMP in 2010.

The BFRMP assigns a level of risk based upon factors of likelihood and consequence (the risk formula), including some uses within Ingleside which attract an ‘extreme’ risk rating based upon a likelihood of ‘almost certain’ and consequence of ‘catastrophic’.

In addition to the above document are additional fire management strategies for the adjoining National Parks, administered by the National Parks and Wildlife Service, and fire management plans for both Ingleside Chase Reserve and Katandra Bushland Sanctuary, administered by Northern Beaches Council which articulate the nature of land and fire management strategies to mitigate risk to existing adjoining communities.

6.8.2 Bayview, Ingleside, Elanora Heights Community Protection Plan

Community Protection Plans (CPPs) are prepared by the NSWRF. Not all parts of the State have a plan (because not all parts need one) however, such a plan is in place for the Bayview, Ingleside, Elanora Heights Community. The CPP is a tool to help the community understand bushfire risk and includes a range of maps. The maps are intended to help the community understand matters such as the level of bushfire threat applicable to their property, survival options before and during fire events, and tips for making properties fire safe.

Refer to **Appendix B** for the Bush Fire Survival Maps for Bayview, Ingleside and Elanora Heights, prepared by NSWRF.

6.8.3 Victorian Bushfires Royal Commission Final Report

The Victorian Bushfires Royal Commission Final Report was released in July 2010, in response to the bushfires of Black Saturday, 7 February 2009. The report made 67 recommendations overall, with 19 that specifically related to planning and building (recommendations 37 to 55). The recommendations generally relate to the Victorian planning framework but the principles could apply otherwise (Teague et al. 2010).

Part 6 of the report provides that ‘protection of human life is the overriding objective in implementing bushfire prevention measures through improved planning and building regulation’. It acknowledges that residential development may not be appropriate in some higher risk locations and it necessary for the planning system to regulate to preclude development identified to pose an unacceptably high bushfire risk (Teague et al. 2010).

The report found that bushfire risk management was not well integrated into the Victorian planning framework and suggested that bushfire risk is increased if allotments are not large enough to create a defensible space around homes. Small lots in higher risk locations create a particular safety risk (Teague et al. 2010).

The report stated that:

'Many of the 173 people who died as a result of the fires had been trying to defend their home, a number of which had been prepared in accordance with CFA advice. These results demonstrate that where people live, the standard of the buildings in which they live, how those standards are maintained and, therefore, planning and building controls are crucial factors affecting safety in a bushfire.

The protection of human life should always be the overriding objective. Although it is not possible to guarantee that any building will survive a bushfire, particularly a ferocious one, the Commission considers that there are some areas where the bushfire risk is so high that development should be restricted' (Teague et al. 2010).

In total, 18 of the 67 recommendations made by the Final Report related to land use planning, citing it as a key aspect in strengthening community bushfire resilience.

6.8.4 Coronial inquiry into the (1994) bushfire at Cottage Point

At approximately 4:30pm on 7 January 1994, a fire originated at Cottage Point to the north-west of Ingleside and continued to burn until 13 January 1994. On the balance of impact that occurred, a Coronial Inquiry was conducted, in part to determine the original cause of ignition which led to the devastation. The exact cause of the fire was not determined by the Inquiry.

Despite firefighting efforts, by 8pm on 7 January, the fire had spread approximately 6.5 kilometres and had advanced to Ingleside. The rate of spread and intensity of the fire was identified to be 'extreme'. The Coronial Inquiry found there was evidence of excessive fuel loadings, mostly occurring on private properties. Even in fuel reduced areas, the fire 'continued with ferocity' which is consistent with contemporary research regarding potential shortcomings in heavy reliance on fuel load management (Hiatt et al. 1995).

In total, the Cottage Point fire destroyed 12,300 hectares of National Park and bushland. Along with many other real and personal property, the fire also destroyed 27 houses and 6 home units. It destroyed or damaged 42 sheds, 13 garages, 44 fences, 33 motor vehicles, 3 caravans, 7 boats and 5 trailers. The total estimated value of property damage (in 1995 dollars) caused by the fire was \$12,115,053 (Hiatt et al. 1995). This property loss estimate does not include the cost for response or full community recovery.

Specific to Ingleside, the fire destroyed at least three dwellings, one mobile home, one shed and one hall. The fire also damaged 12 dwellings/homes as well as other various personal property including fences, sheds, stables, furniture, outdoor equipment and motor vehicles (Hiatt et al. 1995).

Hazard reduction burns had taken place throughout the area, noting a particular burn which had taken place in 1992 in and around Ingleside (as well as other locations), however this effort did not prevent fire from occurring, and at some intensity, in this location. This is consistent with contemporary studies out of the US and within Australia which demonstrate that hazard reduction burning (in and of itself) is not sufficient to prevent fire or its impact in proximity to homes and urban areas, and in some cases does not substantially reduce its intensity (Teague et al. 2010; Kodas, 2017).

The Coronial Inquiry report refers to 'proposed' residential development in Ingleside and acknowledges the 'legitimate' concerns about bushfire risk, particularly in relation to emergency access and the ability to evacuate the area in the event of a bushfire (Hiatt et al. 1995). In detail the Coronial Inquiry report states:

'The Court has considered the submissions and evidence of Messrs. Gash and Kindred in respect of the issues of bushfire risk arising out of the proposed Ingleside housing

development. In summary, the concerns expressed are the new development will place many thousands of people in danger unless proper planning in advance is carried out for their protection. Particular concern was that there will be limited access and exits to the development for transport in times of emergency and restrictions of movement on an already inadequate road system. Along the western side of Chiltern Road houses will be right up against Ku-ring-gai Chase (National Park) causing high bushfire risk for those properties. The effect of the development as the Court understood the submission, was that a huge land bridge of fuel will be placed on a known bushfire path.

Those witnesses were not satisfied that the authorities would take appropriate action to provide safeguards in the development before it was approved and released.

Mr Gash expressed the view that, for example, radiation or buffer zones should be 0.3 of a kilometre wide between such developments and the bushland interface which should rule out any such development in the Warringah-Pittwater Council areas.

In the Courts opinion, having regard to the severity of all bushfires which impacted on residential bushland interfaces throughout the metropolitan area, these witnesses have raised legitimate concerns about this development.

Four important issues have been identified to the Court in respect of future interface developments, namely:

1. Adequate radiation or buffer zones between housing developments and bushland with further adequate fuel reduced areas within the bushland perimeters adjoining the buffer zones.
2. Appropriate access, exit and perimeter roads to and around such new housing estates to accommodate emergency vehicles.
3. Adequate water supply throughout the housing estate with the mains on the outer perimeters positioned so that emergency fire service hoses can be connected without obstructing streets.
4. Houses to comply with the Australian Standard (AS 3959) 'Construction of Buildings in Bushfire Prone Areas'.

Evidence has been led during these proceedings through the Fire Control Officer for Pittwater Municipal Council, William Clarke Sterling Herbison, to the following effect:

- The proposed release of Crown Land is being coordinated by the Pittwater Council and the Department of Planning.
- Authorities are having input into planning issues.
- The planning documents have been referred to the Fire Control Officer by the Pittwater Council for advice.
- The Fire Control staff of Council, the Department of Bush Fire Services and the NSW Fire Brigade will have input into the planning and will carry out a full assessment of the proposal with emphasis very strongly on the fire protection needed in respect of the bushland interface.

These bushfires highlighted the need for positive action to be taken in this regard in the public interest and safety. The Court agrees with the submission of Mr C.W.McEwen of Counsel for the Pittwater Council amongst others, in making the following concession:

Submission P. 36 5.3 – 'with clarity afforded by hindsight, that planning restrictions in developments proximate to natural bushland has not been sufficiently stringent'.

It is not the function of this Court to lay the blame at the feet of Council or Government Departments or the Environmental Court process, however what is needed is uniformity of

practice throughout the state so as to remove conflict and differing interpretation Councils apply in their consideration of developments.

The Court commends to the proper authorities the reasoning of Mr C.W.McEwen in his submission pp.35-44 together with a recommendation in respect of 'Residential Development – the role of Local and State Government'' (Hiatt et al. 1995).

The Coronial Inquiry report found that where new land (Ingleside) is to be considered for further development, it should be done with caution on the basis of limited access and inadequate roads (Hiatt et al. 1995; Macleod, 1996).

The context of development discussed by the Coronial Inquiry is different to that of the current draft Structure Plan however, some similarities appear to exist – particularly with regard to the scale of development proposed (with references made to 'thousands' more residents) and land to the west of Chiltern Road. It is acknowledged that development in these locations was the subject of project group meetings in September 2015 following representations made by NSWRFSS. Land in this location remains identified for low density residential within the current draft Structure Plan.

6.8.5 Emergency management arrangements

The NSW emergency management arrangements include a number of emergency management plans which are in place to guide roles and responsibilities, as well as actions required during an emergency. Following national-level guidance (largely facilitated by the AIDR Handbook Series), is the NSW State Emergency Plan (EMPLAN). Under this document are relevant sub-plans, including the State-wide Bush Fire Plan prepared in 2017 by NSWRFSS.

The State is also divided into discrete emergency management regions, of which the Northern Beaches Council are forms part of the North West Metro region. Regional EM plans are currently being prepared. At the local level is the Local Emergency Management Committee and Local EMPLAN. At this stage, neither the regional or local plans are publicly available.

6.8.5.1 NSW Emergency Risk Management Framework

To more effectively manage emergency risk, the State Emergency Management Committee developed the Emergency Risk Management Framework for NSW and undertook a State Level Emergency Risk Assessment in 2017 (SLERA). The SLERA identified ten top priorities and 24 associated recommendations to mitigate natural disaster impacts and improve the state's approach to emergency management (Office of Emergency Management, 2017a).

The ten top priorities of the SLERA are:

- enhancing land use planning;
- improving data and risk modelling;
- adapting to climate change impacts;
- strengthening local emergency plans;
- boosting infrastructure resilience;
- embedding business continuity planning;
- conducting major training exercises;
- realigning funding to disaster resilience;
- increasing coordinated community engagement; and
- making public warnings consistent (Office of Emergency Management, 2017a).

The associated recommendations will be implemented over the next five years.

The Emergency Risk Management Framework includes 10 outcomes and associated actions, including that: emergency risk management is integrated in to land-use planning, infrastructure strategic planning and asset management (Office of Emergency Management, 2017a).

6.8.5.2 Critical Infrastructure Resilience Strategy

The NSW Critical Infrastructure Resilience Strategy encourages leaders in business and government to support the NSW community by improving critical infrastructure resilience across NSW. It explains that everything is connected, and that critical infrastructure provides secure and reliable essential services such as food, water, energy, transport, telecommunications and health care. These interdependencies mean the urban system is complex and underlines the need to consider the resilience of all infrastructure when planning for new development, as early in the process as possible. A small additional investment in more resilient infrastructure in the planning stage, means decreased interruptions, reduced recovery times, more rapid restoration and commensurate benefits for the community (Office of Emergency Management, 2017b).

6.9 Overview of bushfire attack mechanisms

Bushfires have long remained a fundamental characteristic of the Australian bush landscape, and likewise Australians have long retained a strong affinity with bush environments. There remain a number of common factors which are associated with bushfire hazard and events and these include the incidence of fire weather, availability of fuel along with its type, structure and continuity or fragmentation, and the context of development at the urban / bushland interface.

Bushfire attack refers to the various methods in which bushfire may impact upon life and property and principally encompass:

- direct flame contact
- ember and firebrand attack
- radiant heat flux
- fire-driven wind
- smoke.

In the progression of a bushfire event, these methods interact either exclusively or in concert. It is estimated that approximately 80 to 90 per cent of building lost to bushfire are located within 100m of the bushland interface (CSIRO, 2014), hence the relevance of statutory provisions and recommendations implemented across Australia which respond to various types of buildings within 100m of adjacent classifiable vegetation.

6.9.1 Direct flame contact

Direct flame attack refers to flame contact from the main fire front, where the flame which engulfs burning vegetation is one and the same as that which assumes contact with the building. It is estimated that only 10 to 20 per cent of buildings lost to bushfire occur as a direct result of flame attack (CSIRO, 2014).

6.9.2 Ember and firebrand attack

The convective forces of bushfire raise burning embers into the atmosphere on prevailing winds and deposit them to the ground ahead of the fire front. Typically, ember attack occurs approximately 30 minutes prior to the arrival of the fire front and continues during the impact of the fire front and for several hours afterwards, thus it is the longest lasting impact of bushfire attack. Firebrands occur in a very similar manner but relate to larger items of debris that may still be carried by the wind when alight, such as candle and ribbon barks.

In essence, building loss via ember attack relates largely to the vulnerabilities and peculiarities of each building, its distance from hazardous vegetation and whether an occupant (or the like) is

present to actively defend it. It is estimated by the CSIRO that approximately 80 to 90 per cent of buildings lost by bushfire are lost as a result of ember attack either in isolation or in combination with radiant heat impact.

6.9.3 Radiant heat flux

Exposure to radiant heat remains one of the leading causes of fatalities associated with bushfire events. Measured in kilowatts per m², radiant heat is the heat energy released from the fire front which radiates to the surrounding environment, deteriorating rapidly over distance. In terms of impact on buildings, radiant heat can pre-heat materials making them more susceptible to ignition, or can cause non-piloted ignition of certain materials if the energy transmitted reaches a threshold level. Radiant heat can also damage building materials such as window glazing, allowing openings into a building through which embers may enter. Radiant heat impact is an especially important factor in building-to-building ignition.

In terms of radiant heat exposure for humans, it can cause pain to unprotected skin in milder situations or life threatening and fatal injury in higher exposure thresholds.

Radiant heat flux kW/m ²	Observed effect
1	Maximum for indefinite skin exposure
3	Hazardous conditions, firefighters expected to operate for a short period (10 minutes)
4.7	Extreme conditions, firefighters in protective clothing will feel pain after 60 seconds of exposure
6.4	Pain after 8 seconds of skin exposure
7	Likely to be fatal to unprotected person after exposure for several minutes
10	Critical conditions, firefighters not expected to operate in these conditions although they may be encountered. Considered to be life threatening in less than 60 seconds in protective equipment. Fabrics inside a building could ignite spontaneously with long exposure.
12.5 (BAL-12.5)	Volatiles from wood may be ignited by pilot after prolonged exposure. Standard float glass could fail during the passage of a bushfire.
16	Blistering of skin after 5 seconds
19 (BAL-19)	Screened float glass could fail during the passage of a bushfire.
29 (BAL-29)	Ignition of most timbers without piloted ignition (3 minutes of exposure) during the passage of a bushfire. Toughened glass could fail.
40+	Flame zone – exposure to direct flame contact from fire front.

Figure 8 - The effects of radiant heat (NSWRFS, 2006; Drysdale, 1999; CFA, 2012)

6.9.4 Fire driven wind

The convective forces of bushfire typically result in strong to gale force fire-driven winds which in itself, can lead to building damage. The typical effects of fire driven wind include the conveyance of embers, damage from branches and debris hitting the building, as well as direct damage to vulnerable building components such as lifting roofs or roof materials and the damage / breakage of windows.

6.9.5 Smoke

Smoke emission remains a secondary effect of bushfire and is one which is typically not addressed by bushfire assessments. Irrespective, it is important to note the potentially severe impact of smoke emission on the human respiratory system. It can lead to difficulties in breathing, severe coughing, blurred or otherwise compromised vision, and can prove fatal. It is also important to note that toxic

smoke can occur during bushfire, particularly where buildings or materials are ignited. With regard to evacuation, it can reduce visibility and create difficulties for particularly vulnerable persons.

6.10 Ingleside Bushfire Hazard Context

The Bushfire Protection Assessment prepared by ELA in 2016 includes a detailed analysis of the bushfire hazard context relevant to the Ingleside Precinct. In addition to this and as part of this risk assessment process, ELA has conducted bushfire behaviour modelling relevant to a number of fire weather scenarios for both the existing (in-situ) Ingleside Precinct as well as the proposed (draft Structure Plan) scenario. On the basis of this work and its level of rigour, the hazard extent findings established by the Bushfire Protection Assessment as well as the bushfire behaviour modelling prepared by ELA is adopted for the purposes of this risk assessment, and outlined below.

Figure 9 below sets out the nature of the sub-precincts which are considered throughout the balance of this risk assessment. These sub-precincts include:

- Wirreanda Valley
- Bayview Heights
- North Ingleside
- South Ingleside.

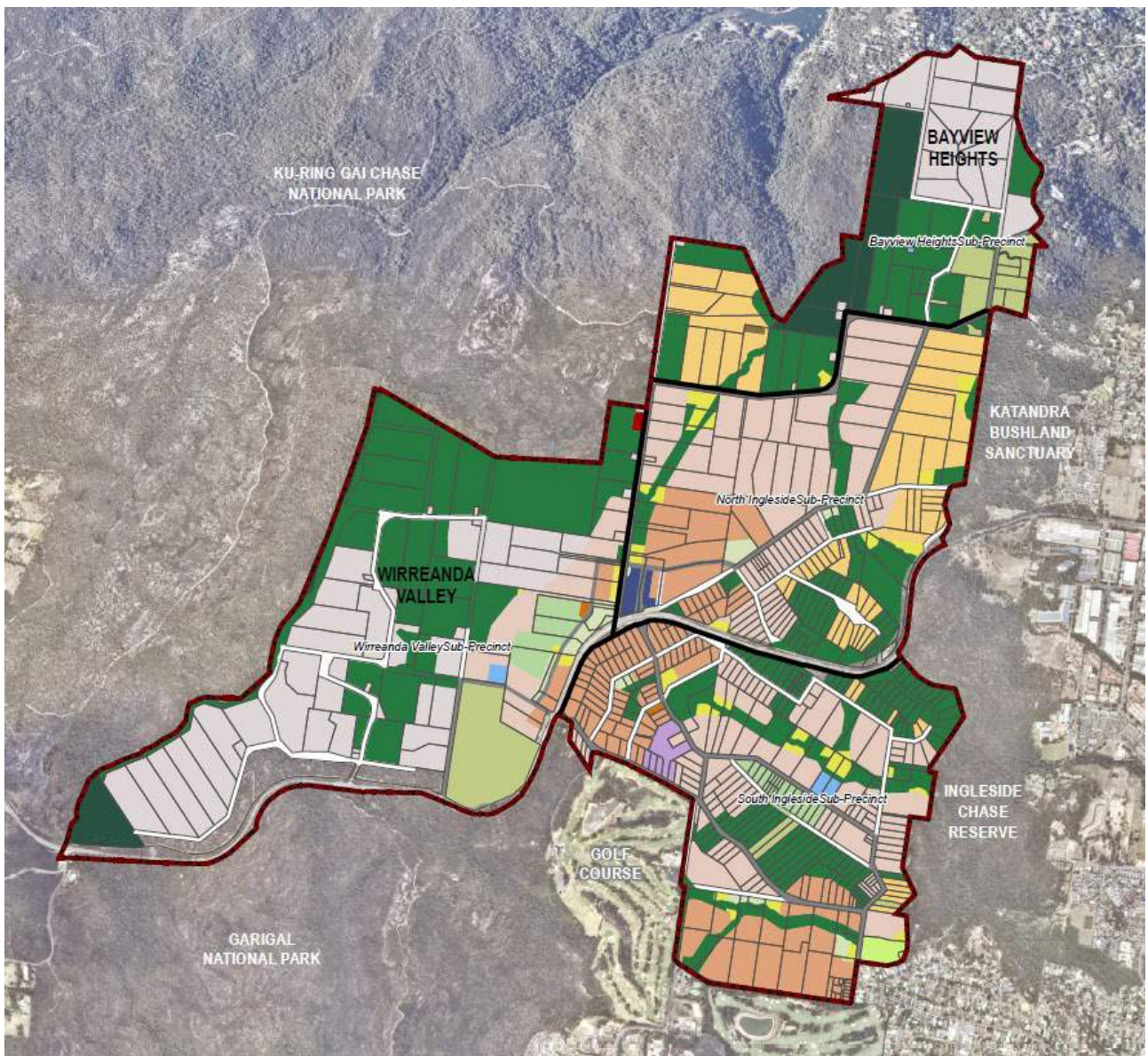


Figure 9 - Ingleside sub-precincts map

6.10.1 Fire weather

It remains important to understand the influence of fire weather with regard to how it can affect bushfire risk levels on a daily, weekly or seasonal basis.

In most parts of NSW, hot-air fire wind is typically generated by north to north-westerlies and cool-air fire wind is generated by south-westerlies which are prevalent during the State's annual fire season which extends from October to March but varies year-on-year due to macro-climatic conditions. Spring is typically the high season in the Greater Sydney area.

Notwithstanding the above, it is noted bushfires do not always conform to widely-accepted characteristics. Other fire weather conditions must also be contemplated such as preceding weather conditions (such as low rainfall or drought), air temperature and relative humidity. If the area has been subject to drought or low rainfall for a period of time, vegetation health tends to deteriorate with increased leaf drop, curing and drying. This contributes to increased ground fuel loads and general ignition susceptibility. Prolonged dry periods also reduce soil moisture content.

Air temperatures of above 30 degrees Celsius are typically conducive to more severe fire weather, as are extended periods of higher than average air temperatures. In conjunction, low relative humidity (i.e. low air moisture content) is also a contributing factor to increased fire weather.

In concert, all of the above factors can impact on the ability for fire to propagate, and alter behaviour and intensity characteristics and as such, fire weather is a significant component of bushfire hazard. Whilst an assessment of vegetation types, fuel loads, effective slope and other factors can be readily undertaken, fire weather can fluctuate across days, weeks and seasons and can have a significant impact on the potential for bushfire threat as well as influence bushfire behaviour and intensity.

The Forest Fire Danger Index (FFDI) is a commonly used method to readily advise the community of the likely ability of fire suppression based on fire weather, which is used to inform the Fire Danger Rating (FDR) System which guides the communication of bushfire warnings across Australia at **Figure 10**.

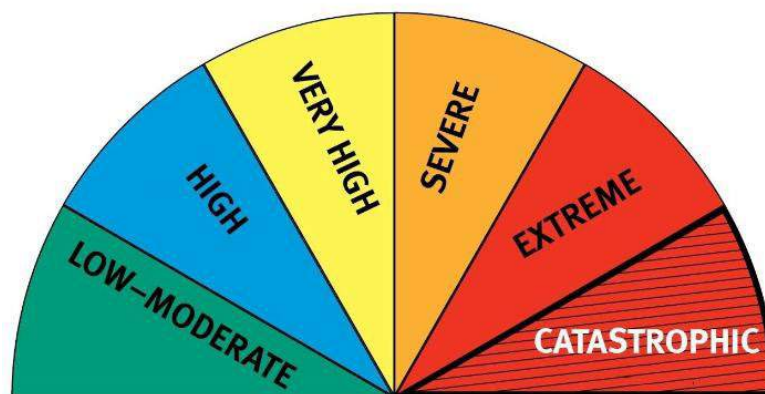


Figure 10 - Fire danger warning ratings

In Greater Sydney, a FFDI of 100 is adopted for both land use planning and building construction purposes. This recognises that, on occasion fire weather across this area reaches (and may exceed) Catastrophic FDR level. NSWRFSS states that during Catastrophic fire weather, leaving early is the only option for survival and homes are not designed to withstand fires in Catastrophic conditions. The highest FFDI recorded over the past 40 years at the Sydney Airport weather station is 116.

A detailed analysis of fire weather history and annual exceedance probabilities (AEP) is provided at the 'Risk Identification' section of this report and constitutes the fire weather which adopted for the purposes of this risk assessment.

6.10.2 Vegetation communities

Fuel load and arrangement represents a considerable component in dictating to a large degree the behaviour of fire in terms of intensity, rate of spread and flame height, and typically relates to dead plant material less than 6mm thick, and live plant material thinner than 3mm. On this basis, it stands to reason that different vegetation groups yield very different fire behaviour and intensity by virtue of their characteristics and fuel load output. The characteristics are not necessarily related to ecological values, but remain a function of the propensity for certain groups of vegetation to ignite and sustain fire due to fuel load and arrangement, it can guide estimates on how quickly fire might spread and the likely fire behaviour and intensity which may occur.

Vegetation type, density and arrangement can further influence fire behaviour and intensity. Vertical and horizontal continuity is also a significant element. Thus, vegetation forms a critical element of analysis throughout this report.

A Bushfire Intensity Modelling Report has been prepared by ELA as an input to this risk assessment process, dated April 2018 and included at **Appendix C**. This is in addition to previous assessments which also had regard to vegetation communities however, the 2018 report analysed these communities within 5 kilometres around the Precinct as opposed to previous reporting which was more constrained in scope.

The methodology adopted is set out in ELA's report included at **Appendix C** however, the current vegetation formation / fuel classification (and resultant fuel loads) are illustrated at **Figure 11**, over page.

Figure 11 demonstrates the bulk of the fuels relevant to bushfire hazard surrounding the Ingleside Precinct comprise:

- Sydney coastal dry sclerophyll Forests (approximate fuel load of 27.3t/ha); and
- Sydney coastal heaths (approximate fuel load of 36.9t/ha).

Small pockets of other vegetation communities are also present. Within the Precinct, the bulk of remnant vegetation in Ingleside is classified as 'low hazard/other' by ELA with an associated approximate fuel load of 13.2t/ha as well as pockets of North Coast wet sclerophyll forests with a corresponding approximate fuel load of 35.9t/ha in accordance with Keith Formations and Keith Class as required by the draft PBP 2017. Thus internal to the Precinct, vegetation communities comprise a mix of largely wet and dry sclerophyll forests and tall heath with concentrations of such vegetation currently occurring in Wirreanda Valley and between North Ingleside and Bayview Heights.

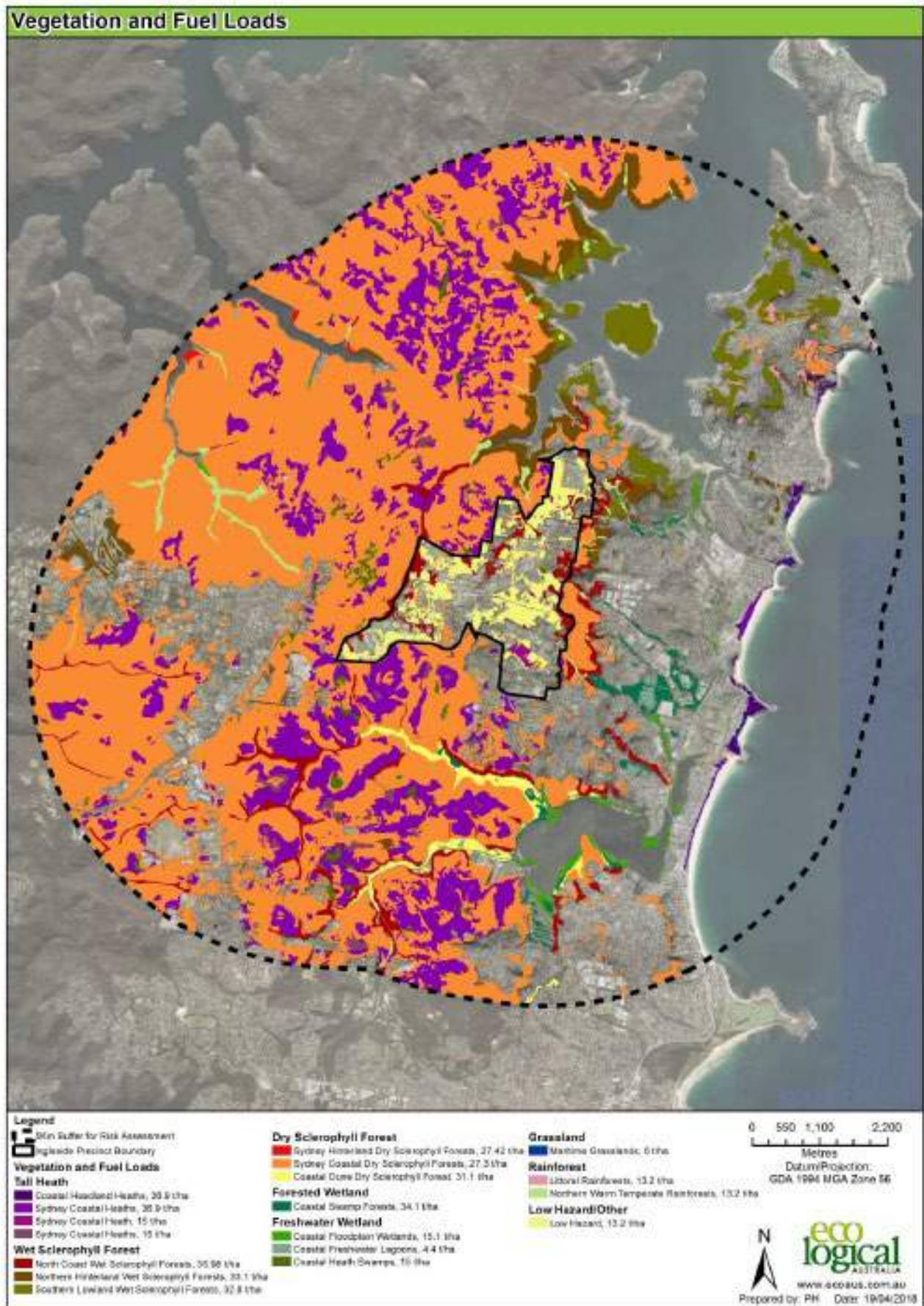


Figure 11 - Current vegetation formation/fuel classification of the study area (Source: ELA, 2018)

6.10.3 Topography

Topography (effective slope) and to a lesser degree, aspect, are also factors which influence fire behaviour and intensity. Topography can have a drastic affect, with the rate of speed doubling for every 10 degrees of upslope and slowing by half for every 10 degrees of downslope, as a general rule. Aspect can also effect bushfire behaviour where areas with northerly and / or westerly aspects experience a higher level of solar access than those areas with a southern or eastern aspect. Notwithstanding, in times of drought and below average rainfall moisture levels in soil and vegetation in more sheltered areas with southerly and easterly aspects can also decrease substantially giving rise to significantly higher fuel abundance where the preceding fire regime has been less frequent or intense.

The contribution of terrain in terms of its influence of fire behaviour is characterised in detail below with regard to the identification of key fire runs relevant to the Ingleside Precinct. Generally, the Ingleside Precinct is located within a landscape comprising areas of complex terrain which is likely to result in varied fire behaviour based upon localised terrain, fuel and wind conditions.

Figures 12 and 13 demonstrate the complexity of terrain within and around the Precinct, to an outer extent of 5 kilometres. **Figure 12** in particular is further contextualised by commentary at Section 6.10.5 in relation to key fire runs.

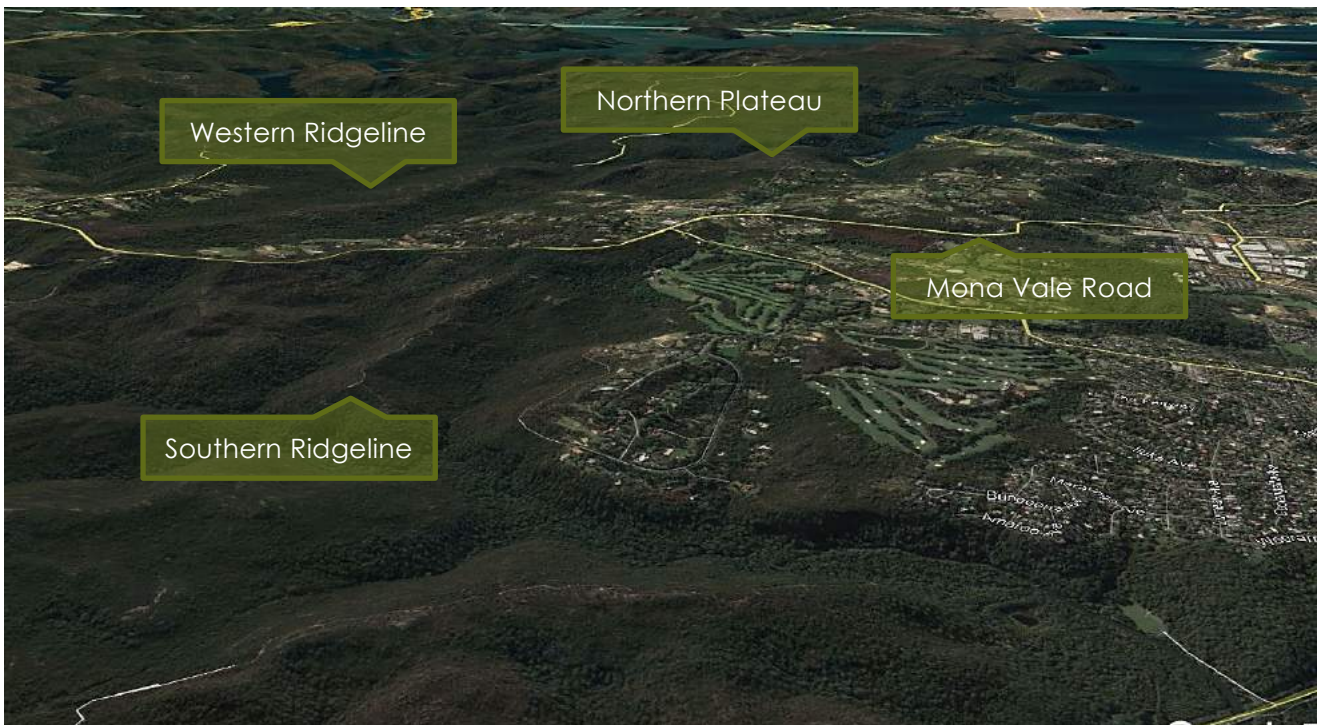


Figure 12 - Indicative terrain imagery of the Ingleside Precinct and surrounds viewed from a southerly direction (Source: Google Earth Pro, 2018)

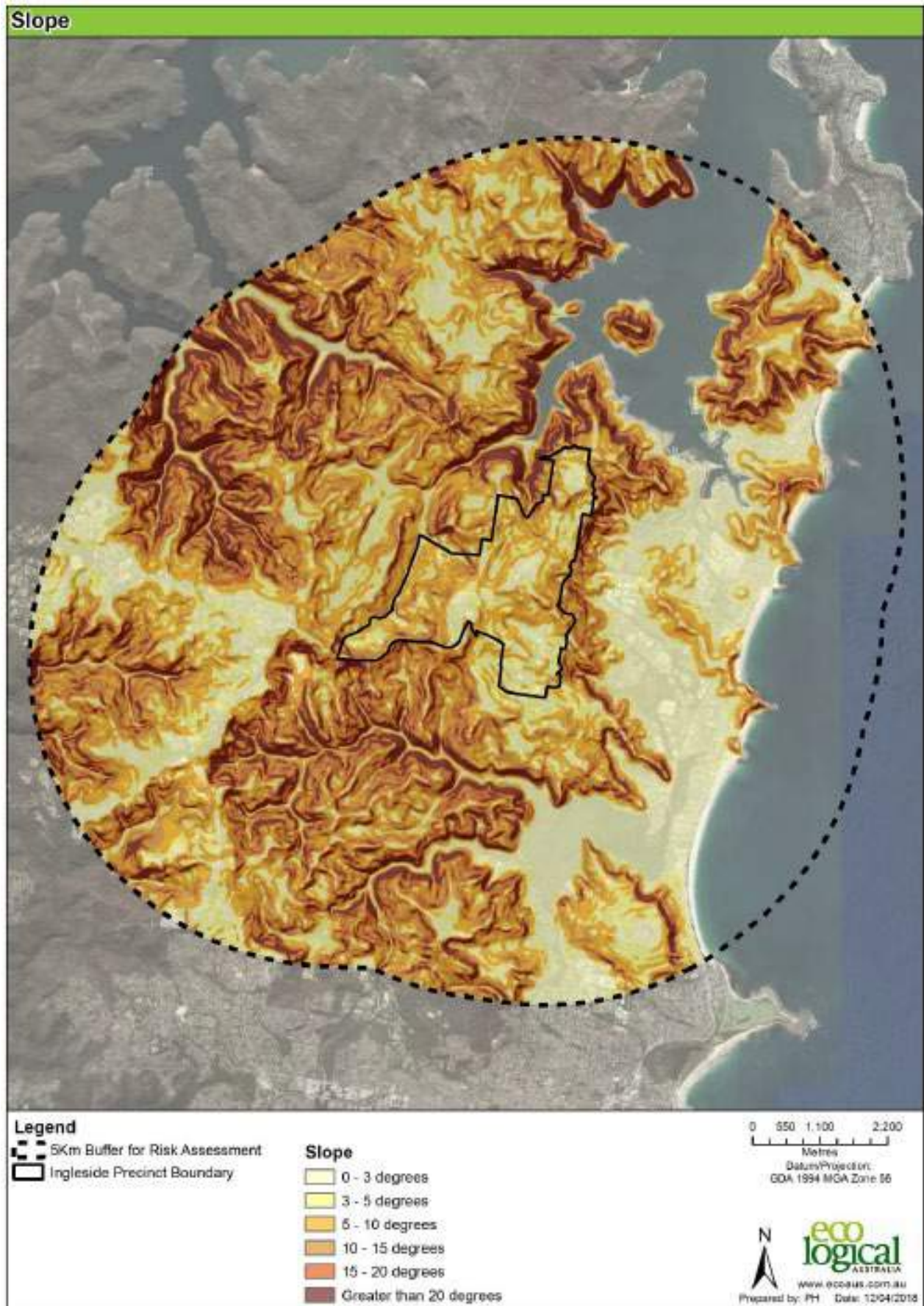


Figure 13 - Slope assessment across the study area (Source: ELA, 2018)

6.10.4 Landscape and localised fire hazard

Two types of hazard are relevant in terms of bushfire hazard including:

- landscape hazard – where large expanses of bushland over tens to hundreds of hectares are located in immediate proximity to, and may traverse, urban periphery suburbs/townships
- localised hazard – which is most commonly presented by fragmented areas of vegetation larger than 1 hectare in size.

These two types of hazard present different types of fire behaviour, fire intensity and potential rate of spread characteristics.

The Ingleside Precinct is exposed to both landscape-level and localised bushfire hazard. For the purposes of this strategic risk assessment, the primary focus remains on landscape level hazard and risk, but noting that localised fragmentation of vegetation can contribute to a 'landscape of fire' in extreme and catastrophic events given the extent of spotting that may occur.

The concept of landscape fire behaviour is considered further in the following section regarding the key fire runs relevant to the Ingleside Precinct.

6.10.5 Key fire runs

The 2018 PBP identifies the need to understand the key potential fire runs to the area or site in question, as well as the potential intensity of those runs. From a contextual perspective, these key fire runs are identified below. The bushfire intensity modelling included at **Appendix C** is considered in more detail later in this report.

6.10.5.1 Wirreanda Valley

Mona Vale Road from the west navigates around the southern extent of a ridgeline which frames the north-western side of Wirreanda Valley, which from a bushfire behaviour perspective – an ignition within Ku-ring-gai Chase National Park on a westerly or north-westerly fire wind is likely to drive an intense fire front up the western side of this slope to the ridgeline before moving down the south-western leeward side of slope. Whilst intensity and speed may reduce as the front moves down the slope, issues around limited situational awareness may arise (residents may not appreciate how close a fire is until it mounts the ridgeline) with limited time to evacuate at that point. In the event of fire front transition through this sub-precinct on a westerly or north-westerly fire wind, it is likely to increase in intensity upon its immediate run toward the North Ingleside sub-precinct, with topography rising in elevation to the west of Chiltern Road.

Ember attack in a fire of reasonable-significant intensity may concentrate within the Valley area with considerable spot fire potential given the extent of existing fuels which remain in-situ across Wirreanda Valley, and wind anomalies borne from highly localised terrain conditions coupled with prevailing wind dynamics on the day may occur but are difficult to predict. This includes behaviour such as localised whirling fire winds and lateral vortices (alternatively known as lee-slope channelling or fire channelling) where fire spreads laterally across a leeward slope in a direction that is approximately transverse to the background wind, in addition to the usual downwind direction (Simpson et al. 2014). This is a particular issue where fire advancement occurs in the opposite manner to which one might typically expect, catching residents potentially off-guard.

To the immediate north of Wirreanda Valley, the topography rises to a plateau (of sorts) before falling steeply to Mccarrs Creek. For Wirreanda Valley, the topographical context of its surrounds means that it is perched upon a 'terrace', noting Garigal National Park to the south falls away from Mona Vale Road. The terrain within the national park is steeply undulating with a ridgeline oriented north-south, immediately south of Wirreanda Valley. Thus, a fire front advancing upon a south or south-westerly wind is likely to increase in general intensity upon the upslope run toward Wirreanda Valley. This also presents a potential risk to Mona Vale Road.

6.10.5.2 North Ingleside and Bayview Heights

To the north-west of North Ingleside and Bayview Heights, the ridgeline which frames the western extent of Wirreanda Valley transitions to a deeply incised channel. East of Chiltern Road, the terrain could be described as more undulating but does present steep localised rises and dips. North Ingleside rises considerably from Mona Vale Road, and continues to rise in elevation toward Bayview Heights. A creek channel is located between Bayview Heights and Chiltern Road which becomes quite steep north of Cicada Glen Road. A fire front or spot fire ignition in this general location would likely grow in intensity upon a westerly or north-westerly fire wind on its run toward Bayview Heights and Cicada Glen Road. To a lesser extent, fire may advance toward Bayview Heights from the east or south-east through the Katandra Bushland Sanctuary.

6.10.5.3 South Ingleside

South Ingleside is bound to the north by Mona Vale Road, to the south by Elanora Country Club and Golf Course, Ingleside Road and Ingleside Chase Reserve to the east and Monash Country Club and Golf Course to the west. A small area of Garigal National Park forms a 'wedge' between Mona Vale Road, Powder Works Road and the Monash Country Club and Golf Course.

South Ingleside falls away from Mona Vale Road and includes several substantial pockets of remnant vegetation. The key fire runs relevant to South Ingleside include south-westerly and westerly driven fire fronts from ignitions in Ku-ring-gai Chase National Park and Garigal National Park, on a southerly fire wind driven through Garigal National Park and to a lesser extent, on a south-easterly or easterly fire wind through Ingleside Chase National Park or on a north-easterly through the Katandra Bushland Sanctuary. Unlike the other areas of the Ingleside Precinct, South Ingleside appears to be more sheltered/protected from significant landscape fire risk, but noting the risk still remains.

External to the Precinct to the immediate south-west lies the pocket community comprising Caladenia Close and Dendrobium Crescent, the residents of which form the Garigal Deep Creek Residents Association and which made a submission regarding fire risk to DPE in 2017. This area is clearly identifiable at the centre of **Figure 12** above, surrounded by bushland to the south-west of the two golf courses. This community is located atop a plateau area where any fire run from the north-west, west, south-west, south or south-east would likely increase in intensity upon the upslope run toward these homes. This is likely a key factor which led to the loss of many of the homes in this location in the 1994 Cottage Point fire.

Whilst this area remains outside of the Precinct at present, this risk assessment has regard to the existing risk profile of this community given its only evacuation route is via South Ingleside.

Figure 14 below illustrates the fireline intensity (discussed later) at FFDI 100 relevant to the Precinct as it currently exists which demonstrates the orientation of key fire runs surrounding the site. This figure and the balance of the bushfire intensity modelling performed by ELA for the express purpose of this risk assessment is discussed later in this report.

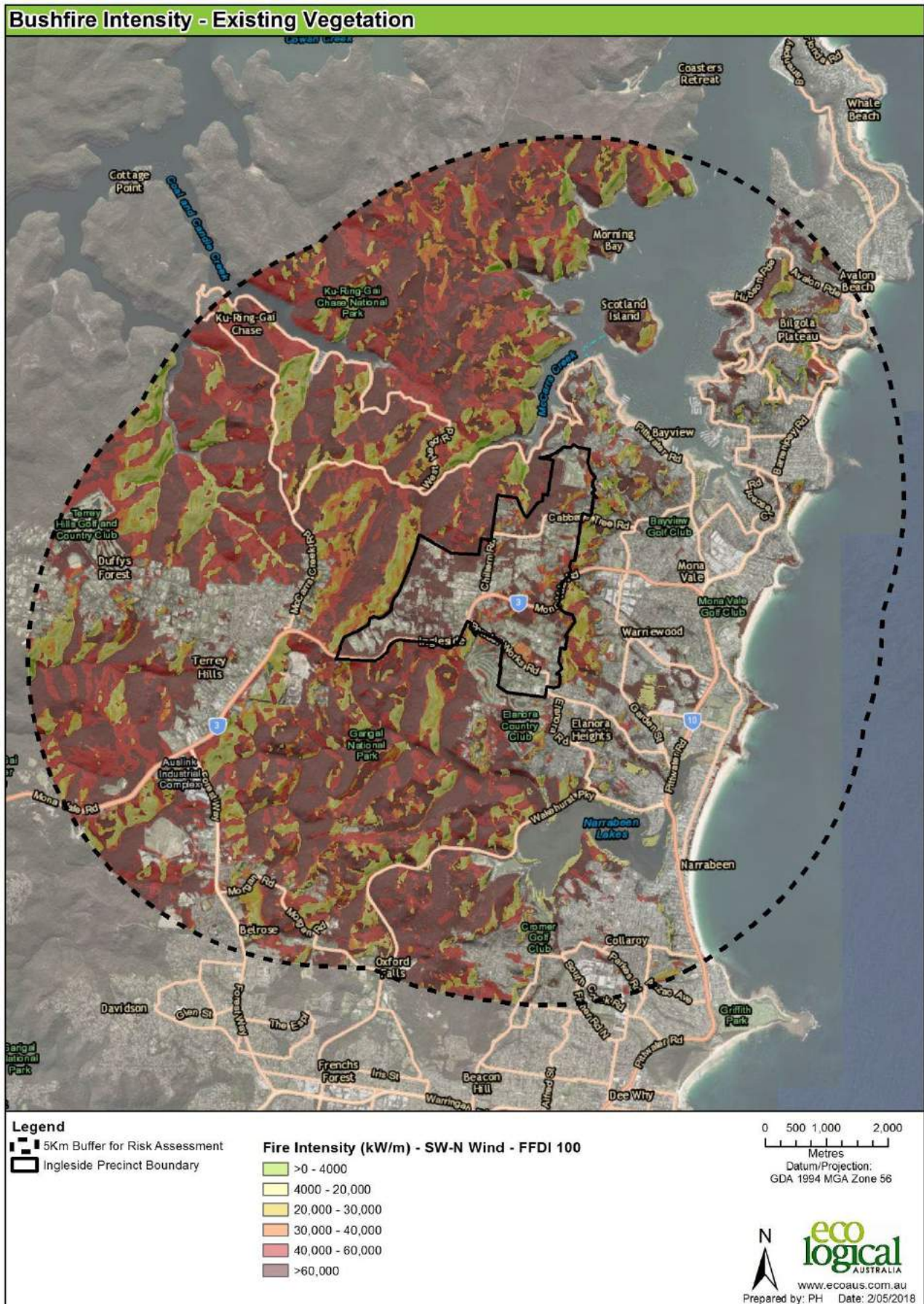


Figure 14 - Potential bushfire intensity – FFDI on a SW-N fire wind scenario (Source: ELA, 2018)

6.11 Summary of key risk context narratives

6.11.1 Risk-based land use planning

As noted, this risk assessment adopts a risk-based land use planning lens. Before the question of whether the design and site-based provisions of PBP can be implemented, is first the question of whether Ingleside is an appropriate landscape for potential further population and development having particular regard to bushfire risk. Given the extent of fire intrusion which occurred in the 1994 event which encompassed almost the entirety of the Ingleside Precinct, the question as to the acceptability of further growth and / or extent thereof, must be first explored.

The background evidence presented by this risk assessment report contextualises the nature of the instruments, programs and processes which each contribute to the pursuit of the establishment of community bushfire risk resilience. Risk-based land use planning remains one of the key opportunities to embed resilience into decision-making processes, as presented by the National Land Use Planning Guidelines for Disaster Resilient Communities (PIA, 2016). As per the National Strategy for Disaster Resilience and Productivity Commission Report into Natural Disaster Funding, land use planning is perhaps the most potent policy lever in addressing potential future disaster risk. This being the case, a risk-based land use planning lens approach allows for the consideration of bushfire risk to be embedded within decision-making processes, allowing decisions to incorporate consideration of an evidenced-based picture of both current and future potential bushfire risk.

The Coronial Inquiry which released its report in 1995 articulated the need for careful and strategic land use planning given the significance of the event which occurred in 1994 and the apparent propensity of future risk exposure in Ingleside. This has been echoed by the Garigal Deep Creek Residents Association formed by local residents to the south of the Precinct but whom were severely impacted by the 1994 event and hold concerns regarding the proposed density of the Ingleside Precinct, and that to the south of Mona Vale Road in particular.

In relation to land use planning approaches to bushfire risk reduction, there remain two key elements:

1. Strategic planning processes – establishing whether a land use action **should** occur; and
2. Statutory planning (development assessment) processes – establishing **how** a land use action can occur.

On the basis of the above, it is necessary to understand that often, statutory planning provisions (such as bushfire protection measures, etc.) relate to how a land use activity might occur. Thus, the same instrument is unable to be appropriately applied to query whether an activity should in fact occur. Herein lies the value of strategic risk-based land use planning processes, ensuring that the first question of whether a land use action 'should' occur is addressed to determine appropriateness or otherwise having regard to the risk profile, before any consideration of 'how' development may occur, where development may be possible.

The application of risk-based land use planning considerations in the development of the draft Structure Plan for the Ingleside Precinct to date appears to be questionable. Both the NSWRFs and the Coronial Inquiry raised particular issues with a portion of land to the west of Chiltern Road and another to the north of Cicada Glen Road, identified as subject to potential low density residential under the draft Structure Plan. Both the NSWRFs and the Coronial Inquiry report identify these areas as largely inappropriate to accommodate further residential development given the extent of bushfire risk, however these areas remain within the draft Structure Plan and poised for potential low density residential development.

Moreover, the Coronial Inquiry found that if further development in Ingleside were to be developed, it should be done so with caution due to limited access and inadequate roads (Hiatt et al. 1995; Macleod, 1996).

Having regard to the above, the adoption of risk-based land use planning approaches to the consideration of bushfire risk in Ingleside, in relation to both existing and future risk, is justifiably a key narrative of this risk assessment.

6.11.2 Relevance of fire history

The relevance of fire history, as noted in the 2018 PBP, is an important factor in determining the suitability or scope of potential development within an area. A key indicator of future risk is the nature of past events. Noting this however, it is equally as important to contemplate and understand the difference in settlement contexts and bushfire protection contexts that exist now, compared with that which may have existed during previous fire events.

The following is to be considered in conjunction with the Coronial Inquiry summary provided above at Section 6.7.4 of this risk assessment report in framing the context of bushfire history relevant to Ingleside.

6.11.2.1 Ingleside fire history

Over recorded history, the area has endured a number of fire events of relatively regular frequency. Across the broader Northern Beaches, fire events have been recorded as far back as the 1890's, with events occurring in 1918, 1928, 1939, a particularly intense run of multiple events between the years of 1942 and 1957, 1967, 1971 and 1972 (Macleod, 1996). On 16 December 1979 a state of emergency was declared as a fire front extending 12 kilometres in width burned through the areas of Terrey Hills, Ingleside, Duffys Forest, Mona Vale, Elanora Heights, Cromer and Forestville, claiming over 100ha of bushland and six homes over a three day period (Macleod, 1996). Again, the context of settlement is appropriate to consider, noting the area was not developed to the extent that it is today.

In early January 1994, fire weather conditions developed as a result of little summer rainfall, high temperatures (37-38 degrees Celsius), low relative humidity (as low as 20 per cent) with a gusting north-westerly wind (Macleod, 1996). As noted at Section 6.7.4 above, an ignition occurred at Cottage Point, a small settlement on the edge of Cowan Creek and nestled deep within Ku-ring-gai Chase National Park, in the late afternoon of 7 January 1994. The cause of the ignition could not be determined, however the fire burnt in a south-easterly direction, driven on a hot, dry north-westerly fire wind. On the first day, Cottage Point was isolated almost immediately and had spread 6.5 kilometres in three and a half hours, reaching the area of Bayview a short time later (Macleod, 1996). The following day, the fire expanded substantially and it is on this day the fire transitioned across almost the entirety of Ingleside and into Bayview, Warriewood, Elanora Heights and Terrey Hills. This included the transition of the fire front across existing golf courses to the south of Ingleside which are typically low fuel environments. Over the next two days, the fire continued to advance through to Oxford Falls and burning out the Garigal National Park (Macleod, 1996).

No life was lost in the Warringah Pittwater fires, however more broadly across NSW that day four people lost their lives as multiple fires impacted various communities. In total, the Cottage Point fire burned through 231ha in Warringah Pittwater. 27 houses and two units were destroyed along with damage to a further 60 houses and four units along with a host of other items such as caravans, trailers, boats, garages, machines, etc. (Macleod, 1996; Hiatt et al. 1995).

Specific to Ingleside, the fire destroyed at least three dwellings, one mobile home, one shed and one hall. The fire also damaged 12 dwellings/homes as well as other various personal property including fences, sheds, stables, furniture, outdoor equipment and motor vehicles (Hiatt et al. 1995).

On 8 January, resident reports with respect to rate of spread, intensity and fire behaviour indicate the fire moved through Ingleside quickly and with a level of intensity. One Ingleside resident described the speed of the fire as a 'roaring wall of flame' which enveloped the area rapidly whilst Police were attempting to evacuate Ingleside (Macleod, 1996). That resident went on to explain that the fire approached their property with a level of ferocity and speed that meant that by the time the Police arrived to advise them to evacuate, the opportunity to do so had already passed. That resident resorted to shelter-in-place, including the Police who took shelter within the same

home (Macleod, 1996). This is re-affirmed by statements contained within the Coronial Inquiry report which found that:

‘The spotting potential was high having regard to the strong influence of the north-westerly winds and spotting was actually occurring. This led to losses being suffered in residential areas as well as isolated areas of bushland. Even in fuel reduced areas, the fire continued with ferocity, the only appreciable diminishment noticed in those hazard reduced areas being during milder weather conditions’ (Hiatt et al. 1995).

This statement made by the Coronial Inquiry remains a salient observation with regard to urban residential property loss and the somewhat limited effect that prescribed burning can have at the more extreme end of the fire weather conditions spectrum, aligning with contemporary domestic and international fire loss research.

Taking the above into consideration and having regard to the both the frequency and intensity of fire events which have occurred both in the immediate and wider Warringah Pittwater area, historic event evidence exists which establishes Ingleside as a bushfire prone area within a known ‘fire path’ which is subject to potential ‘extreme’ or ‘catastrophic’ events.

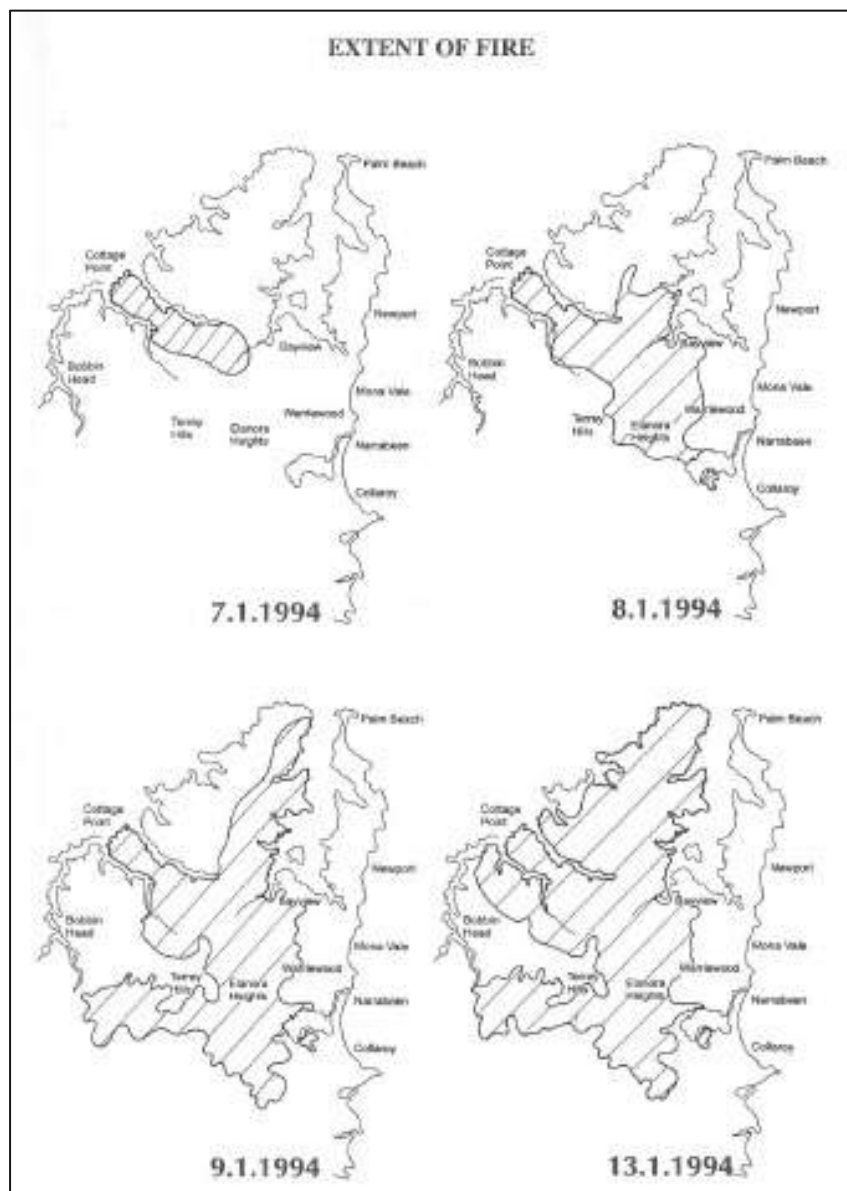


Figure 15 - Illustration of fire extent 7-13 January, 1994 (Source: Macleod, 1996)

6.11.2.2 'Burnt Out? Experiences of the January 1994 Bush Fires in Warringah and Pittwater'

In 1996 a local historian, Virginia Macleod, released a book by the above title, a compendium of local accounts and contextual information about the history of bushfire in the Warringah Pittwater area, as well as the event which prevailed in early January 1994.

Beyond mere fire history, the book provides additional detail regarding various aspects of the 1994 event which is worthy of consideration with respect to firefighting and water supply, communications, animals (particularly relevant given the semi-rural and considerable equine industry which currently exists in the area), community evacuation and environmental impact.

With regard to the immediate emergency response, Macleod (1996) states the response effort from 58 local fire units was assisted by other NSW fire brigades, ACT Urban and Rural fire brigades, National Parks and Wildlife Services and the Army however, these efforts were hampered by poor reticulated water pressure under extreme demand and the volume of water being drawn from the network, reducing pressure to a 'dribble', according to residents' reports. Water supply matters were not a topic of consideration within the Coronial Inquiry however, that is not to say that evidence submitted did not raise it. Irrespective, it did not appear to warrant specific investigation as part of that process.

The research conducted by Macleod (1996) indicated issues with communications prevailed during the fire event. Whilst telephone communications (land-line based) remained in-tact, radio contact between brigades, and between brigades and headquarters could not be maintained (Macleod, 1996). This is further established by the Coronial Inquiry report which states that 'communication, according to the evidence, was one of the major problems faced by all services involved' (Hiatt et al. 1995). Notwithstanding this, this appeared to be a matter of emergency response planning rather than any specific issue relating to the capacity, performance or failure of physical telecommunications infrastructure. However, it is worthwhile noting the significant change in communications processes and procedures as well as hard infrastructure which has evolved since 1994, including a much stronger reliance on internet and mobile phone coverage, both of which are sensitive to electricity shortages and outages.

The primary messages conveyed via Macleod (1996) is that whilst evacuation was not mandated by emergency services, many people recognised the value in being prepared to evacuate – though many adopted a 'wait and see' approach which led to instances of last minute attempts to evacuate. On 8 January, Police did intervene to alert residents to evacuate however, reports state that a number of residents were reluctant to do so or did not see the need (Macleod, 1996). Of those that did, some did not appear to know where to evacuate to or experienced difficulty in traversing emergency services road blocks that had been set up to limit public access to the area (Macleod, 1996).

6.11.3 Current context versus the 1994 situation

The 1994 event is an important reference point in understanding potential risk to the suburb of Ingleside. However, this must be considered on balance, with advancements in bushfire policy, strategy, warnings and preparedness as well as the current physical context of Ingleside compared with that which existed in 1994.

In broad terms (and because it cannot be tangibly measured), the bushfire resilience and emergency response landscape is today quite different to that which was in place in 1994. Significant research has led to innovations in (to name a few):

- bushfire awareness and preparation;
- emergency warnings and how they are communicated to the public;
- emergency response policy and strategies;
- evacuation triggers and arrangements;
- national-level risk-based land use planning guideline measures;

- the construction of essential infrastructure;
- the construction of dwellings (pursuant to various iterations of AS3959 since 1991);
- the introduction of APZ arrangements, fuel-free and fuel-managed zones;
- the introduction of the Warringah Pittwater BFRMP and associated mitigation measures (i.e. fuel management policies, strategies and measures);
- ad-hoc changes to the settlement pattern of Ingleside; and
- the introduction of 'neighbourhood safer places' and the concept of refuge centres, etc.

Having regard to the above, the relevance of the 1994 event (and others) must be considered in-line with the evolution of information technology, land use planning, infrastructure servicing, building construction, land management and emergency management contexts which have occurred over the 25 years since this event. This includes changes in telecommunications, the advent of social media platforms and vastly improved data intelligence capacity and capabilities borne from advancing technological innovations.

6.11.4 Existing versus proposed risk

In order to understand the profile of potential future risk, it is first important to articulate the risk profile of the current community. Thus, this risk assessment has regard to the nature of the current content of Ingleside and its community, as a pathway in understanding and conceptualising how this might change over time, pursuant with the draft Ingleside Structure Plan and based upon the draft Ingleside Land Use and Infrastructure Strategy.

This risk assessment therefore considers these two situations using a range of fire weather scenarios. This risk assessment does not seek to measure any other potential option, but may offer recommendations relating to other potential options to be explored and considered, relative to potential risk exposure and acceptability.

7 Bushfire Risk Identification

In accordance with NERAG, it is critical that all risks of interest are identified and acknowledged (AIDR, 2017). The following section considers the relevant risk elements of:

- Likelihood;
- Consequence; and
- Acceptability of land use planning risk.

Community risk acceptance represents an entirely different (albeit entirely relevant and important) aspect of risk consideration however, this remains outside the scope of this report. Part of the difficulty in gauging community risk acceptance is the nature of the proposal, and whilst existing community views can be gauged it would not be representative of future residents. To this end, the findings of the 2017 BNHCRC report into community attitudes towards bushfire risk are considered to be adequately representative.

As per the National Land Use Planning Guidelines for Disaster Resilient Communities, because risk is the combination of likelihood and consequence of events, risk exists on a spectrum from minor and frequent, to incredibly rare and catastrophic (PIA, 2016). The level of risk assigned to the interface of likelihood and consequence provides a graduated spectrum of risk from low to high. There is no common accepted terminology for defining specific levels of risk or even for the descriptors of likelihood and consequence – however hazard-specific guidance (such as the national best practice flood risk management document, Managing the Floodplain) can provide the commonly used terminology for the relevant natural hazard management process (PIA, 2016).

This risk spectrum for climate-related hazards (such as bushfire, flood, cyclonic and storm tide events, droughts and heatwave) will likely increase over time as well. How climate will affect specific hazards can be addressed by the addition of climate-specific considerations into hazard specific modelling (such as bushfire, flood or storm tide modelling).

Likelihood level	Consequence level				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
Very rare	Low	Low	Low	Low	Medium

Figure 16 - Spectrum of risk (Source: PIA, 2016)

For the purposes of this risk assessment, the likelihood and consequence criteria relate to the average occurrence of an FFDI 100 fire event which is the accepted fire weather event for land use planning and building construction provisions across Greater Sydney.

7.1 Consideration of potential likelihood

As per data recorded by the Bureau of Meteorology at the Sydney Airport and Richmond weather stations since 1972, the highest recorded FFDI over this period was 116 which occurred on 26 November 2015 (BoM, 2018). This is also identified to represent the current maximum FFDI for a 1 in 50-year fire weather event on the basis of a Generalised Extreme Value analysis derived by Douglas et al. 2014 (ELA, 2018). This approach represents a solid methodology to understand the annual exceedance probability (AEP) of localised fire weather. A 1 in 50-year fire weather event is considered a robust approach to mapping fire weather extremes and is generally consistent with the fire weather threshold adopted for the purposes of land use planning (PBP) and building construction (AS3959) FFDI thresholds in NSW which is FFDI 100.

Other significant fire weather events have occurred since daily recordings commenced from 1972, with 2013 identified as a particularly intense year with several days recording an FFDI of over 75, one of which included an FFDI at 111, recorded on 13 October 2013 (BoM, 2018).

FFDI 100 is the accepted threshold for both land use planning and building construction provisions which are in place across Greater Sydney. It accordingly represents the fire weather scenario adopted for the purposes of this risk assessment process.

The above represents the most severe fire weather recorded to date in the Sydney metropolitan area however, severe fire events can occur at much lower FFDIs, when the Fire Danger Rating is lower. House loss from fire events with an FFDI as low as circa 50 have been recorded (Leonard & Bianchi, 2012; Bianchi & Lucas et al. 2010). Thus, it is important to also consider the lower end of the FFDI spectrum and the fire events which may lead to property loss on a more frequent occasion. At Sydney Airport, the number of days an FFDI of 50 is exceeded in a given decade is 10.9, and over FFDI 75 is 1.7 days per decade (Lucas, 2007; Leonard & Bianchi, 2012).

7.1.1 Potential impact of climate change

Having regard to climate change, a range of models exist to potentially forecast changes to FFDI and the frequency of elevated fire weather days. Typically, this appears to include changes to maximum temperatures and relative humidity to 2050, guided by an Intergovernmental Panel on Climate Change scenario approach (Leonard et al. 2014).

Focusing on the scope of this assessment, and on the basis of commentary from NSWRFs, an FFDI scenario higher than that recorded for the Sydney Metropolitan area is utilised to replicate the potential impact of climate change on maximum FFDI, but not necessarily fire weather frequency. Based upon commentary from NSWRFs and acknowledging this risk assessment does not seek to undertake fire weather modelling, an FFDI of 134 is adopted as a potential climate change scenario for Ingleside. This is based on the FFDI which occurred in parts of Victoria on 7 February 2009, otherwise known as Black Saturday (Teague et al. 2010; Leonard & Bianchi, 2012). It is however noted that other reports (Bianchi et al. 2012) identify an alternate Black Saturday FFDI at 155.

Whilst from a scientific perspective, this approach is likely to either under or over-estimate potential climate change impact on fire weather trends in this particular locality, it does provide a reasonable 'yardstick' of highly catastrophic fire weather which has occurred in Australia. Importantly however, it is necessary to also note the Victorian Bushfire Royal Commission Final Report did have regard to climate change, and whether the FFDI which occurred on that day was potentially a symptom of a changing climate. Teague et al. (2010) found that it could not be overtly contended that the fire weather on that day was 'unprecedented' and that especially high FFDIs had occurred throughout history, including those which also led to devastation such as Ash Wednesday in 1983, Black Tuesday in 1967 and Black Friday in 1939.

In terms of fire weather frequency and the potential effects of climate change over time of the number of elevated fire weather days which may affect Ingleside, a clear upward trend is apparent when considering fire weather data across 38 selected weather stations across Australia and in the nationally averaged anomaly (Clarke et al. 2012). There is also a noticeable 'jump' in FFDI at many weather stations from 2000. This data has regard to the known modulation of the fire weather

climate by ENSO, showing increased FFDI in years of apparent El Niño (Clarke et al. 2012). Whilst frequency of increased fire weather is trending across the country (refer to Figure below), Clarke et al. (2012) did not note any change in the trend magnitude in annual cumulative FFDI at Sydney Airport. That is to say, over the period 1972 to 2010, no statistically significant upward trend in FFDI at this weather station was apparent.

This is an important finding to note, however a fire weather scenario at FFDI 134 is adopted irrespective as a potential indicator of long-range climate fluctuation. It is not however, included within the averaged fireline intensity analysis prepared by ELA included at **Appendix C**.

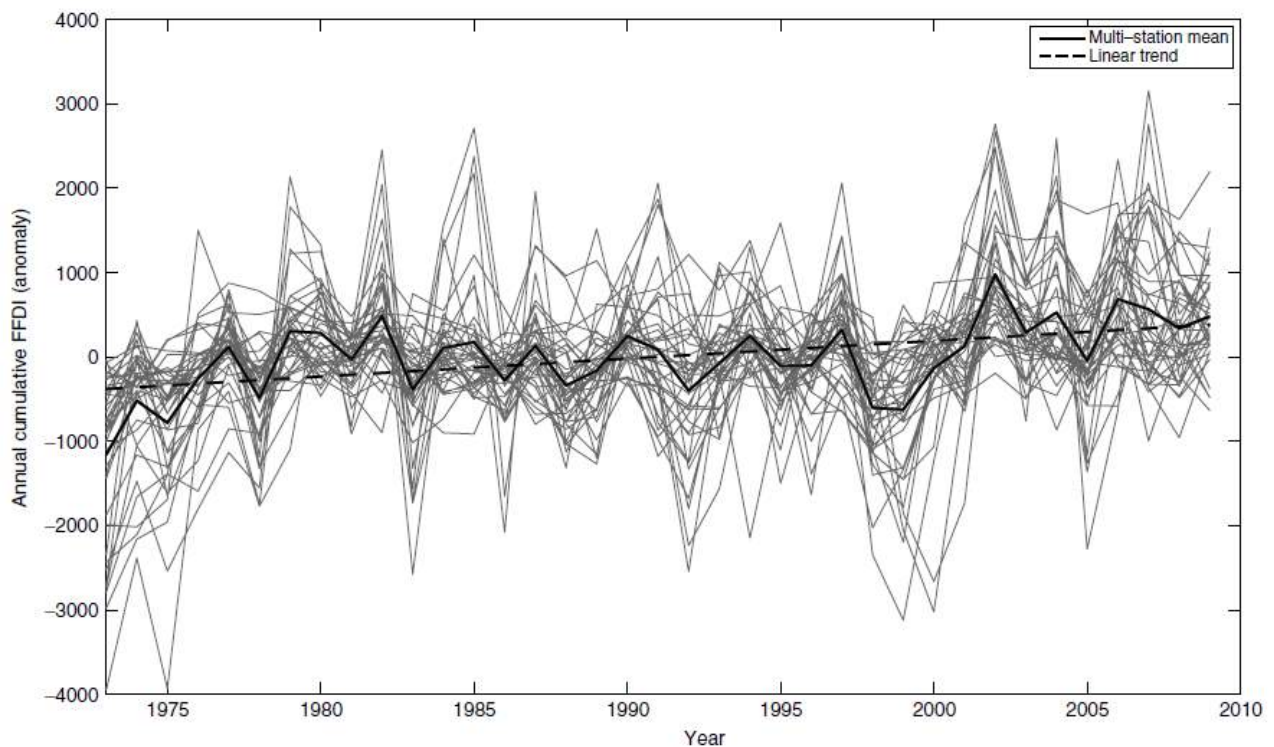


Figure 17 - Time series of annual cumulative FFDI anomaly at each selected weather station across Australia. The thick line indicates the multi-station mean. The thick dotted line indicates the linear trend (Source: Clarke et al. 2012)

The Metropolitan Sydney Climate Change Snapshot (Office of Environment and Heritage, 2014) which is based on NSW and ACT Regional Climate Modelling (NARClIM) data provides the following:

- Maximum temperatures are projected to increase between 2020-2039 by 0.3-1.0 degree Celsius and by 1.6-2.5 degrees Celsius between 2060-2079;
- Minimum temperatures are also projected to increase over the above periods;
- The number of hot days will increase and the number of cold nights will decrease;
- Rainfall is projected to decrease over spring and winter periods, but projected to increase over summer and autumn periods; and
- Both average and severe fire weather days are projected to increase in summer and spring by 2070 (affecting both the peak risk season as well as the prescribed burn periods).

In coastal environments, including that of the Northern Beaches LGA, the magnitude of climate change impact on fire weather is likely to be less than other parts of the state – but is still forecast to increase in both frequency and intensity, with subsequently less opportunity for suppression intervention by frontline firefighters. On 8 January 1994, the day Ingleside was impacted by the 1994 Cottage Point bushfire, the FFDI recorded at the Sydney Airport weather station was 40, and 62 at the Richmond weather station (BoM, 2018). The Richmond weather station recorded a series of

preceding days with elevated FFDIs, indicative of very low drought factor, low relative humidity and high temperatures in the days and months leading up to 8 January 1994. The Warringah Pittwater BFRMP (2010) states that the area experiences an average of 48 bushfire each year, of which events each 5 to 7 years on average can be considered major fire events.

An FFDI of circa 62 on 8 January 1994 reflects a 'Severe' Fire Danger Rating – below that of 'Extreme' and 'Catastrophic'. Thus, the fire weather evident on that day is well below the maximum recorded in the area, yet still resulted in profound damage and loss within and around Ingleside.

7.2 Summary of likelihood

Having regard to the above, and the statements contained with the Warringah Pittwater BFRMP, the likelihood of extreme fire weather in and around Ingleside is considered '**almost certain**', having regard to the spectrum of risk, presented above. Having specific regard to FFDI 100 fire weather events, likelihood could be considered '**likely**' noting these events, over recorded history, are infrequent but have occurred.

7.3 Consideration of potential consequence

The following section outlines the identified potential consequences of bushfire of varying magnitudes with specific regard to the Ingleside Precinct.

7.3.1 Bushfire attack indicators

In order to understand the nature of risks posed to people within the Ingleside Precinct, it is first critical to contemplate the elements of bushfire risk which may be relevant. **Appendix B** includes the NSWRFBS Bush Fire Survival Maps for Ingleside North and Ingleside South, based on an 'extreme' Fire Danger Rating (FFDI 75-99) and which are contained within the Community Protection Plan. These maps demonstrate the majority of the current Ingleside Precinct is subject to 'ember attack', followed by 'flame impact' which accounts for a large proportion of the area – including that part which is already developed, with smaller areas identified as subject to 'radiant heat impact' as opposed to 'flame contact' (NSWRFS, 2015).

Thus, under 'Extreme' conditions almost all of the Precinct is exposed to at least one form of bushfire attack. The small proportion of the Precinct subject only to ember attack, as it currently exists, includes very little land, most of which is in private ownership and is unlikely to represent a safe location for evacuation. The Bush Fire Survival Maps indicate that under these conditions, leaving early is the only option. Staying and defending even a well prepared property is not advised by the NSWRFBS (2015).

Coupling this evidence with the findings of the 2017 BNHCRC research into community awareness and attitudes to bushfire warnings, only 12 per cent of residents are estimated to heed early departure warnings on days of elevated fire danger (Whittaker & Taylor, 2018).

The Bush Fire Survival Maps are further considered, along landscape-scale fireline intensity scenarios, as part of the bushfire risk analysis at Section 8 of this report.

7.3.2 Risk to people

The current estimated population of the Ingleside Precinct is 1,081¹ (ABS, 2016a). The proposed draft Land Use and Infrastructure Strategy articulates an increase in the ultimate population of the Ingleside Precinct to approximately 9,000 persons (DPE, 2017).

In terms of the characteristics of the existing Ingleside community in accordance with the 2016 Population Census, the median age of the Ingleside resident is 42 years which is slightly higher than both the LGA and State medians, with a slightly higher proportion of persons aged 65 and over compared with both the LGA and State averages (ABS, 2016a; ABS, 2016b). The level of English proficiency is significantly higher than the State average and slightly higher than the LGA average, whilst tertiary education levels are slightly lower than the State average and significantly lower than the LGA average (ABS, 2016a; ABS, 2016b). Despite this, median weekly household income at \$2,317.00 is higher than that of the LGA average and significantly higher than the State average at \$1,486.00 (ABS, 2016a; ABS, 2016b).

Based upon these characteristics, the current population of the Ingleside Precinct does not present as particularly 'vulnerable'. Refer to table below for potential indicators of community socio-economic 'vulnerability'.

¹ Calculation of SA1 data for 1142117, 1142118 and 1142107 which generally depicts the proposed Ingleside Precinct with some minor exceptions.

Table 4 - Potential indicators of community socio-economic 'vulnerability'

	Aged persons % above 65	% children aged 0-14	Home ownership (outright)	Household median weekly income	SEIFA (index of relative socio-economic disadvantage)	Disabled/infirm persons (core activity need for assistance)	% 0 vehicles per dwelling
Ingleside Precinct*	18.1%	14.9%	51%	\$2,317	1094	3.6%^	1.9%
LGA	16.8%	19.7%	34.5%	\$2,178	1092	3.6%	6.6%
NSW	16.3%	18.5%	32.2%	\$1,486	N/A	5.3%	9.2%

* Combined data for SA1 1142118, 1142117 and 1142107

^ LGA dataset on basis of data unavailability at SA1 scale

Whilst the current Ingleside community does not appear to demonstrate evidence of socio-economic vulnerability, the bushfire risk indicators identified above must be intersected with the current (and future proposed) population. The Bush Fire Survival Plans included at **Appendix B** provide a fairly clear indication of the nature of risk associated with the existing population. Observations relating to risk to people as a result of a fire event which replicates that used for these maps includes:

- The majority of the Ingleside Precinct (as it currently exists) is subject to a combination of flame impact, radiant heat exposure and ember attack;
- Only small pockets throughout the Precinct are identified as subject to only ember attack, the largest area being the Elanora Country Club Golf Course in the southern extent of the Precinct;
- Under the conditions identified to prepare these maps, early evacuation is the only appropriate option and this is articulated by NSWRF (2015). Very limited areas exist in the area in which safe shelter and defence could occur without posing a risk to life as a result of flame impact or radiant heat;
- Pursuant to the findings of the BNHCRC 2017 research into community attitudes and awareness, only 12 per cent of persons surveyed in that instanced stated they would 'leave early' before a fire / ignition was obvious (Whittaker & Taylor, 2018). Extrapolating this data for Ingleside, approximately 951 (out of 1,081 people, but not including those who may not already be at home) persons would currently evacuate the Ingleside Precinct once a fire / ignition was known, a warning was released and residents took time (in most cases) to verify the warning via neighbours, friends or media sources (Whittaker & Taylor, 2018). Pursuant to evacuations which occurred on Black Saturday, residents will make decisions to leave at various points in time until the time of fire front impact;
- Under the proposed draft Structure Plan, this increases to a total of approximately 7,920² persons needing to evacuate after a fire / ignition was known, a warning was released and residents took time (in most cases) to verify the warning via neighbours, friends or media sources (Whittaker & Taylor, 2018). Based upon the current (intended) road configuration and capacity, it is likely this process would require several hours. Emergency warnings may not necessarily allow for hours, but minutes;

² This figure represents 88 per cent of the proposed population of Ingleside at 9,000 persons, noting 12 per cent of persons are likely to evacuate early.

- This represents an ultimate population increase of over 730 per cent from the current population of the Ingleside Precinct;
- Having regard to a 2012 study of life and house loss in 260 bushfire events across Australia conducted by the CSIRO, late evacuation is the most common activity persons were engaged in at time of death (30.3 per cent) followed by sheltering inside a structure (24.8 per cent) and defending a property outside (22.4 per cent) (Blanchi et al. 2012). However, this was not the case on Black Saturday, where approximately 14 per cent lost their life on the road attempting to evacuate and 69 per cent of the 173 persons who lost their life that day were passively sheltering within a building (as opposed to actively defending) (Teague et al. 2010);
- The Coronial Inquiry into the 1994 Cottage Point fire found that future development of the Ingleside area should be undertaken having careful regard the inadequacies of the road network of the area (Hiatt et al. 1995);
- The draft Ingleside Land Use and Infrastructure Strategy identifies a proposed upgrade to Mona Vale Road which is the main arterial route spanning east-west through the Precinct. The Upgrade, which has been the subject of Roads and Maritime Safety (RMS) applications and impact assessments, will increase the capacity of Mona Vale Road from two lanes (one lane in either direction) to four lanes between Terrey Hills and Mona Vale. Currently, the road is a combination of two and four lane sections between these locations. The entirety of these upgrades are scheduled for completion by circa 2023;
- In addition to Mona Vale Road, Powderworks Road is a significant movement pathway to the south-east (out of the Precinct) whilst Cabbage Tree Road and Minkara Road join the suburb of Bayview to the north-east. These two roads at present would require substantial upgrade to be considered suitable for emergency evacuation purposes given their respective design and construction at present;
- Based upon a population of approximately 9,000 the current draft Structure Plan incorporates four roads (five directions) which could be used for emergency evacuation immediately out of the Precinct, which is unchanged from the current situation; and
- There are non-residential activities within the precinct which periodically serve large numbers of people (i.e. school camp facilities and the like) which may experience difficulty in evacuation due to their location and/or the nature of potential occupants (i.e. children).

On the basis of the above, the consequence of risk to people will vary depending upon the magnitude of the fire weather event when ignition occurs. This could vary anywhere between **'Medium'** to **'Extreme'** for both the current and proposed future populations of the Ingleside Precinct having regard to the above observations.

Given the evidence discussed above, the current settlement pattern of the Ingleside Precinct is exposed to existing bushfire risk exposure, a fact which is acknowledged by the local community in submissions received by DPE in response to the draft Structure Plan. Based upon aerial imagery provided by Northern Beaches Council from 1997 to 2016, the settlement pattern of the area has not changed substantially however, it could be contended that a slight increase in clearing has occurred over this period which may relate to APZ clearing. As such, the settlement pattern of Ingleside does not appear to have substantially changed since 1997, three years following the 1994 Cottage Point fire.

This is relevant when considering the findings of the 1995 Coronial Inquiry report which discussed the development potential of Ingleside and that it should be considered having particular regard to the adequacy or otherwise of the existing road network. Thus, the prominence of evacuation routes and connectivity to surrounding areas becomes key.

In addition to the above, the nature of the likely change to the population of the Ingleside Precinct is worthwhile considering. The settlement pattern of the Precinct as it currently exists is largely 'semi-rural' or likened to 'rural residential' or 'lifestyle residential' with relatively larger allotments than the

typical urban area. The draft Structure Plan includes a mix of medium density, low density and rural residential allotments which not only presents a substantially different settlement pattern, but it is also likely to attract 'urban' residents. This requires a risk analysis which considers:

1. the suitability of the intended draft Structure Plan including the proposed settlement pattern, land uses and density – with respect to withstanding the nature of bushfire risk likely in this location;
2. The tangible ability for up to 9,000 persons (an increase of over 730 per cent on the current population) to evacuate in an emergency using the same evacuation routes which currently exist (but are intended to be constructed to a higher standard); and
3. the awareness of the ultimate resident base of the Precinct with respect to the fire history and risk landscape they will move into.

These matters are further addressed throughout the balance of this report.

7.3.3 Risk to property

The relevance of the Bush Fire Survival Plans at **Appendix B** as the bushfire attack indicators remains equally as relevant to property risk as they are in considering risk to people.

In Ingleside, the 1994 Cottage Point fire destroyed three homes and damaged a further 12 along with a range of other non-habitable buildings. As identified above, the settlement pattern of Ingleside has not changed substantially since aerial imagery was captured in 1997, some three years following the 1994 fire. The exception appears to be slightly more clearing which may now be in place for APZs, however this remains speculation only.

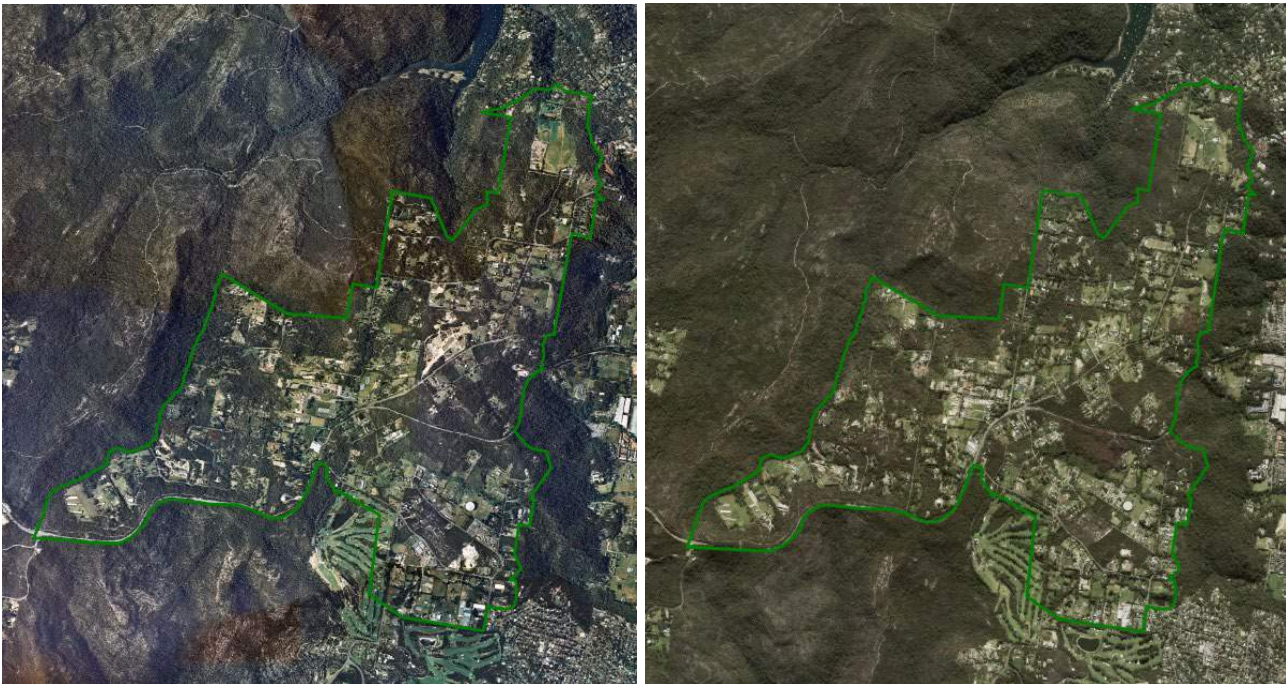


Figure 18 - Aerial imagery of the Ingleside Precinct captured in 1997 and 2016 (Source: Northern Beaches Council, 2018)

The current average lot size in the Ingleside Precinct is 1.36ha³, whilst the draft Ingleside Land Use and Infrastructure Strategy recognises an intended transformation of this average lot size to 550m² in designated low density areas which comprise the largest intended residential zone under the draft Structure Plan.

The draft Land Use and Infrastructure Strategy identifies that 30 per cent of the Precinct area is poised for conservation purposes whilst a further 30 per cent will remain un-changed. Thus, only 40 per cent of the balance Precinct area will accommodate development, of some density given the overall population is expected to reach 9,000. In review of the draft Structure Plan, the conservation area is achieved by the retention of vegetated areas which permeate the Precinct, refer to **Figure 19** below. This is intended to contribute to the green 'character' of the Precinct.

These conservation areas largely reflect the nature of the existing situation of Ingleside, which embodies dense vegetation throughout the Precinct. These conservation areas, depending upon their overall design, may act as 'wicks' which can promote fire intrusion beyond the boundary of the Precinct, and towards existing and proposed homes. This is particularly relevant for corridors extending into the Precinct from the west, north-west and south-west. They can act to fragment the Precinct and provide fuel to encourage the growth of spot fires in and around residences (and

³ Average allotment sizes by sub-precinct include – Wirreanda Valley 2.67ha, Bayview Heights 1.49ha, North Ingleside, 0.84ha and South Ingleside 0.44ha

people). They can also present an issue in terms of the facilitation of safe evacuation (and emergency services access).

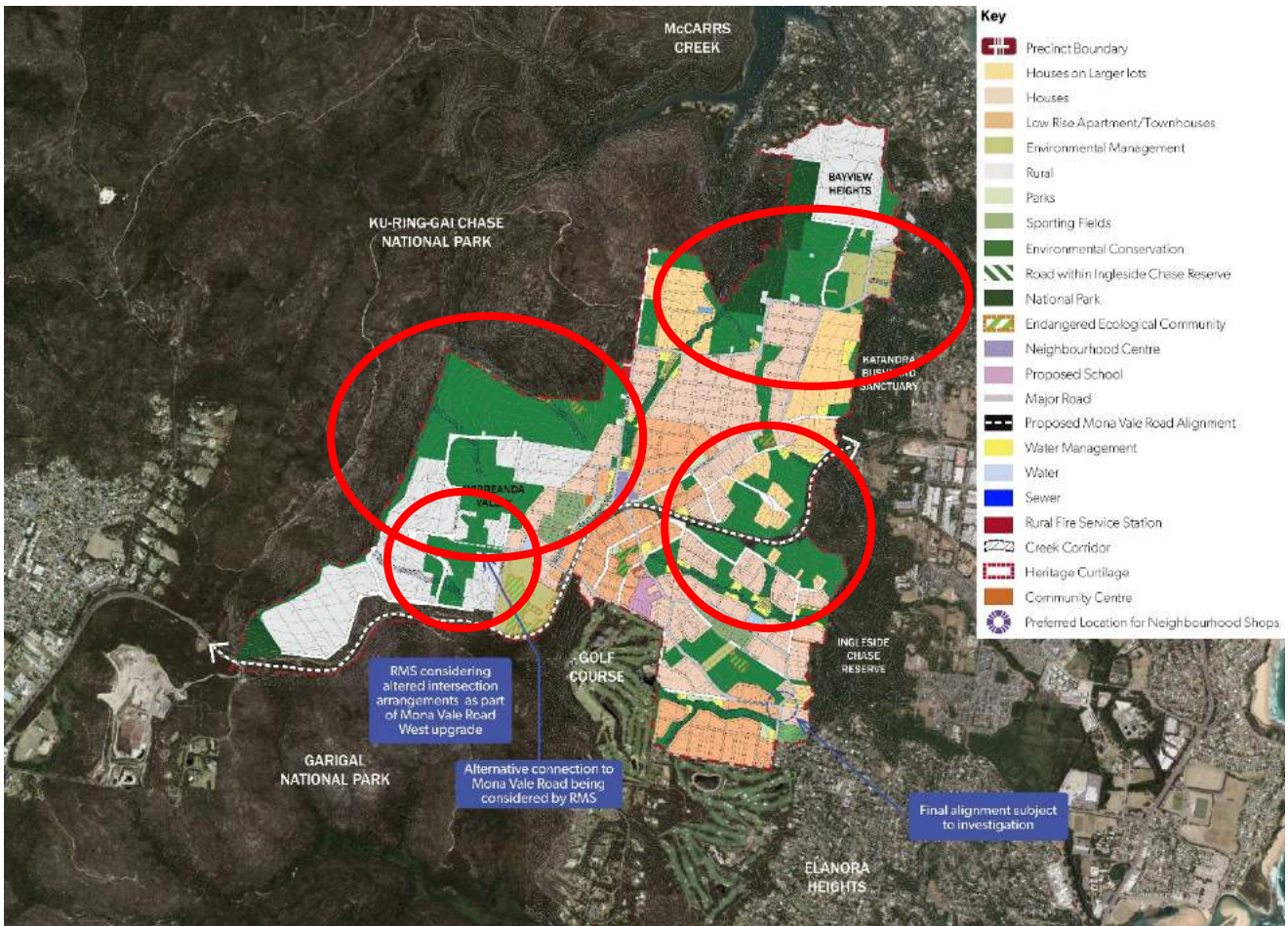


Figure 19 - Draft Ingleside Structure Plan and identified core conservation areas internal to the Precinct

Having regard to the 2017 California fires and in particular, the Napa/Sonoma fires saw thousands of buildings lost, as well as dozens of fatalities. This included a higher proportion of vulnerable persons such as the aged and persons with disabilities who found it difficult to evacuate in the middle of the night, when the fire front impacted upon the community of Santa Rosa. The urban 'intrusion' of fire within the urban residential area of Santa Rosa (known as the 'Tubbs Fire') took many by surprise, with entire suburban neighbourhoods impacted (Smith & Agrawal, 2017). In this particular case, the Tubbs fire moved rapidly toward Santa Rosa throughout the night, requiring emergency evacuation of residents in the early hours of the morning on 8 October 2017. In the aftermath, residents have been critical of two things. The first, the lack of warning received. The second, the land use planning rationale which led to these particular suburbs of Santa Rosa being destroyed by wildfire (Smith & Agrawal, 2017).

Urban fire intrusion is created when natural vegetation – corridors or patches – are retained in and amongst the urban area. This is leveraged by ember attack which creates spots fires in these locations, whilst also attacking the vulnerabilities of each particular building, creating fires which can quickly grow out of control. House-to-house ignition then becomes an issue, where in urban contexts, homes are generally more tightly located which allows radiant heat exposure from a burning dwelling next door to impact upon doors and windows of surrounding dwelling, which eventually leads to their failure and thus, onset of sequential house loss (Leonard, 2016). This is the nature of what occurred in Santa Rosa. This is also the nature of what occurred during the Canberra bushfires in 2003 and the Wye River and Separation Creek fires in Victoria on Christmas day in 2015 (Leonard, 2016).

In the context of Wye River, a mix of houses – some built to AS3959 standard and some which were not – were lost. Leonard (2016) states this is because ‘no house is an island. It is surrounded by other houses, by landscaping, by add-ons, by natural debris, and the environment whose aesthetic appeals to its owners’.

At the time this risk assessment report was prepared, only preliminary reports with regard to the nature of dwelling loss were emerging from the 2018 Tathra fire. In this particular case, it would appear that a combination of ‘ferocious’ ember attack and the vulnerabilities of particular dwellings is largely responsible for the loss of 65 dwellings in Tathra (Nicoll, 2018). No dwelling built to AS3959 standard was lost as a result of the Tathra fire (Nicoll, 2018). Whilst it is too early to draw any conclusions between how dwellings built to standard survived in one location (Tathra) but not another (Wye River), it does demonstrate that AS 3959 construction does not necessarily guarantee dwelling survival. However, it certainly increases the likelihood of survival provided owners continue to maintain the dwelling and manage the land surrounding it.

The concept of urban fire intrusion is a matter to be carefully considered with respect to the draft Ingleside Structure Plan in combination with the key fire runs relevant to the area and noting the ferociousness of ember attack observed in Ingleside and surrounds in 1994.

In terms of existing and future property risk within the Ingleside Precinct, the combined array of bushfire protection measures highlighted by PBP offer a yardstick by which strategic consideration can be undertaken.



Figure 20 - PBP bushfire protection measures in combination (Source: NSWRF, 2018)

Table 5 - Strategic overview of BPM characteristics

Bushfire Protection Measure	Ingleside (existing)	Draft Structure Plan
Access	Roads out of the Precinct include: <ul style="list-style-type: none"> • Mona Vale Road (east and west) • Powderworks Road • Cabbage Tree Road 	No additional roads out of the Precinct are contemplated. Mona Vale Road is intended to be upgraded to a dual-lane carriageway in either direction.

	<ul style="list-style-type: none"> Minkara Road 	Other roads will likely undergo design upgrade however, no additional road network connections between Ingleside and surrounding areas is proposed.
Water Supply and Utilities	<p>Much of the existing Precinct is not serviced by reticulated water supply and electricity is largely via poles and wires. Two existing reservoirs are located in the Precinct.</p> <p>A telecommunications tower is located adjacent to Mona Vale Road and Garigal National Park.</p> <p>NBN is not currently available within the Precinct.</p>	<p>Preliminary infrastructure servicing reporting identifies South Ingleside can be readily serviced by reticulated water supply. North Ingleside will likely gain access some three years after any potential re-zoning, and a new potable water reservoir and new sewer pumping station would be required to locate in North Ingleside.</p> <p>Existing investigations indicate that both Wirreanda Valley and Bayview Heights are unlikely to be serviced by reticulated water connection.</p> <p>The current electricity network has been identified as insufficient to service the proposed extent of development. Over time, the existing network is intended to be undergrounded.</p>
Asset Protection Zones	Currently provided on an ad-hoc basis, pursuant to tenure, etc.	APZs are mandated under current planning and building provisions and must be adhered to under regulation.
Building Construction and Design	Currently a mix of complying and non-complying structures, based on age and the version of AS3959 in place at the time of construction.	Building construction provisions are mandated where it is required and is adhered to via planning and building controls.
Landscaping	Currently ad-hoc.	To a degree, landscaping can be 'managed' under regulations (be it planning or Rural Fires Act) but is difficult to enforce in perpetuity.
Emergency Management Arrangements	As per the State Bush Fire Plan and EMLAN.	As per the State Bush Fire Plan and EMLAN.

The elements required to be addressed in detail by a bushfire strategic study, as per PBP 2018, are further contemplated at Section 10 of this risk assessment report.

Having regard to the commentary in **Table 5** as well as preceding commentary on urban fire intrusion, the desire to achieve a 'green character' within Ingleside is at clear odds with the nature of the bushfire risk. In this case, serious consideration will need to be given to the priorities of either ecological conservation or housing need/housing affordability. If development is desired in Ingleside, significant concessions would need to be considered.

7.3.4 Proposed vulnerable land uses (special fire protection purposes)

In terms of understanding potential increased risk to the community, consideration of existing and proposed vulnerable land uses is key.

7.3.4.1 Aged care facilities

There are several aged care facilities within the surrounding area of Ingleside which include Opal Seaside in Warriewood and the Aveo Minkara Resort Retirement Village in Bayview. The Ingleside Precinct itself does not currently incorporate any aged care facilities. In order to avoid an increase in risk to vulnerable persons, it is advisable that this situation remain unchanged.

The draft Land Use and Infrastructure Strategy does not make any statements with regard to 'anticipated need' for aged care facilities in Ingleside.

7.3.4.2 Child care facilities

There are several childcare facilities in the immediate area of the Ingleside Precinct which include Sandcastles Child Care in Elanora Heights and Clare's Child Care in Elanora Heights. No existing child care facilities are currently located within the Ingleside Precinct at present.

A Demographic and Social Infrastructure Assessment conducted by Elton Consulting (2016) has indicated that three to four child care centres will be required once the precinct is fully developed and this has since been incorporated into the draft Ingleside Land Use and Infrastructure Strategy.

Aside from risk to life and the trauma that could prevail from exposing young children to natural hazard, should an event transpire on a weekday parents generally attempt to collect their children and can make dangerous decisions in order to do so. This is a strategic issue which requires just as much contemplation as do asset protection zones.

7.3.4.3 Schools

One school is currently located in Ingleside, Hamazkaine Arshak and Sophie Galstaun College (known as Galstaun College). This school is situated north of Mona Vale Road and west of Chiltern Road. An outdoor education / activity centre is also located in the very northern extent of Wirreanda Valley, known as Camp Kedron. This facility hosts school camps, church groups, youth and community organisations, including overnight accommodations and typically receives school students by coach bus, which are then likely to depart the site and return days later to collect the students. A nearby scout camp operates in a similar fashion.

The draft Ingleside Land Use and Infrastructure Strategy identifies the need for a new primary school within the Precinct, based upon the population projections associated with the draft Structure Plan. This school is proposed to be situated in the area enclosed by Powderworks Road, Wattle Road, Manor Road and King Road.

The existing school is not reflected on the draft Structure Plan. **Figure 21** identifies the location of these facilities. It is understood the existing school facility is intended to relocate out of the Precinct over time.

The introduction of any new Special Fire Protection Purposes within the Ingleside Precinct into the future should be avoided.

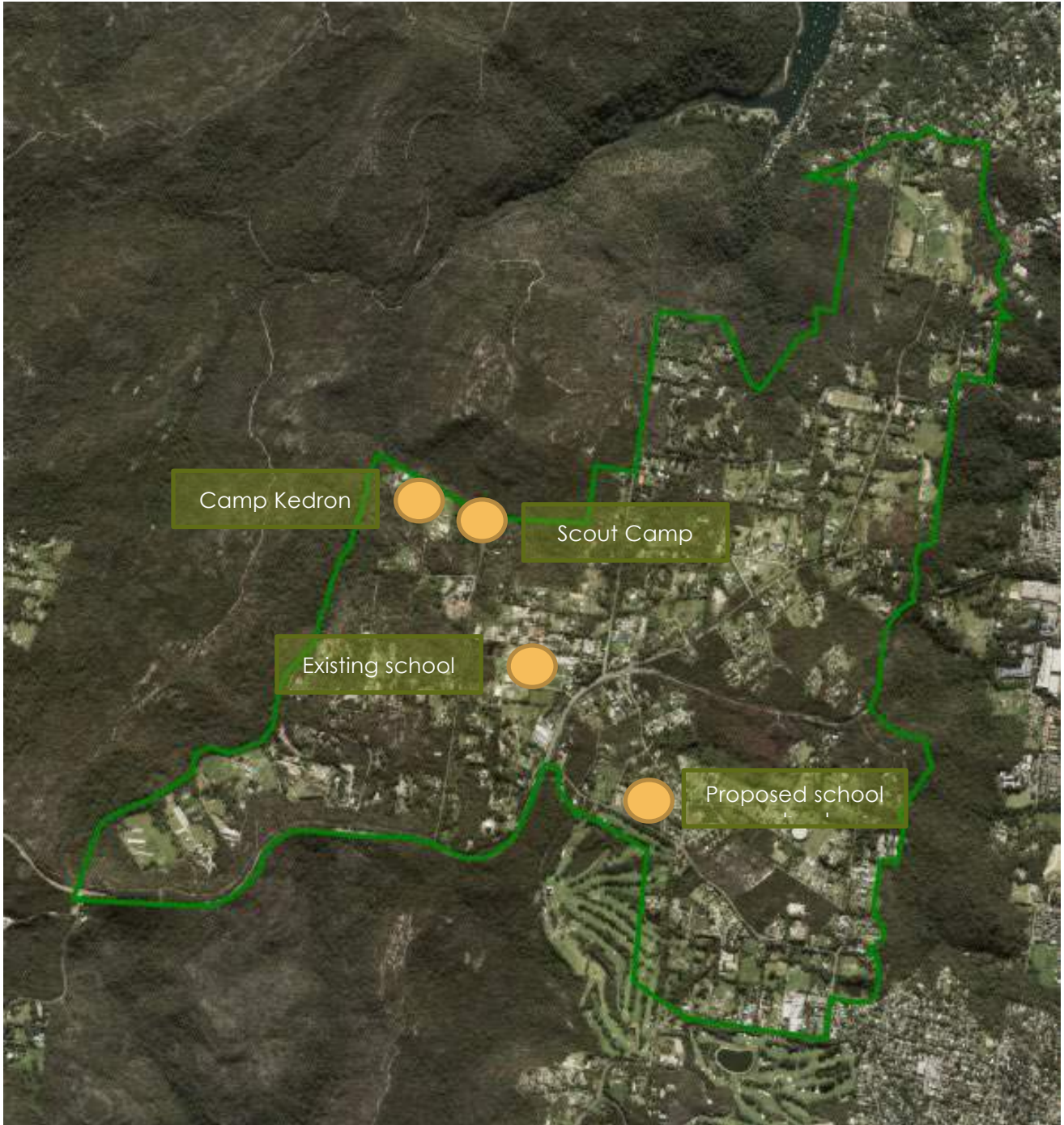


Figure 21 - Existing and proposed strategically identified special fire protection purposes (Source: Derived from DPE, 2017 and Northern Beach Council, 2016)

7.3.5 Risk to infrastructure

A range of infrastructure servicing investigations have been conducted which set out the existing and proposed infrastructure servicing requirements. These are explored below.

7.3.5.1 Water supply

Water supply is one of the key bushfire protection measures identified by NSWRFs in PBP 2018.

There are three main reservoirs which currently supply water to the Ingleside Precinct and surrounding area. The first being the Ingleside Park Reservoir which is located within South Ingleside on Wattle Road. This reservoir currently also services properties outside of the Ingleside Precinct. The second reservoir is the Minkara Reservoir situated between North Ingleside and Bayview Heights. This reservoir supplies water to a selection of properties the Precinct. The third reservoir is the Elanora Heights Reservoir which is situated approximately 400m south of the Precinct.

Development of South Ingleside can potentially be supplied from the Elanora Heights reservoir via lead-in main connections. Due to elevation changes across the Precinct, it is unlikely the Elanora Heights reservoir would be able to service North Ingleside through lead-in main connections. This area will likely require a new potable water reservoir and will take three years from the time of potential rezoning for the new potable water reservoir to be planned and delivered to North Ingleside.

The new potable water reservoir will also have to include the area north of the Cicada Glen Road which is not currently serviced for potable water.

Based on the service requirements for water supply, the provision of water infrastructure to South Ingleside is estimated to be significantly cheaper than North Ingleside due to the need for new potable water reservoirs and a water pumping station to specifically service North Ingleside. The location of any such infrastructure, should it be provided, will need to be carefully considered having regard to the bushfire threat to North Ingleside.

Having regard to the above, it is noted existing investigations further identify that it is unlikely that Sydney Water will service Wirreanda Valley or Bayview Heights, and existing water supply in these sub-precincts is largely derived from rain water tanks. Whilst this is an existing situation, it does remain at odds with the extent of risk posed by potential fire runs and intensity relating to these areas.

It is additionally noted the Belrose pumping station failed in the 1994 Cottage Point bushfire. Irrespective of future development, its upgrade may need to be considered as a strategic priority and should be investigated further.

7.3.5.2 Roads and the road network

The NSW Government is proposing to upgrade Mona Vale Road from two to four lanes between Mccarrs Creek Road in Terrey Hills to Powderworks Road, and also from Lane Cove Road moving east to Foley Street in Mona Vale. This upgrade is intended to transition the road into a major strategic route within the region and support an increase to the volume of traffic using this route.

Consideration of risk relating to road infrastructure is generally associated with permitting safe evacuation rather than direct impact on the road itself however, damage can occur as a result of traffic accidents, tree falls and melting pavement as a result of bushfire attack. Road reserves for this reason should typically be void of vegetation wherever possible.

Mona Vale Road, in particular, as the recipient of significant funding for upgrade, traverses bushland to both the immediate east and west of the Ingleside Precinct. Aside from the evacuation considerations in relation to same, the potential for infrastructure damage is possible.

No other upgrades to the road network from Ingleside to surrounding areas are currently proposed.

7.3.5.3 Electricity Infrastructure

Consideration of electricity supplies is important from a bushfire resilience perspective in terms of the communities ability to access information and warnings, to power pumps to essential services (i.e. to pump stations and reservoirs), etc. Notwithstanding this, power outages in bushfire events is common however, undergrounding of services can mean all the difference during emergencies in addition to avoid a potential new ignition source.

At present, three zone substations provide electricity to the Ingleside Precinct however, none are located within the Precinct. These include the Mona Vale 11kV Zone Substation located approximately 1.4km away, the Terrey Hills 11kV Zone Substation located on Mona Vale Road approximately 4.8km away, and the Narrabeen 11kV Zone Substation approximately 2.1km from the Precinct. A network of overhead power lines and pole mount and pad mount substations are positioned within the Ingleside Precinct. It is noted that the existing provision of electrical infrastructure will not substantially service the proposed development in the precinct.

It is estimated the electricity load required from the extent of proposed development within the Precinct will be approximately 14 MVA. Reporting has identified the current lot yield projections can be wholly supplied by installing a minimum of two new 11 kV feeders from the Mona Vale Zone Substation that lead into the Precinct. The installation of these new feeders is not currently included in the planned Mona Vale Road upgrades. There is potential to install the ducts below the ground as a part of the works to accommodate the feeders required to supply electricity to the precinct. New development will require undergrounding of transmission infrastructure and will likely lead to the replacement of existing poles and wires which is preferable.

At present during an event, the existing pole and wires network is likely to be severely impacted.

7.3.5.4 Telecommunications

Telecommunications is also essential during emergency situations however, often telecommunications towers and the like can come under attack, presenting a level of risk during an event.

The Ingleside Precinct is currently serviced by an overhead telecommunications network with additional fibre optic cable availability. These fibre optic cables traverse the Precinct along the Mona Vale Road and Lane Cove Road reserves. The NBN is currently not available within the precinct and building the service has not commenced within the Precinct.

The provision of fibre to new developments is understood to be subject to competition between potential providers. While it is preferable that fibre is provided to new developments, it is not deemed essential infrastructure that is required to substantiate rezoning. The developer will also be responsible for funding the lead-in works and local reticulation for the NBN if they decide to supply fibre through the NBN.

In order to function during emergencies, the NBN must be powered both at the source and at the node (i.e. at either end of the connection). If a power source fails at one end, the NBN connection will cease to operate. NBN Co has developed emergency systems and processes during times of emergency and disaster but this does remain a shortfall of the system.

7.3.5.5 Gas utilities

Gas infrastructure and bushfire are at obvious odds and thus, it is important the treatment of gas utilities is undertaken with the potential threat of bushfire in mind.

The precinct has a secondary gas main which generally traverses the reserves of Cabbage Tree Road, Lane Cove Road, Mona Vale Road and Walter Road. Existing gas infrastructure is located within close proximity to South Ingleside. There are also minor gas lines situated along Powderworks Road and a small section of Chiltern Road, to the north of Mona Vale Road.

The extension of the existing gas network will be assessed in future by Jemena. If found that extending the network will result in an increased customer base and recuperate the investment to

extend the network, Jemena may fund the required infrastructure, otherwise this may be the responsibility of future developers. It is understood the extension to the existing gas network will stem from the existing infrastructure and will not require additional stations to be installed within the Precinct.

7.3.6 Risk to the environment

7.3.6.1 Biodiversity assessments

A draft biodiversity study of the Ingleside precinct was conducted by ELA in 2016. This study identified approximately 351ha of native vegetation and ten biometric vegetation types within the Biodiversity Certification Assessment Area (BCAA). Of the native vegetation, 85 per cent was deemed to be in good condition, with weed invasions predominately situated along tracts, edges and small, isolated areas. Of the 291.87ha of native vegetation not currently listed as being threatened and is identified as being in 'good' condition, 48 per cent will be conserved, 29 per cent retained with no change in status, 22 per cent will be impacted through development land use, and 1 per cent identified for water management land use.

The ELA study identified two Endangered Ecological Communities (EECs) within the BCAA, being the Duffy's Forest Ecological Community and Coastal Upland Swamp. These two EECs are listed under the Threatened Species Conservation Act (TSC Act) and the Coastal Upland Swamp is listed under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Both EECs have a combined area of 9.4ha. The ELA study found the proposed development will affect 0.35ha of this area, retaining a vast majority (96 per cent) of the present EECs. In addition to the currently conserved land within the Ingleside Precinct, just over 30 per cent of current lands are proposed to be converted to Environmental Conservation or Environmental Management.

The Biodiversity Certification Assessment Methodology (BCAM) predicted there would be 16 threatened fauna species present on site in accordance with habit surrogates (ELA, 2016). Their presence in the Precinct is reliant on native vegetation. There is an additional eight threatened fauna species and 13 threatened flora species, however these species were not found during the study conducted by ELA. Instead, these species were taken into consideration on balance of previous sightings, known population locations and existing information on the habitat requirements (ELA, 2016).

The study has identified threatened flora within the area which include *Grevillea caleyi* and *Microtis angusii*. There were 39 live *Grevillea caleyi* was detected within the proximity of the Baha'i temple, near the Mona Vale Road and Addison Road intersection. None of these individuals are within proximity of the proposed urban land use, however previous bushfires in the precinct have stimulated germination of the seedlings. The *Microtis angusii* is listed under the TSC Act and the EPBC Act. A total of 4,276 individuals were identified within the precinct. It is noted that 69 per cent of these individuals are within conservation areas and 9 per cent are situated within development areas and land use for the remaining populations will not change.

Threatened fauna which are likely to occur within the precinct with the presence of suitable habitat have been recorded. The Giant Burrowing Frog and Red-crowned Toadlet have been recorded in the Katandra Bushland Sanctuary and Ingleside Chase Reserve in the east. North of Powderworks Road, the Eastern Pygmy Possum has been recorded. The Koala, Resenberg's Goanna and the Southern Brown Bandicoot may potentially occur in habitat areas within or connected to the Kuring-gai Chase National Park. Any potential impacts on the habitats of the Southern Brown Bandicoot also triggers a red flag.

As a result of the above considerations, the ELA study identifies drainage lines as potential breeding habitat for the Southern Myotis and have been recorded in the Ingleside Chase Reserve in the east. To retain the wellbeing of all fauna, it is understood that the Mona Vale Road upgrade will accommodate for fauna crossings to link to larger habitat areas outside of the BCAA. It is also recommended by the ELA study that additional measures for increased ecological connectivity are considered.

The biodiversity assessment provided several key recommendations for general management. These include that

- development should retain and manage the identified areas of 'high' ecological value. Areas identified as 'moderate' ecological value are also to be retained. Smaller areas of 'moderate' value should encompass long-term management provisions, or otherwise the rehabilitation or restoration of remaining area fragments and linkages to other priority areas;
- conservation areas such as National Parks and Council reserves should have a vegetation buffer to retain wildlife corridors and protect such areas. Buffer areas will additionally assist in the management of bushfires in an ecological and development sense. Asset protection zones must be excluded from conservation areas;
- investigation into how controlled 'ecological burns' can be used to accommodate foraging habitat for threatened species, rejuvenate native shrub growth in woodland, riparian and heath habitats and control the invasion of weeds should be undertaken;
- best practice soil erosion control during construction to avoid sediment flow into watercourses and management units should be adopted; and
- the corridor links between Garigal and Ku-ring-gai Chase National Park is to be maintained (ELA, 2016).

7.3.6.2 Riparian corridor assessment

An additional riparian corridor assessment was also undertaken by ELA in relation to identified watercourses in the Ingleside Precinct including Wirreanda, Crystal and Cicada Glen Creeks. Sub-catchments feeding into these watercourses stem from forest reserves situated within and external to the Precinct. The study also identified some of the smaller, local creeks serve as headwaters for larger creeks such as Mullet and Narrabeen Creeks. These watercourses act as partial corridors which link to several sensitive environments that surround the Precinct such as the Ku-ring-gai Chase National Park, Garigal National Park, Ingleside Chase Reserve and Narrabeen Lagoon.

The ELA report identified 20 watercourses within or immediately adjacent to the Precinct which vary in condition. Out of the 20 watercourses, ten watercourses were found to have a high recovery potential, six with a moderate recovery potential and four with low recovery potential. Although, many of the riparian corridors situated in the centre of the Precinct were found to be in a degraded condition, the ELA study identified the proposed Structure Plan offers an opportunity to enhance the riparian connectivity and aquatic habitat of the degraded corridors (ELA, 2016). Opportunities to enhance the aquatic ecological values of these riparian corridors may include rehabilitating the remaining vegetation in areas zoned for public or private land use, drainage, and through education infrastructure (ELA, 2016).

To separate water and environmental land uses from the proposed development areas, all creeks have been allocated a mandatory riparian buffer. In most cases, the draft Structure Plan exceeds the minimal requirements for buffer areas, with widths varying between 23m to over 400m. The importance of the riparian functions in the upper catchments of the area are supported by the draft Structure Plan and exceed the DPI Water guidelines.

The study found that over 60 per cent of the riparian corridors in the Precinct are protected and are to be managed for environmental conservation.

The ELA report identified that the draft Structure Plan does not impose any additional road crossings extending which may further fragment riparian areas. Further recommendations from the ELA study include the provision of riparian protection areas situated along Wirreandra, Cicada Glen, Narrabeen and Mullet Creeks and their tributaries. Protection measures identified include detainment and treatment facilities or expanding the buffer zone are, and these should be situated adjacent to riparian corridors and vegetated with local native species. The incorporation of

additional wetlands is to be considered and open space and/or conservation lands are to rejuvenate aquatic habitats where possible.

7.3.6.3 Biodiversity credits and offsets

The new *Biodiversity Conservation Act 2016* commenced in August 2017 and is a key pillar of the NSW Government's framework for biodiversity assessment and management, together with the land management framework established in the *Local Land Services Act 2013* (as amended by the *Local Land Services Amendment Act 2016*).

The *Biodiversity Conservation Act 2016*, with the *Biodiversity Conservation Regulation 2017*, outlines the framework for addressing impacts on biodiversity from development and clearing. Its purpose is to avoid, minimise and offset impacts on biodiversity from development through the Biodiversity Offsets Scheme.

Noting the current draft Structure Plan was derived ahead of the recent introduction of this legislation, it now seemingly requires a greater number of biodiversity credits to be accommodated, from the loss of good condition native vegetation to accommodate development. One option available to reconcile the biodiversity credits and offsets situation is to place higher focus on retaining larger consolidated areas of native vegetation or the identification of areas of native vegetation which can possibly improve ecological connectivity. Such an outcome would further heighten the strategic challenge prevailing within in Ingleside with regard to bushfire hazard versus ecological value and maintaining a 'green character'.

7.3.6.4 Synthesis of environmental risk factors

The combined desire to create a 'green character', to preserve ecological corridors and limit biodiversity offsets, and to develop a land use planning/settlement pattern rationale which is bushfire resilient are not aligned. Where only localised bushfire risk is present, it is essentially 'easier' for these competing interests to co-exist however, this is less appropriate in landscape risk environments where fragmented vegetation inadvertently invites fire into urban and semi-urban areas either by the fire front itself or via spot fires which can grow to a considerable intensity before being drawn back in toward the direction of the approaching fire front. This creates an environment of confusion as communities encounter a 'landscape of fire' and become uncertain of where the fire front actually is.

This is an existing risk issue facing Ingleside at present however, the draft Structure Plan does not respond to this issue. Whilst Asset Protection Zones and a range of other measures can be adopted, the question of whether the draft Structure Plan is appropriate having regard to urban fire intrusion via vegetated corridors needs to be addressed. This may require some level of prioritisation with regard to density and built form versus ecological values.

It may be the case that corridor enhancement can be achieved via lower-fuel options i.e. altering the ecological status of the corridor by omitting high-risk species and altering the vegetation community, or by deliberately narrowing the proposed corridors to an extent that maximum rate of spread cannot be achieved (circa 80m), or by focusing on the use of fire-wise species. Whilst this may augment the environmental intent of the corridors, it could offer a suitable trade off against bushfire risk.

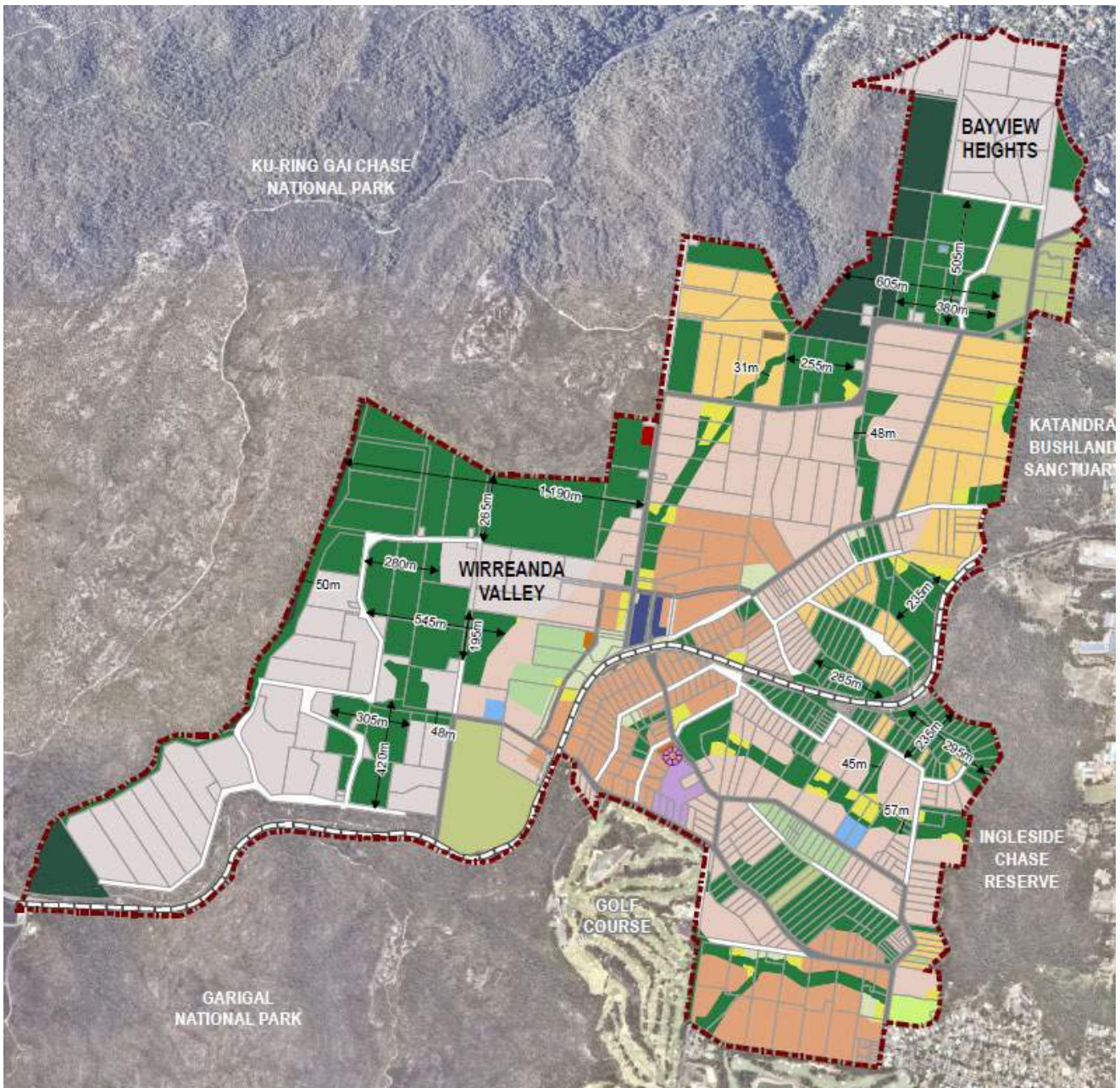


Figure 22 - Approximate extent of proposed vegetated corridors

7.3.7 Economic risk

The specific existing and potential future economic risk from bushfire in the Ingleside Precinct is challenging to identify however, there remain a number of key indicators worthy of consideration. Firstly, the total economic costs of bushfires in NSW and the ACT is currently estimated at \$100m per annum, expected to grow in costs by 2.2% each year to 2050, on a national basis (Climate Council, 2016). This does not take into account the potential impact of climate change.

Secondly, the Insurance Council of Australia has identified that following disaster events across the country, approximately 1 in 20 properties are not insured; approximately 70 per cent of properties are under-insured and about two-thirds of renters do not have contents insurance (Wynne, 2017). One of the critical issues in this regard is understanding that 'insured value' is not just the construction or purchase price, but must take into account current building standards – including compliance with AS3959 which can add a substantial cost onto the rebuild of the exact same dwelling, if built prior to current standards (Wynne, 2017).

The Australian Business Roundtable for Disaster Resilience and Safer Communities and Productivity Commission Inquiry Report into Natural Disaster Funding Arrangements outlined earlier in this report provide additional economic risk context for consideration.

In 1994, the Cottage Point fire caused an estimated \$12,115,053 in property loss and damage (in 1995 dollars) (Hiatt et al. 1995). This property loss estimate does not include the cost for response or full community recovery. Thus, there remains a history of economic loss and damage in the area, to be considered.

Extended economic costs of bushfire can include loss to the local tourism industry, loss of environmental values, nature reserves, parks and infrastructure, loss of agricultural production/business (noting the existing stature of equine industry activity currently occurring in Ingleside), loss of cultural heritage values, etc. (Handmer & Haynes, 2008).

The draft Ingleside Land Use and Infrastructure Strategy incorporates extensive investment in the Precinct to deliver amenity and infrastructure servicing and networks to facilitate development, into the hundreds of millions of dollars. The protection of this investment (and the infrastructure itself) must therefore form a key consideration with respect to the development potential of the Precinct.

7.3.8 Other consequences

While life safety should be seen as the most important aspect of decision making for land use planning, evacuation and bushfire risk management, there are a wide range of other considerations that must inform all decisions to ensure a resilient Ingleside.

There is an expectation that new communities are located, design and developed to be able to withstand bushfire impacts however, the question is whether this expectation applies to the full scale of potential events including catastrophic events.

The social impacts of natural disasters, including those on health and wellbeing, education, employment and community networks are significant. The social costs of natural disasters equal the more traditionally defined economic costs – and are sometimes even higher. It is clear that a greater effort should be invested in the preparedness of individuals, in particular long-term psycho-social recovery.

The Australian Business roundtable⁴ have stated that further investment in disaster resilience is essential to lessen the forecast increase in costs. This includes physical measures, such as resilient infrastructure, and community measures, such as preparedness programs.

Investment in disaster resilience yields a double dividend. First, in the avoided impacts of disasters when they occur. And second, in the broader co-benefits that arise even in the absence of a disaster. For infrastructure investments, for example, co-benefits may include employment opportunities, improved service reliability, greater business confidence and incentives for innovation. Such co-benefits support economic growth and social capital in Australian communities.

The other considerations that must be included in the development of a bushfire responsive land use strategy for the Ingleside Precinct include:

Insurance

The ability to secure affordable insurance cover for residential, commercial and other assets which adequately covers all eventualities. This is critical to provide confidence to homeowners, mortgage lenders, business and the community, and to encourage investment and economic prosperity. Insurance is also critical for response and recovery from any disaster.

⁴ Australian Business roundtable for Disaster Resilience and Safer communities: *Building resilience to natural disasters in our states and territories* 2017

For example, uninsured or underinsured business in the Lismore CBD following flooding from Cyclone Debbie in early 2017 contributed to up to 1 in 6 businesses not re-opening 5 months after the floods, which impacts significant on individual owners, their supplies and customers, family and community, along with the economic vitality of the CBD and attractiveness for investment and activity. Under insurance is a major risk to the government, who will be expected to step in and assist those impacted by a natural disaster.

Property values

Following major disasters property prices can respond negatively depending on the location and extent of damage sustained, damage to nearby properties, amenity values, business and other impacts. Property values in eastern Christchurch (worst impacted by the earthquakes) fell significantly, while areas not badly damaged recovered much quicker. In Bundaberg following flooding in 2011, some land values fell by extremes of up to 40%. Across south-east Queensland the lower end of the market in areas affected by flooding saw a downward trend in values that lasted for some time before rebounding, due mostly to visible effects of flooding lingering in those suburbs.

The potential implications, perceived or real, of bushfire hazard and risk mapping, land use changes or other policy changes that may affect the value of existing real estate also need to be considered.

Socio-economic considerations

The most recent business roundtable report *Building resilience to natural disasters in our states and territories* provides compelling evidence and case studies that the intangible costs of natural disasters are as high as, or higher than, tangible costs. Often intangible costs persist over a persons' lifetime while most tangible costs are a one-off. Some of those costs include direct health care system costs, productivity loss, costs of informal care, non-pecuniary costs, administrative and other costs, transfer payments, mental health, family violence, displaced families and disconnected communities and a whole range of other impacts that are felt by families, friends, colleagues and tax payers.

Community wellbeing and resilience

The psychological impacts of natural disasters can range from mild or even positive opportunities for some individuals, to serious mental health implications, relationship breakdowns, impacts on employment, crime, social networks and others. Resilience of individuals and communities needs to be built up prior to natural disasters, through awareness, planning and preparing, etc. Land use planning plays an important role in avoiding or mitigating the worst effects of bushfire and other natural disasters, and how the community and individuals can respond to and recover from disasters.

7.3.9 Summary of risk consequence

Risk consequence relevant to the Ingleside Precinct is identified on a sliding scale or spectrum and cannot be considered in isolation of likelihood. A FFDI 100 fire weather event is adopted for the purposes of considering consequence. At FFDI 100, the consequence of fire is catastrophic but fire does not derive the same level of impact uniformly across people, property, infrastructure, the environment or the economy – thus, the need to consider a sliding scale of events relative to FFDI.

The consequence criteria provided by NERAG is not fit-for-purpose when discussing land use planning risk. Rather, it was derived for emergency services utilisation, noting this risk assessment (whilst it intersects with emergency management) serves a land use planning purpose only.

Rather, the current Fire Danger Rating Index (FDR) system makes a point of clearly articulating community messaging regarding the risk to the community during certain events and from which clear expectation is thus set in terms of the potential impact on the community and built environment. **Table 6** below presents a bushfire consequence criteria system specifically for land use planning purposes.

On the basis of the below, it will depend upon the nature / scale of the event as to the extent of consequence noting however, the FFDI 100 fire weather event is in fact in the Catastrophic category, thus the need to plan for infrequent but highly extreme events as well as the more frequent but less extreme events.

Table 6 - Land use planning bushfire consequence criteria

NERAG Level	Fire Danger Rating	NSWRFS Community Messaging	Risk Consequence for Land Use Planning
Catastrophic	CATASTROPHIC	<p>For your survival, leaving early is the only option.</p> <p>Leave bush fire prone areas the night before or early in the day – do not just wait and see what happens.</p> <p>Make a decision about when you will leave, where you will go, how you will get there and when you will return.</p> <p>Homes are not designed to withstand fires in catastrophic conditions so you should leave early</p>	<p>Significant property and infrastructure loss / damage</p> <p>Displacement of community</p> <p>High reconstruction costs and protracted community recovery (years)</p> <p>Potential life loss may occur</p>
Major	Extreme	<p>Leaving early is the safest option for your survival.</p> <p>If you are not prepared to the highest level, leave early in the day.</p> <p>Only consider staying if you are prepared to the highest level – such as your home is specially designed, constructed or modified, and situated to withstand a fire, you are well prepared and can actively defend it if a fire starts.</p>	<p>Property and infrastructure loss / damage</p> <p>Displacement of parts of the community</p> <p>High reconstruction costs and protracted community recovery</p> <p>Potential life loss may occur</p>
Moderate	Severe	<p>Leaving early is the safest option for your survival.</p> <p>Well prepared homes that are actively defended can provide safety – but only stay if you are physically and mentally prepared to defend in these conditions.</p> <p>If you're not prepared, leave early in the day.</p>	<p>Potential property and infrastructure loss / damage</p> <p>Displacement of parts of the community</p> <p>Reconstruction costs and protracted community recovery</p>

Minor	Very High	Review your bush fire survival plan with your family. Keep yourself informed and monitor conditions. Be ready to act if necessary.	Some potential for property and infrastructure damage
	High		
Low Moderate			
Insignificant			

7.4 Defining ‘acceptable’ land use planning risk

With respect to land use planning for natural hazards, defining exactly what represents ‘acceptable’ risk can be a difficult task. Understanding community expectation of what represents acceptable risk versus unacceptable risk is the basis of much research both in Australia and internationally.

Whilst flood hazard has the benefit of a national best practice framework in place, guided by AIDR Handbook 7 – Managing the Floodplain, there is no similarly overarching national best practice framework for undertaking bushfire risk assessments.

Irrespective of the type of natural hazard, there is a difference between property risk and life safety risk. Development up to bushfire attack level (BAL)-29 (for new subdivisions) either tacitly or explicitly results in acceptance of bushfire risk beyond this extent by government for property – house loss has and can occur beyond the minimum BAL-29 extent (irrespective of whether a dwelling is constructed to AS3959 or not). Thus, bushfire protection measures such as Asset Protection Zones, etc. can be applied and so forth but there remains an understanding that despite this combination of planning, building and other bushfire protection measures, house loss may still occur in more extreme events.

However, the issue of risk acceptability is about risk to life, and the identified need to examine the broader consideration of holistic bushfire risk management sought by governments and communities. Whilst this is more than just the ability to evacuate, this does represent much of the bottom line. Thus, the key to risk acceptability in this regard is ensuring from a government perspective that all necessary risk treatment measures are considered and applied to minimise risk.

Consistent with other land use planning approaches to dealing with natural hazard across NSW and as a principle, the level of exposure can increase, but not the level of risk. That is, the number of dwellings subject to maximum BAL-29 may increase in line with the prevailing statutory framework to potential support development within Ingleside, however, the risk for life safety, property damage and infrastructure resilience should be minimised through appropriate risk mitigation measures. This means that additional resilience measures need to be analysed and initiatives taken to improve the resilience of existing assets, preserve life safety, and ensure new development is also able to withstand and ‘bounce back’ from any potential effects from large-scale/intense bushfire events.

The recent Productivity Commission Inquiry into natural disaster funding arrangements (2014) made the following statement:

‘Responsibility ultimately rests with state governments to clearly articulate the state-wide natural disaster risk appetite in planning policy frameworks and the embedded trade-offs, guide local governments’ interpretation and implementation of these policies, and ensure that local planning schemes and development decisions are consistent with state planning policy’.

The ALARP (as low as reasonably practicable) principle is commonly applied to define boundaries between risks that are generally intolerable, tolerable and broadly acceptable, and is a useful tool, particularly for land use planning purposes, notwithstanding it was removed from the most recent version of NERAG. It helps to prioritise a risk hierarchy and determine which risks require action and which do not.

Section 4 of the 2018 PBP incorporates a number of key strategic planning principles and criteria which define instances where development can be facilitated, and those instances where bushfire

risk is so great that further development becomes inappropriate. It is these principles and criteria which are adopted for the purposes of benchmarking this assessment. This is expanded upon throughout this report and evaluated at Section 11.

7.4.1 Risk of property loss

The CSIRO, in conjunction with the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC), remain among the leading property loss research agencies in Australia, having produced a multitude of reports, studies and tools to assist in developing a solid evidence base to support policy-level decision-making.

With respect to property loss, CSIRO studies have found that approximately 98% of all building loss has been found to occur on days when the FFDI exceeded 45 (Blanchi & Lucas, 2010). In events where the FFDI exceeds 50, fire suppression at any part of a fire line is virtually impossible due to the intensity and unpredictable behaviour of a fire (Leonard & Blanchi, 2012). Land use planning, building design, fuel management, strategic intervention of fire brigades and community preparedness are the only effective defence mechanisms available once the FFDI has exceeded 50 (Blanchi & Lucas, 2010; Leonard & Blanchi, 2012).

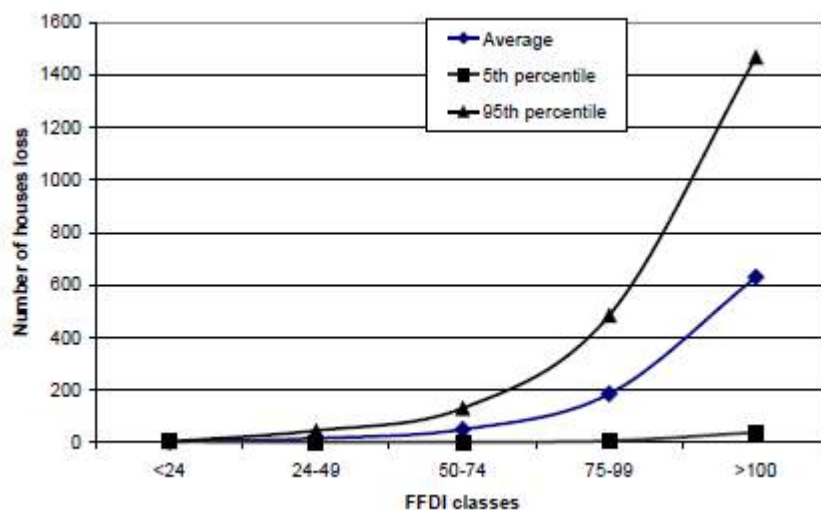


Figure 23 - Average house losses for different FFDI classes (Source: Leonard & Blanchi, 2012)

Extensive property loss research reveals that approximately 80 per cent of property loss occurs within 100m of the bushland interface, with the full extent of loss typically occurring within circa 700m of the bushland interface in urban contexts (Leonard & Blanchi, 2012; McAneney & Chen, 2004 and Ahern & Chladil, 1999). This is particularly relevant given recent bushfire disasters across the globe which have penetrated urban areas.

Based upon GIS data, no part of the proposed Ingleside Precinct is more than 700m from either landscape or localised hazard sources. That is to say, the entirety of the Precinct is within the full observed extent of property loss.

Of the above 80 per cent property loss extent (100m from bushland), approximately 80 per cent of dwellings lost to bushfire are lost as a result of ember attack, or the combined effect of radiant heat and subsequent penetration of embers which impact upon the most vulnerable parts of a dwelling (doors, windows, decks, roof spaces, etc.).

Current statutory frameworks address the risk of property loss via the implementation of planning and building controls, including a range of measures which represent a combination approach to limit the reliance on any one mitigation measure. Overall, this approach works to enhance property resilience. For new subdivisions, this includes the exclusion of any BAL outcomes higher than BAL-29, the implementation of urban design measures to enhance separation and implement management zones or Asset Protection Zones, as well as road network requirements, water supply, landscaping and building design and construction measures. This approach seeks to separate dwellings from

nearby bushland and represents the current 'tolerable threshold' for statutory instruments, once a strategic decision has been made with regard to the appropriateness of the risk profile of a location or landscape to accommodate development.

These strategic approaches are only recently emerging. Thus, historical perceptions of bushfire risk management have focused on design-based approaches as being sufficient (i.e. that bushfire risk management can simply be 'mitigated by design'). However, it is now universally understood that such measures are not sufficient to determine 'acceptable' risk without fit-for-purpose strategic-based assessment of risk, particularly from a land use planning perspective (i.e. addressing the question of whether a land use action 'should' occur, versus 'how').

Within the Precinct, and despite previous investigations which focussed almost exclusively on 'mitigation by design', the question regarding the appropriateness of development of Ingleside is more strategic and one that statutory planning measures cannot answer, and were never designed to answer. Statutory planning measures exist to reduce risk – only once a decision has been made at a strategic level with regard to the appropriateness of the strategic / landscape risk profile of an area and its suitability for development or population increase.

Section 8 incorporates an analysis of property risk including the extent of the existing area as well as the proposed Precinct which is identified as subject to potential flame contact, radiant heat exposure and ember attack.

Having regard to the above however, it is likely not the case that risk to property is the paramount issue for Ingleside (though it is one of several matters) – on the basis that a level of property loss is 'accepted' to a degree by existing land use planning and building construction frameworks. Property and infrastructure may be lost in a catastrophic event, but the key determinate of 'acceptable' risk is life safety risk, and the bottom line is whether the proposed land use rationale, density and settlement pattern supports and enables life safety, including safe evacuation.

7.4.2 Risk of life loss

In considering risk to life, it is incumbent to examine historical bushfire-related life loss research. In 2012, the CSIRO in conjunction with the former Bushfire Corporative Research Centre undertook a comprehensive study into matters of both life and house loss across utilising over 110 years (1901-2011) of data across 260 bushfire events (Blanchi et al. 2012). Over this period, a total of 825 known civilian and firefighter fatalities have occurred (Blanchi et al. 2012).

Important findings of this seminal research are as follows:

- it is evident that fire weather and proximity to forest are very strong contextual drivers for defining the potential for fatalities to occur;
- 85 per cent of fatalities occur within 100m of bushland;
- 50% of all recorded fatalities have occurred on days exceeding FFDI 100 (most fatalities occur as a result of infrequent but high magnitude events);
- late evacuation is the most common activity persons were engaged in at time of death (30.3 per cent) followed by sheltering inside a structure (24.8 per cent) and defending a property outside (22.4 per cent);
- for those instances where sufficient data is available with respect to fatalities occurring during the act of evacuation, most were trapped on roads by either fallen trees or become bogged, the remainder having run off the road due to poor visibility as a result of smoke conditions;
- in terms of location of fatal exposure, 50 per cent occurred out in the open (including persons found outside structures and outside vehicles), 28 per cent occurred inside structures and in events where FFDI exceeded 100, fatalities within structures represented over 75 per cent of life loss;

- the percentage of fatalities within structures appears to be increasing over time, mostly attributed to the 2009 Victorian Bushfires where 118 of the 173 fatalities occurred inside a structure;
- during the 2009 Victorian Bushfires, findings demonstrate that most of those persons who lost their lives 'could not respond appropriately to the risk the bushfire presented' on that day;
- increasing percentages of fatalities occurring within structures in later fires (1965-2011) were persons aged 65 and over, as well as those with physical and / or mental disability;
- most fatalities occur between the hours of 3pm and 9pm – when FFDI is at its peak (3pm) and when summer cool-change winds occur. 90 per cent of fatalities occur immediately after afternoon wind changes;
- 41.9 per cent of fatalities which occurred from 1965 to 2011 'were aware of the fire with enough time to save their lives; had a fire plan and were following intended actions which were ineffective', with 21.8 per cent who also had enough time to save their lives but either had no fire plan or that plan was not followed, and includes persons who were 'waiting to see'. 10.9 per cent were unaware of a fire and only realised when it was too late, and a further 10.7 per cent were either children or adults following the instructions of another person. 6.1 per cent were either physically or mentally incapable of implementing an effective survival strategy (Blanchi et al. 2012).

In considering the above findings, there remain two key contextual matters which reflect the extent of fatalities in certain situations, including:

1. there is a direct relationship between fire intensity (as a function of FFDI) and both property and life loss, over distance from the bushland interface; and
2. the afternoon cool-wind change is likely a key phenomenon in situations where life loss occurs. These winds change the direction of the fire front, where the wide fire flank transitions to the head of the fire, creating a drastic spike in fire intensity and rate of spread over a wide distance and in a direction which is not anticipated by the general community. These situations can lead to higher proportions of people taking passive shelter (i.e. the window to evacuate has passed) and attempting late evacuation. Topographic conditions can also result in the same effect, where residents may not be aware of an approaching fire until it reaches a nearby ridgeline.

In addition and in contemplation of the various recorded situations which led to fatalities as a result of evacuation, it is critical to note none of these scenarios (tree fall, vehicle bogged or crash/run off the road) are readily able to be effectively modelled by traffic / evacuation assessments, a result of situations occurring on the day and which cannot be easily anticipated (general likelihood of these scenarios may be anticipated but not location, etc.).

Planning for bushfire evacuation is an immensely difficult task. Unlike flood and other events, bushfire events are not a 'known quantity'. There is no surety in when or where an ignition may occur, the direction it may spread, the extent of possible ember attack, etc. The impact of smoke and limited visibility in emergency situations, coupled with wind impact, can lead to issues on the road network as residents attempt to evacuate as per above.

Evacuation planning processes also presuppose that the intended location in which one seeks to evacuate to, and the pathway to get there, is safer than from which they came. This represents a drastic assumption and significant shortfall in any attempt to conceptualise a person's decision-making and behaviour in an emergency situation, even in instances where a fire plan may be in place and be acted upon.

The extent of warning time and ability to evacuate to safety (including the aspects of access and egress) represent the most fundamental characteristics which determine risk to life. In this sense, there are three key elements of relevance to land use planning:

1. The extent of warning time available (window of evacuation opportunity);

2. How the settlement pattern supports / enables:
 - a. separation from hazard sources;
 - b. limits urban penetration of fire by built form; and
 - c. the act of community evacuation (processes); and
3. Evacuation destinations (designated evacuation centre or Neighbourhood Safer Place [NSP]).

Whilst it is the preference of emergency and disaster managers in Australia that persons evacuate to the home of friends or family – which is certainly not contended by this risk assessment – it is the role of land use planning to allocate land and identified planning-based measures to enable strategic decisions to be made in the future with regard to evacuation facilities and NSPs. Thus, whilst such formalised evacuation locations may not be the preference of emergency and disaster managers, land use planning should not inadvertently void the option or require retrofitting to community infrastructure at a later date as a result of limited-range strategic planning.

Given the above factors, whilst land use planning can facilitate the design of a multi-optioned road network (among other things) to underpin emergency evacuation, evacuation is principally an emergency management process which is subject to any range of circumstantial factors which may occur prior to and during an event. Whilst these can be explored to an extent, it is incumbent upon government stakeholders to ultimately decide if the proposed road network is acceptable from an emergency evacuation perspective.

In analysing this question, the following key points remain relevant for consideration by this risk assessment and project stakeholders:

- the estimated population increase from 1,080 to 9,000 people;
- the historic impact of previous fire events in Ingleside;
- the topography and natural environment within which Ingleside is located; and
- The existing / proposed evacuation options out of the Precinct (all of which traverse National Park / Conservation land to exit Ingleside).

Thus, any Structure Plan for the Ingleside Precinct relies on stakeholder (i.e. local and State government, and fire service) agreement that sufficient evacuation opportunity is afforded by any such Structure Plan insofar as land use planning can contribute, recognising the broader range of factors and processes involved in evacuation activities.

8 Bushfire Risk Analysis

8.1 Risk analysis methodology

The risk analysis component of this land use planning-based risk assessment involves several discrete methodologies. Broadly, the risk analysis is informed by:

- Preparation of fireline intensity assessment (bushfire behaviour assessment) with a focus on a planning-based design scenario of FFDI 100 on a SW – N fire wind (as the primary fire driven wind)
- Preparation of risk exposure mapping based on a primary loss extent (representing the spatial extent of 85 per cent life loss and 80 per cent house loss from bushfire in Australia) relevant to the design fire scenario derived above
- Data interrogation of the above spatial extents to examine the extent of land subject to existing versus proposed risk, including proposed land use zoning extents

A discussion of overall risk is subsequently provided on the basis of observations drawn from the above data analysis process and findings.

8.2 Fireline intensity assessment

In accordance with PBP 2018 which requires a landscape risk analysis relevant for strategic planning purposes, a bushfire intensity assessment has been undertaken by ELA and is included at **Appendix C**. The intent of this assessment is to identify the hazard landscape and the key fire runs relevant to the Ingleside Precinct.

A fireline intensity approach has been adopted, consistent with that process undertaken for other planned precincts across metropolitan Sydney. This approach was discussed at an early stage with NSWRFs to confirm its acceptability and appropriateness for use. Advice from NSWRFs confirmed the acceptability of the approach but placed emphasis on how the data from the assessment would be used to inform 'risk'.

As noted by Leonard et al. (2014) '*at a landscape scale, the preferred metric for indicating the potential severity of these impact mechanisms is fire-line intensity. Fire-line intensity is a standardised measure of the rate that an advancing head fire would consume fuel energy per unit time per unit length of fire front introduced by Byram (1959)*'.

Leonard et al. (2014) goes on to provide that '*one of the main benefits of the fire-line intensity metric is that it can be used to estimate the potential flame length (e.g., Byram, 1959; Alexander and Cruz 2012) and thus the radiant heat expected at various distances from potentially hazardous vegetation. Radiant heat measures can in turn be used to estimate required minimum distance from hazardous vegetation needed to afford safety levels to people and/or buildings (e.g. Cheney, Gould et al. 2001; Zárate, Arnaldos et al. 2008; Siggins, Newnham et al. 2013). Fireline intensity can also be used to derive estimates of flame length, radiant heat and other fire metrics to provide approximate estimates of Bushfire Attack Level (Standards Australia, 2009), which can provide a connection between landscape scale bushfire metrics and site level decisions for building design*'.

On this basis, fireline intensity assessment presents a fit-for-purpose approach to bushfire hazard mapping for this project. This assessment is then transitioned into risk mapping to critically analyse the extent of the proposed development area which is subject to flame contact, radiant heat and ember attack.

8.2.1 Fire run scenarios

A series of different fire weather scenarios are adopted for the purposes of this assessment. Firstly, it is important to consider historical fire weather to determine the 1 in 50 year event attributes based upon maximum FFDI recorded as well as wind direction, measured at both the Sydney Airport and

Richmond weather stations, being the two closest to Ingleside. This methodology is set out in further detail by ELA at **Appendix C**. The FFDI for a 1 in 50 year event is as follows:

Table 7 - FFDI for a 1 in 50 year event (Source: ELA, 2018)

Weather Station	Max Recorded FFDI	All directions	N to SE	SE to SW	SW to N
Sydney Airport	116	116	63	47	116
Richmond Airport	96	105	52	45	105

The 1 in 50 year event represents a very similar design event utilised for existing planning and building controls across Australia, including AS3959. For the Sydney metropolitan area, this FFDI is 100.

On the basis of the data formed in **Table 7** and upon discussion with project stakeholders, a range of fire weather events were identified upon which to create several hazard mapping scenarios, these are as follows:

1. N to SE wind – FFDI 63
2. SE to SW wind – FFDI 47
3. SW to N wind – FFDI 116
4. Average of the above scenarios
5. SW to N wind – FFDI 62 (representing the approximate conditions experienced on 8 January 1994 during the Cottage Point fire)
6. SW to N wind – FFDI 100 (reflecting current planning and building provisions for metropolitan Sydney)
7. SW to N wind – FFDI 134 (representing the conditions experienced on Black Saturday in Victoria and potential climate change conditions).

These scenarios have been produced by ELA to reflect both:

1. Existing hazard – the current settlement pattern of Ingleside
2. Proposed hazard – the proposed draft Structure Plan settlement pattern.

These scenarios are mapped at **Appendix C**, providing a spatial representation of potential fireline intensity impact relevant to the Ingleside Precinct.

8.2.2 Fire run modelling results

On the basis of results contained at **Appendix C**, the most significant threat to the Ingleside Precinct on a landscape scale is primarily associated with vegetation external to the Precinct to the north, north-west, west, south-west and south. To a lesser extent, threat is also present to the south-east, east and north-east on the basis of more constrained fire runs, but fire runs which are still able to reach maximum rate of spread. In essence, the entirety of the Precinct is surrounded by potential fire runs which have the ability to penetrate the Precinct subject to varying wind conditions (and subsequent intensity) on the basis of localised hazard relating to patches and corridors of vegetation which exist, and are intended to be retained within the Precinct.

The Bushfire Intensity Assessment performed by ELA at **Appendix C** demonstrates the most severe fire run threat is associated with vegetation occurring within both Ku-ring-gai Chase National Park and Garigal National Park, with the most severe fire wind driven from the south-west through the north. To this end, the primary threat to the Ingleside Precinct is from an ignition occurring within Ku-ring-gai Chase National Park, driven on a hot and dry westerly wind, similar to that which occurred

in the 1994 Cottage Point fire. A late afternoon wind change could 'turn' the fire in a direction which residents may not anticipate, correlating with a dramatic and intensified fire front, densification of ember attack and increased radiant heat flux on approach to Ingleside. Winds are also likely to increase in such a scenario, both that driving the main fire front, and opposing ground-level winds as oxygen is drawn back toward the main fire front. Such a situation can result in multi-directional fire approach – as spot fires are drawn toward the main fire front in an opposing direction. These situations can confuse residents who become disorientated and are unable to clearly detect where the main front is and its direction.

8.3 Risk exposure mapping

Whilst fireline intensity assessments derive considerable information in terms of the context and characteristics of the hazard using various scenarios, it continues to map the hazard and not necessarily exposure to risk.

Handbook 7 – Managing the Floodplain provides national best practice methodologies with regard to the risk assessment, evaluation and treatment of flood risk (noting that a similar national framework for bushfire does not currently exist). In analysing flood risk, the concepts of how flood depth and velocity impact of dwellings/building is fundamental in critically assessing risk. Similarly for bushfire, the impact of potential flame contact, radiant heat exposure and ember attack are relevant – but it cannot be assumed that 100 per cent of dwellings subject to bushfire attack are likely to be lost.

Having regard to the above, risk exposure mapping has been developed (**Appendix D**) for:

1. Landscape risk exposure (including localised patch and corridor 'filtering' as per PBP 2018)
 - a. Existing risk – the current settlement pattern of Ingleside (2017 cadastre)
 - b. Proposed risk – the proposed draft Structure Plan settlement pattern
2. Localised risk exposure (distinct from landscape-level risk)
 - a. Existing risk – the current settlement pattern of Ingleside (2017 cadastre)
 - b. Proposed risk – the proposed draft Structure Plan settlement pattern.

Table 8 – Risk exposure mapping methodology

	Existing risk	Proposed risk
Landscape risk exposure	Current settlement pattern of Ingleside (2017 cadastre) FFDI 100 on SW-N fire wind Includes patch and corridor 'filtering' as per PBP 2018 – removing small, narrow and isolated patches and corridors of vegetation which do not contribute to landscape-level risk Bushfire hazard extent Exposure extents (based on upper extent of 80 per cent house loss) for: Potential flame contact Radiant heat exposure Ember attack	Proposed draft Structure Plan settlement pattern FFDI 100 on SW-N fire wind Includes patch and corridor 'filtering' as per PBP 2018 – removing small, narrow and isolated patches and corridors of vegetation which do not contribute to landscape-level risk Bushfire hazard extent Exposure extents (based on upper extent of 80 per cent house loss) for: Potential flame contact Radiant heat exposure Ember attack

Localised risk exposure	<p>100m risk extent – reflects 85 per cent life loss zone, and is current extent of statutory planning and building controls</p> <p>700m secondary loss extent</p>	<p>100m risk extent – reflects 85 per cent life loss zone, and is current extent of statutory planning and building controls</p> <p>700m secondary loss extent</p>
	<p>Current settlement pattern of Ingleside (2017 cadastre)</p> <p>FFDI 100 on SW-N fire wind</p> <p>All patches and corridors within the Precinct remain. Focus is adjusted to account for localised risk associated with internal patches and corridors of vegetation, as per the current settlement situation in Ingleside</p> <p>Bushfire hazard extent</p> <p>100m risk extent – reflects 85 per cent life loss zone, and is current extent of statutory planning and building controls</p>	<p>Proposed draft Structure Plan settlement pattern</p> <p>FFDI 100 on SW-N fire wind</p> <p>All patches and corridors within the Precinct remain. Focus is adjusted to account for localised risk associated with internal patches and corridors of vegetation, as per the current settlement situation in Ingleside</p> <p>Bushfire hazard extent</p> <p>Application of indicative asset protection zones, as a function of vegetation formation and slope</p> <p>100m risk extent – reflects 85 per cent life loss zone, and is current extent of statutory planning and building controls</p>

Landscape-scale risk is the primary focus of this risk assessment. This is on the basis that localised risk is of a lower scale and more readily-able to be mitigated and managed via the suite of BPMs outlined in PBP 2018 than is landscape level risk. Section 4 of PBP 2018 recognises the need for Strategic Bushfire Studies to contemplate the threat posed by landscape-scale risk. Statutory measures may only go so far in protecting against landscape-scale risk. Further, a ‘combined’ risk exposure mapping scenario assumes all vegetation (both landscape and localised) is burning at the same time, which is unlikely to be the case. Thus, the desired to remove small and narrow patches and corridors⁵ of vegetation from the landscape risk analysis.

Based upon stakeholder feedback, principally that received by NSWRFs at a workshop conducted on 30 April 2018, the above methodology was supported.

The suite of risk exposure maps utilise a baseline FFDI 100 SW-N fire wind scenario (representing current worst case scenario as maintained by existing planning and building provisions for metropolitan Sydney). Thus, it is important to note the risk exposure maps reflect a catastrophic fire event.

For each of the existing and proposed risk exposure scenarios outlined above, the hazard mapping produced by ELA has been intersected with life and house loss extent data to reflect a risk-based approach.

As previously noted, existing Australian research reveals that 80-90 per cent of property loss occurs within 100m of the bushland interface, with the full extent of loss typically occurring within circa 700m of the bushland interface in urban contexts (Leonard & Bianchi, 2012; McAneney & Chen, 2004 and Ahern & Chladil, 1999). This is particularly relevant given recent bushfire disasters across the globe which have penetrated urban areas.

⁵ Corridors less than 50m in width and patches of 1ha or less, as per PBP 2018

Table 9 - Indicative distances between hazardous vegetation and loss from bushfire for severe events (Source: Leonard et al. 2014, Leonard & Bianchi, 2009; Ahern & Chladil, 1999)

Bushfire Attack Mechanism	Typical upper distance for 80% of all house losses (m)	Typical upper distance for house ignition from forest (m)	Maximum reach (km)
Ember attack	100	700	10
Radiant heat exposure	70	160	Unknown
Flame exposure	50	100	Unknown

Additionally, comprehensive data interrogation performed by CSIRO demonstrates that 85 per cent of bushfire fatalities in 260 events from 1901 to 2011 have occurred within the first 100m of the bushland interface, including persons attempting to evacuate (Blanchi et al. 2012). Importantly, this research notes that these fatalities occurred subsequent to both landscape and localised (i.e. roadside, etc.) vegetation. The 100m extent also reflects the extent of current planning and building provisions.

Notwithstanding the above, no part of the Precinct is more than 700m from adjacent hazard thus, it is the case that the entire Precinct is subject to potential ember attack despite risk mapping which has been prepared on the basis of 'primary loss extent' which is explained in the following section.

The typical upper distance for 80 per cent of all house losses has for some time been the basis of planning and building control instruments across the country which apply mitigation measures for between 100m and 150m from the hazard source. In more intense (catastrophic) events, urban intrusion is more pronounced – such as that which occurred in the Canberra bushfires in 2003 and the Santa Rosa fires in California in 2017, events which have and continue to re-shape approaches to bushfire risk management.

In the Canberra fires, property landscaping, the unique design features (vulnerabilities) of particular homes, timber fencing and house-to-house ignition caused urban fire intrusion which did penetrate approximately 700m into suburbia. This places planning and building responses in sharp focus, as understanding the cause of urban fire intrusion can help us make resilient settlement planning decisions. One explicit element of urban fire intrusion is house-to-house ignition which at present, is not widely mitigated via planning or building controls in bushfire prone areas.

It is on the basis of the above that is important to consider the suite of fireline intensity, bushfire attack mechanisms and life and house loss data to construct a spatial representation of potential risk exposure for both the existing and proposed scenarios for Ingleside.

Refer to **Appendix D** for full-size risk exposure maps.

In addition to risk exposure mapping referenced above, this data has been interrogated via geographic information systems (GIS) processes to analyse the specific extent of existing and proposed risk exposure, having regard to both landscape and localised risk.

8.3.1 Concept of 'primary loss extent'

Both the risk exposure mapping and data evaluation commentary below relates to the concept of the 'primary loss extent'. That is the extent, measured in distance from a landscape-scale hazard source, which reflects the majority of life and property loss from bushfire events in Australia.

As previously noted, 85 per cent of recorded bushfire fatalities from 1901 to 2011 across Australia occurred within the first 100m of bushland. This 100m extent also represents 80 per cent of recorded house loss. This being the case, the first 100m from bushland represents the 'primary loss extent' where the majority of potential life and property loss risk is located.

For this purpose of this risk assessment, the 'primary loss extent' is based upon the landscape risk mapping set (both existing and proposed risk) which continues to incorporate all major patches and corridors of vegetation within the Precinct, but 'filters' out smaller patches (less than 1ha) and narrow corridors (less than 50m in width) by virtue of their inability to support a fire of a magnitude which is likely to reach maximum rate of spread.

This concept is not to say that life and house loss do not occur beyond this 100m extent. However, from a research perspective it does represent the primary (or majority) extent of life and house loss from varying magnitudes of bushfire events in Australia.



Figure 24 - Excerpt of proposed landscape risk exposure mapping, illustrating the 'primary loss extent'

8.3.2 Concept of 'secondary loss extent'

As per **Table 9**, whilst the 'primary loss extent' represents approximately 85 per cent of recorded fatalities and 80 per cent house loss from recorded bushfire events in Australia between 1901 and 2011, the full extent of loss typically occurs within circa 700m of the bushland interface in urban contexts (Leonard & Bianchi, 2012; McAneney & Chen, 2004 and Ahern & Chladil, 1999).

This 700m extent thus represents the 'secondary loss extent'. No part of the Ingleside Precinct is more than 700m from a hazard source thus, the entirety of the Precinct is subject to the 'secondary loss extent'.

Beyond the 100m bushland interface, no existing statutory or building provisions apply, thus the extent of this risk is typically transferred to others such as emergency services, the community and insurers. With growing data trends regarding urban fire intrusion, which is symptomatic of a both vegetated corridors as well as house-to-house ignition, it is clear that risk responsive land use planning has the ability to respond to the 'secondary loss extent' via land use allocation, settlement patterns and density.

8.3.3 Landscape risk exposure

The following sections provide a synopsis of risk analysis data based on hazard and risk exposure based upon area exposed as well as land use extent. This section is to be read in conjunction with the Landscape Risk Exposure – Proposed map included at **Appendix D**.

This section relates primarily to land or property exposure based upon the area of land located within the identified exposure zones. Population exposure is a separate discussion, refer to Section 8.3.4.

8.3.3.1 Wirreanda Valley Sub-Precinct

The Wirreanda Valley Sub-Precinct is not envisaged to accommodate development of any significant extent but remains part of the draft Structure Plan for a number of reasons. Principally, its retention within the Precinct must be on the basis that opportunity exists for the balance of the Precinct to, in various ways, enhance the bushfire resilience of this Sub-Precinct.

It is noted that existing road connections from this area to Mona Vale Road are intended to be removed as part of the road upgrade project. Thus, it is important to consider whether the draft Structure Plan in its current format is improving or in fact reducing bushfire resilience for this Sub-Precinct. Additionally, re-vegetation is proposed throughout this area of the Sub-Precinct which may inadvertently escalate risk (discussed further at Section 8.3.5).

As evident at the table below, there is a negligible decrease in the total proportion of land located within the primary loss extent, and an almost 10 per cent increase in the extent of land which constitutes hazard (i.e. additional vegetated area).

Table 10 - Landscape risk exposure analysis for Wirreanda Valley Sub-Precinct

Extent of land subject to:	Existing	Proposed
Hazard area within sub-precinct	46.55%	55.04%
Potential flame contact exposure	33.66%	26.29%
Radiant heat exposure	39.23%	30.72%
Primary ember attack exposure	44.45%	34.94%
Proportion of land within primary loss extent	90.99%	89.97%
Proportion of land within secondary loss extent	100%	100%

From a draft Structure Plan zoning perspective, the majority of land subject to potential flame contact are roads (including Mona Vale Road [approximately 25 per cent of the extent of Mona Vale Road located within the Sub-Precinct is exposed] which is a key evacuation route for the Precinct), followed by rural and residential land. Of critical note, the proposed re-located rural fire service station and proposed sewer pump station location are both identified as subject to potential flame contact, in addition to other forms of bushfire attack including radiant heat exposure and ember attack.

8.3.3.2 Bayview Heights Sub-Precinct

Similarly to Wirreanda Valley, further development is not contemplated for the Bayview Heights Sub-Precinct. Road upgrades may result in some additional (minor) removal of existing vegetation, as well as intended clearing north of Cicada Glen Road. As demonstrated at the table below, a very minor reduction in the extent of land within the primary loss extent is evident however, the total proportion is still high at 93 per cent.

Table 11 - Landscape risk exposure analysis for Bayview Heights Sub-Precinct

Extent of sub-precinct land subject to:	Existing	Proposed
Hazard area within sub-precinct	58.46%	54.82%
Potential flame contact exposure	30.67%	25.15%
Radiant heat exposure	35.24%	31.25%
Primary ember attack exposure	39.52%	38.19%
Proportion of land within primary loss extent	97.98%	93.00%
Proportion of land within secondary loss extent	100%	100%

Despite these figures, it is noted that both the Coronial Inquiry Report and correspondence issued by NSWRFs to the former Pittwater Council in 2014 noted that development north of Cicada Glen Road should ideally be avoided. Whilst the above table currently demonstrates some marginal reduction in risk of the existing situation, this would likely change with the reversion of development intent north of Cicada Glen Road.

Rural lands and houses on large lots are identified as the most exposed land use zones to all forms of bushfire attack, subsequent to the draft Structure Plan. Land identified for essential infrastructure is also identified as exposed to all forms of bushfire attack, including potential flame contact, relating to the proposed sewer pump station and water reservoir.

8.3.3.3 South Ingleside Sub-Precinct

Some removal of vegetation, coupled with the added fragmentation of small patches and narrow corridors of vegetation (which have been 'filtered' out of this assessment which focuses primarily on landscape-level risk) sees a 10 per cent decrease in hazard extent within the Sub-Precinct. This translates to an overall reduction in the proportion of Sub-Precinct land located within the 'primary loss extent' from 81 per cent to 64 per cent.

Only a small extent of this risk exposure extent relates to landscape-scale hazard associated with any National Park. Rather, the vast majority of the risk exposure extent internal to the South Ingleside Sub-Precinct is associated with patches and corridors of vegetation which penetrate the Precinct from the south-east, connecting with Ingleside Chase Reserve.

Table 12 - Landscape risk exposure analysis for South Ingleside Sub-Precinct

Extent of land subject to:	Existing	Proposed
Hazard area within sub-precinct	33.15%	22.89%
Potential flame contact exposure	31.43%	23.75%
Radiant heat exposure	39.47%	31.21%
Primary ember attack exposure	48.66%	41.36%
Proportion of land within primary loss extent	81.81%	64.26%
Proportion of land within secondary loss extent	100%	100%

With respect to proposed land use zones, roads, houses on large lots and residential land are among the highest exposed proposed land uses. The existing water reservoir is also identified as partially susceptible to potential flame contact.

8.3.3.4 North Ingleside Sub-Precinct

The extent of clearing proposed by the draft Structure Plan within North Ingleside, and acknowledging the effect of small patch and narrow corridor filtering, the exposure of North Ingleside is reduced however, this statistic in isolation of all other compounding risk issues is deceiving and is not the only consideration with respect to the potential development of this Sub-Precinct. Density, settlement pattern and evacuation are all issues which this exposure analysis does not contemplate. This includes the extent of exposure of persons and property within the primary risk extent relating to landscape scale risk, of almost 50 per cent. These matters are addressed at Section 8.3.5 and indicate the risk exposure of North Ingleside is in fact contrary to the data expressed below which only focuses on the extent of vegetation removed to cite proposed development.

Table 13 - Landscape risk exposure analysis for North Ingleside Sub-Precinct

Extent of land subject to:	Existing	Proposed
Hazard area within sub-precinct	38.62%	12.16%
Potential flame contact exposure	36.56%	17.33%
Radiant heat exposure	44.12%	23.41%
Primary ember attack exposure	52.42%	31.91%
Proportion of land within primary loss extent	91.04%	44.07%
Proportion of land within secondary loss extent	100%	100%

In terms of proposed land use exposure, roads and residential zones are the highest exposed areas, including approximately 26 per cent of the Mona Vale Road corridor which forms part of this Sub-Precinct.

8.3.3.5 Strategic landscape risk observations

Overall, 91 per cent of the current Ingleside Precinct is located within the primary loss extent. Pursuant to the draft Structure Plan, over 73 per cent of the proposed Ingleside Precinct remains exposed to the primary loss extent. Despite an 18 per cent reduction, this remains a significant level of continued exposure considering the intended population increase of approximately 733 per cent. In both the current and proposed scenarios, 100 per cent of the Precinct is located within the secondary loss extent.

8.3.4 Localised risk exposure

Localised risk exposure relates primarily to exposure to the extent of hazard contained within the Precinct. As per Localised Risk mapping included at **Appendix D**, the majority of the Precinct is subject to localised risk exposure, in both the existing and proposed draft Structure Plan scenarios.

The only Sub-Precinct subject to an increase in localised risk between existing and proposed is Wirreanda Valley. Similarly to landscape risk exposure, despite some perceived decrease in risk exposure at a localised level, the extent of exposure in each Sub-Precinct is still considerable. All Sub-Precincts remain subject to over 70 per cent localised hazard and risk. When considered in conjunction with the landscape exposure risk analysis above, the apparent reduction in risk actually gives rise to a number of specific nuances requiring further contemplation. These are discussed in the following section.

The proposed draft Structure Plan scenario includes indicative⁶ asset protection zones however, it is acknowledged that minimum separation distances to meet the combined statutory planning and building policy requirements for new subdivision (not to exceed bushfire attack level [BAL] 29) are likely to be larger than the minimum asset protection zone provisions contained within PBP 2018.

Whilst localised risk can usually be mitigated via the identified suite of BPMs contained within PBP 2018 referenced previously, it remains the combination of landscape and localised risk exposure which is of relevance.

8.3.5 Overall exposure and risk analysis

Whilst the above exposure data illustrates a decrease in exposure of land from the existing situation to that proposed under the draft Structure Plan it is important to contemplate that the analysis is based upon land / property exposure – not population. In reality, the proposed population increase means the reverse is true and the extent of population exposure will in fact increase.

Also, despite the perceived decrease in land exposure, the total proportion of land within each Sub-Precinct within the primary loss extent is still significant. Both the Wirreanda Valley and Bayview Heights Sub-Precincts are both intended to retain over 90 per cent risk exposure which is a combination of hazard extent within each Sub-Precinct as well as exposure to the relevant bushfire attack mechanisms of flame contact, radiant heat flux and ember attack. South Ingleside retains over 60 per cent exposure and North Ingleside, over 40 per cent.

North Ingleside is worthy of particular focus. Whilst the exposure analysis (and landscape risk exposure map – proposed) undertaken for the draft Structure Plan (proposed scenario) gives the impression of significant risk reduction for North Ingleside, it is:

- a) intended to be the largest urban Sub-Precinct within Ingleside;
- b) identified to accommodate a higher proportion of the population increase within Ingleside;
- c) subject to a number of existing and proposed vegetated corridors and patches which are linked with areas of landscape risk to the north and west, which may inadvertently promote fire front intrusion into the heart of the Sub-Precinct;
- d) including over 50 per cent of its area (and thus, a considerable portion of its intended population) within the primary loss extent; and
- e) more difficult to service via infrastructure and thus, is intended to be developed after South Ingleside.

The resultant effect of these matters means the development of North Ingleside includes almost 50 per cent of its area within the primary loss extent, which relates to landscape-scape exposure. So whilst a small area could be mitigated from flame contact and radiant, it comes at a cost to a large proportion of properties to achieve this. It is also likely to escalate pressure on the road network from an evacuation perspective. With more people attempting to access the road network in a short period, the development of North Ingleside (following South Ingleside, as provided by the draft Land Use and Infrastructure Strategy) will not increase the number of evacuation options but will add further people and vehicles to the evacuation network. It is however, recognised that design upgrades to Cabbage Tree Road and Minkara Road out of North Ingleside may slightly increase traffic flow from the Sub-Precinct but the bushfire risk to which these roads are currently and intended to remain exposed to is considerable.

8.3.5.1 Evacuation

From an evacuation perspective, approximately 25 per cent of the Mona Vale Road corridor within both the Wirreanda Valley and North Ingleside Sub-Precincts is identified as subject to potential

⁶ Indicative only, not to be used for decision making. APZs shown do not reflect that which may actually be applicable due to data (topographical) constraints

flame contact under the draft Structure Plan. This poses a significant risk to the primary evacuation route (east and west) for the entire Precinct. Additionally, it is noted Garigal National Park rises substantially to meet both Mona Vale Road and Powderworks Road at the north-western extent of the South Ingleside Sub-Precinct. On a south-westerly driven fire wind, a fire event could close both Mona Vale Road and sever access to Powderworks Road the intersection of these two thoroughfares. Whilst Manor Road may remain open to traffic, this situation would severely restrict the evacuation opportunity for residents in Wirreanda Valley, reducing the evacuation network to one option, via Chiltern Road. Accordingly, the resilience of the main arterials poised to support evacuation processes within Ingleside would need to be designed to a level which responds to its vulnerabilities to the magnitude of strategic network risk.

More generally, the extent of potential flame contact exposure to the proposed road network is significant. This is recognising that perimeter roads are identified, however this can become a double-edged sword when this same road network is intended to facilitate evacuation – especially given known behaviours regarding the propensity for late evacuation, despite repeated messaging conveying the need for early departure. Thus, the question of road network resilience to flame contact comes into sharp focus.

Table 14 - Draft Structure Plan road network exposure to potential flame contact (landscape risk - FFDI 100 scenario)

Element of road network subject to potential flame contact	Bayview Heights	North Ingleside	South Ingleside	Wirreanda Valley
Existing Road	74.5%	37.1%	51.7%	56.9%
Major Road	61.9%	41%	33.5%	20.7%

8.3.5.2 Environmental conservation and re-vegetation

Wirreanda Valley is the only Sub-Precinct where revegetation works seek to expand the extent of hazard internal to the Precinct, increasing from 46 per cent to 55 per cent. Approximately 90 per cent of Wirreanda Valley is subject to the combination of hazard extent and primary loss extent, meaning only 10 per cent of land within the Sub-Precinct is more than 100m from bushland. Wirreanda Valley is also constrained from a road network and subsequent evacuation perspective both existing, and given the draft Structure Plan seeks to remove existing road connections from the Sub-Precinct to Mona Vale Road, instead diverting traffic to Chiltern Road.

Having regard to existing land uses, Camp Kedron, the scout camp and other potentially vulnerable activities such as animal rescue shelters, etc. are located in the very northern area of the Sub-Precinct, in the location where revegetation is intended to occur. These existing land uses are considered to be incompatible with the intention to revegetate this area. Revegetation in this area also alters the overall risk profile of Wirreanda Valley as a whole, extending landscape-scale hazard connectivity and the susceptibility of fire intrusion within Wirreanda Valley. The conservation and corridor design of the draft Structure Plan is likely to result in the isolation of the very western extent of the Sub-Precinct which cannot evacuate directly to Mona Vale Road but instead, must traverse bushland within the Sub-Precinct to travel to Chiltern Road. There does not appear to be a safe location within this western pocket for residents to shelter-in-place if evacuation opportunity was constrained.

Whilst revegetation and environmental conservation is important, in instances such as Ingleside such activities must be balanced against matters of bushfire risk and life safety.

8.3.5.3 House-to-house ignition

In addition to vegetated urban corridors which can, depending upon design, inadvertently encourage urban fire intrusion, such intrusion can also result from house-to-house ignition.

House-to-house ignition is caused when one (or more) houses ignite, applying extreme radiant heat to immediately neighbouring dwellings. Depending upon the particular design / vulnerabilities of adjoining dwellings, the application of radiant heat from the burning dwelling can fracture glazing or cause non-piloted ignition of timber building materials, causing adjoining dwellings to also adjacent dwellings. A key mitigation measure to reduce this risk in higher-exposure locations is via land use density. Dwellings on larger lots generally promote building-to-building separation. Whilst this is not a statutory measure identified by PBP 2018, strategic risk-responsive land use planning is positioned to respond to this particular risk.

In the specific context of Ingleside (as established at Section 6) and having regard to the CSIRO research contained at **Table 9**, no part of the Ingleside Precinct is more than 700m away from bushland. As such, the entirety of the Ingleside Precinct is subject to potential ember attack which is a key factor in the propensity for house-to-house ignition to occur.

9 Bushfire Risk Evaluation

The framework for risk evaluation is derived from Table 4.2.1 of Section 4 of PBP 2018, incorporating the content of a Bushfire Strategic Study. This content is slightly expanded to consider additional matters including:

1. Access and egress from an internal and external evacuation perspective;
2. Evacuation centres and neighbourhood safer places; and
3. Disaster management (emergency management preparation).

9.1 Bushfire landscape assessment

This section builds upon commentary provided at Section 6.9 and Sections 7 and 8 of this report which relate to the characteristics of hazard and anticipated primary and supplementary fire runs relevant to each sub-precinct within Ingleside. These sections cover:

- Vegetation formations;
- Topography;
- Fire weather and history; and
- Potential bushfire intensity and behaviour.

PBP 2018 states the landscape assessment '*considers the likelihood of a bush fire, its potential severity and intensity and the potential impact on life and property in the context of the broader surrounding landscape*'.

Based upon the content of these previous sections, the bushfire risk landscape relevant to Ingleside is considered significant. Likelihood of a catastrophic-level event is identified as 'likely' with lower-scale events being more common, and identified as 'almost certain'. Fire weather periods which have exceeded FFDI 100 have occurred on occasion in the region, with a severe event (circa FFDI 62) having occurred in January 1994 being the Cottage Point fire which caused over \$12 million in damage in Ingleside.

Event consequence occurs on a graduating scale – the more extreme the fire weather, the more extreme the consequence. As fire weather increases, the ability for fire suppression by firefighters decreases. As such, potential consequence may be on a spectrum from low to extreme depending upon factors of ignition, fire weather and fuel.

The key factors which inform the bushfire landscape assessment relevant to the Ingleside Precinct, as established previously throughout this report, include:

- Maximum FFDI recorded at either the Sydney Airport or Richmond weather station is 116. Fire weather beyond FFDI 100 has been recorded on several occasions in the area since 1976;
- The 1994 Cottage Point fire impacted the entirety of the Ingleside Precinct. Whilst no fatalities occurred within the Precinct, it caused over \$12 million in damage at that time;
- Each Sub-Precinct is subject to different fire runs but the primary landscape-scale fire runs are associated with Ku-ring-gai Chase National Park to the north-west and Garigal National Park to the south-west. This places North Ingleside, Wirreanda Valley and Bayview Heights in the immediate path of the primary fire run relevant to Ingleside;
- These parks are subject to land management and hazard reduction practices at present;
- Ignitions occurring in the above locations and based upon recorded fire weather patterns, are likely to make a run toward the Ingleside Precinct, and likely to reach maximum rate of spread quickly;

- The FFDI 100 bushfire intensity scenario prepared by ELA at **Appendix C** demonstrates fireline intensity mostly over 30,000kW/m on approach to the Precinct and in major corridors within the Precinct – mostly attributable to Wirreanda Valley and Bayview Heights;
- Ember attack is likely to be severe based on the extent, type, connectivity and arrangement of fuels across the landscape and
- Spotting behaviour is likely to also be severe as ember lead to ignitions in localised patches and corridors internal to the Precinct.

9.2 Land use assessment

Based upon the evidence presented by this report, it is considered the draft Structure Plan is not responsive to the magnitude of bushfire risk identified, the nature of complex and compounding risk issues and intended density/population increase which is envisaged.

Building upon the content of landscape fire behaviour described above, the following is noted:

1. Bushfire risk currently exists within Ingleside which must be acknowledged;
2. Opportunities to enhance existing community bushfire resilience via a strategic approach to land use planning is desirable, noting the extent of risk which exists;
3. A level of urban penetration of fire could be reasonably expected in both the existing and proposed scenarios, largely associated with key environmental conservation corridors identified by the draft Structure Plan as well as the possible extent of ember attack; and
4. House-to-house ignition within the urban area of the Precinct is possible/likely under the current draft Structure Plan.

Keeping the above in mind and having regard to the draft Structure Plan, the following planning-based issues relating to the draft Structure Plan are identified (to be read in conjunction with **Figure 25** below and full version at **Appendix E**):

1. **Density / settlement pattern and whole-of-Precinct evacuation** – the Precinct is subject to several key fire runs associated with Ku-ring-gai Chase and Garigal National Parks which raises question with regard to the ability to evacuate the Precinct at an ultimate population of 9,000, taking into consideration the absence of any new road network connections between Ingleside and adjoining areas, and the nature of evacuation challenges which emanated in the 1994 event discussed by the Coronial Inquiry.
2. **Appropriateness of development to the west of Chiltern Road** – the Cottage Point fire Coronial Inquiry suggested development in this location was inappropriate. In analysing the land use intent in this location, Wirreanda Valley is one of the highest-exposed Sub-Precincts (over 90 per cent) and with a major vegetated corridor proposed (linking directly with Ku-ring-gai Chase National Park) through the centre. The revegetation of this location is incompatible with the intent to develop, and increases potential exposure to landscape-scale risk (rather than localised risk) for new development.
3. **Isolation and evacuation constraints for the western pocket of Wirreanda Valley** - in addition to the above, the ability for the balance area of Wirreanda Valley to evacuate must be considered, and therein lies a potential challenge. The intended development context in this location seeks to remove existing road connections from Wirreanda Valley to Mona Vale Road, instead re-routing residents to Addison Road or Chiltern Road, and adding additional population which may also need access to this same road network in an emergency. Combined with the vegetated corridor to be retained through the Sub-Precinct, the draft Structure Plan may inadvertently increase risk exposure to people and properties in Wirreanda Valley.

4. **Increase in landscape fuel connectivity in Wirreanda Valley** – this north-western area of Wirreanda Valley is currently subject to fragmented fuels which is sought to transition as a result of environmental conservation activities. Camp Kedron, which is a children's outdoor education facility, along with several animal shelters and a Scout Camp facility, are located in this proximate area. On balance of the landscape-scale risk posed to these facilities, their ongoing operation should be investigated. An increase in fuel connectivity in this location increases the extent of risk exposure to the balance of Wirreanda Valley.
5. **Potential vulnerability of the evacuation network (Mona Vale Road and Powderworks Road)** – approximately 25 per cent of Mona Vale Road within the Wirrenada Valley and North Ingleside Sub-Precincts is identified as subject to potential flame contact. In addition, an ignition within Garigal National Park driven toward Ingleside on a south-westerly fire wind has the potential to transition rapidly upslope to impact upon the key intersection of Mona Vale Road and Powderworks Road, which could effectively close both roads in this location.
6. **Appropriateness of increased density north of Cicada Glen Road** – both NSWRFs (in its comments to the former Pittwater Council in 2014) and the Cottage Point fire Coronial Inquiry identify this 'peninsula' area of Ingleside as undesirable to accommodate further development / population, even on larger allotments. The road access (via Cicada Glen Road) is currently and proposed to remain subject to bushland and both sides of the carriageway, placing this road at significant risk of fire overrun during an event.
7. **Increase in landscape fuel connectivity north of Cicada Glen Road** – environmental conservation activity is proposed to the immediate east of existing properties north of Cicada Glen Road where two corridor linkages are sought to converge however, this location conflicts with the potential high-order value of Cicada Glen / Cabbage Tree Road to function as a key evacuation route, placing it at potential risk of increased flame contact. This corridor is already extremely vulnerable given its design, grade, and location.
8. **Exposure, isolation and evacuation constraints west of Cicada Glen Creek in North Ingleside** – this small triangular-shaped pocket of proposed urban residential development wedged between Cicada Glen Road and Cicada Glen Creek is incompatible with the extent of landscape-scale risk to the immediate west and north-west.
9. **Access and egress arrangements in Bayview Heights** – whilst no new development is intended within the northern area of Bayview Heights, it is currently subject to one point of access and egress to the south, and a fire trail which is located on the hazard side of the estate. Most of the dwellings in this part of Ingleside are on large, cleared allotments however should emergency evacuation be required, the single access and egress road is a particular point of vulnerability which the draft Structure Plan does not address.
10. **Access and egress arrangements on Laurel Road West and ability to achieve defensible space** – this area of existing dwellings, similar to Bayview Heights is surrounded by bushland, though not the expanse of landscape-scale risk which lies to the west of Ingleside. Irrespective, Laurel Road West is a steeply graded carriageway which traverses bushland and presents a one way in / out situation. The allotments themselves are narrow and for the most part, unable to achieve defensible space on surrounding land.
11. **Ability to achieve defensible space for properties on the northern side of Laurel Road East** – several existing allotments on Laurel Road East (similar to above) are of a size which makes them incapable of achieving defensible space within the property boundary.
12. **Density of the 'Wilga-Wilson' area having regard to evacuation ability for residents of Caladenia Close and Dendrobium Crescent to the south-west** – the evacuation traffic modelling undertaken specifically for this area adopts evacuation assumption which, it is the view of this risk assessment, do not represent likely evacuation route decisions that would be made by residents when considering the primary fire runs relevant to this area.
13. **Intersection treatment of Wilga Street with Powderworks Road** – the draft Structure Plan indicates the ultimate design of this intersection is yet to be confirmed and the evacuation

traffic modelling for the Wilga-Wilson area included possible intersection design treatments. This particular point of the road network is potentially vulnerable to substantial evacuation bottlenecks – both on Wilga Street and north on Powderworks Road, with potential flow on effects for Manor Road and Ingleside Road.

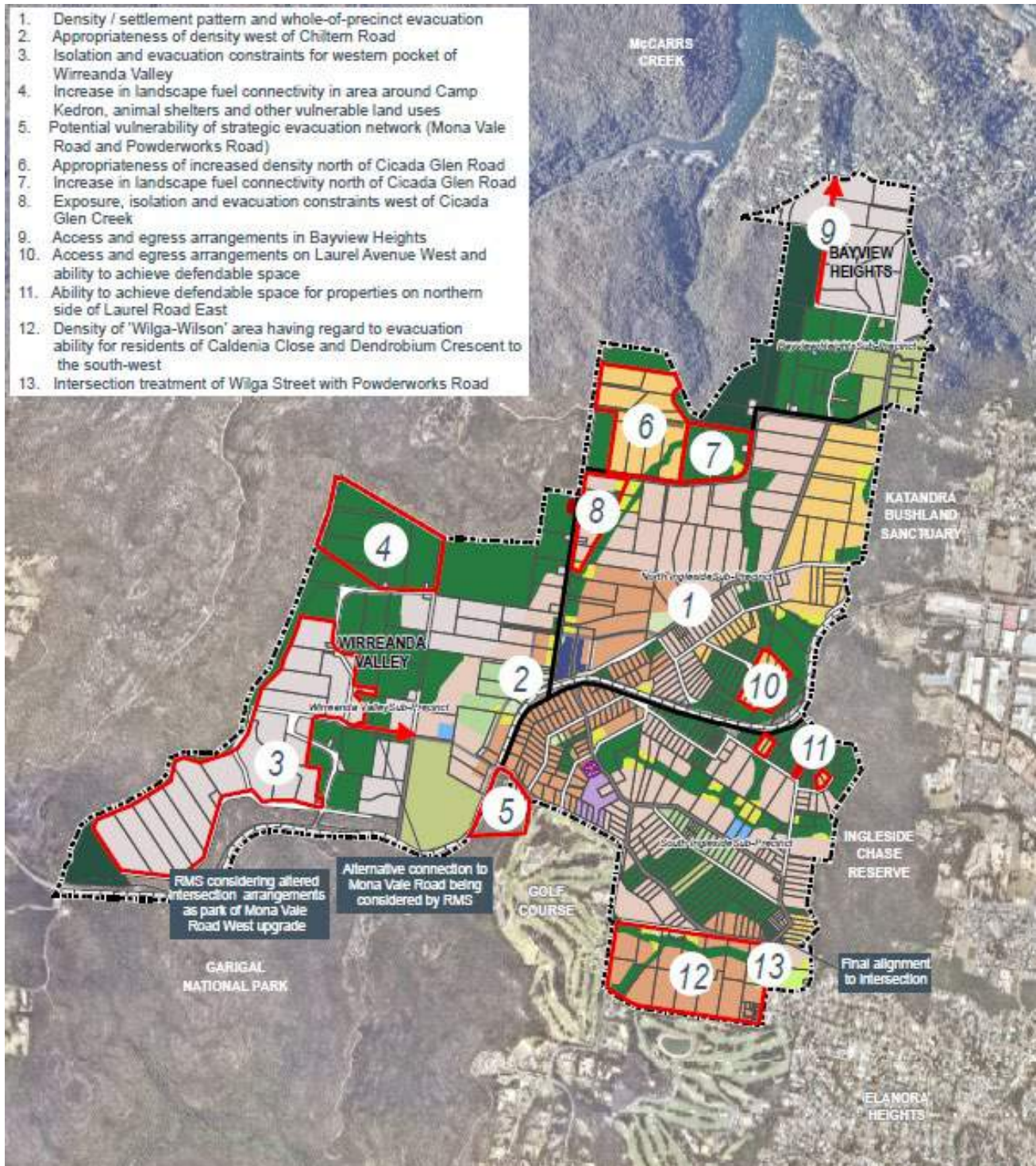


Figure 25 – Identified and use vulnerabilities associated with the draft Structure Plan

9.3 Access and egress (including evacuation, evacuation centres and NSPs)

Mona Vale Road is the core arterial route orientated east / west through the Precinct and is intended to be upgraded to a four-lane carriageway in both directions to Terrey Hills and Mona Vale. Approximately 25 per cent of the stretch of Mona Vale Road within both the Wirreanda Valley and North Ingleside Sub-Precincts is exposed to potential flame contact, thus representing a substantial vulnerability to a primary component of the evacuation route within Ingleside.

In South Ingleside, Powderworks Road and Manor Road are also key evacuation network routes. Manor Road is relatively un-constrained however, Powderworks Road is exposed to potential vulnerability at its intersection with Mona Vale Road where the Garigal National Park rises to meet this intersection. The closure of this intersection in an event could result in significant evacuation network issues for the Sub-Precincts to the north of Mona Vale Road, both with respect to the existing and proposed scenarios.

To the south-east where Powderworks, Manor and Ingleside Roads converge to flow through to Elanora Heights, there is substantial risk of potential bottlenecking in an emergency evacuation situation however, this is recognised by the existing draft Structure Plan insofar as identifying the need for additional investigation in this location.

The above represent key vulnerabilities which will need to be addressed, irrespective of any Structure Plan. It is further noted that additional opportunities for road connections (i.e. Mona Vale Road and Ingleside Road) exist, as well as possible fire trail / emergency egress trails on Laurel Road East.

The Sub-Precincts to the north rely on Mona Vale Road, Minkara Road and Cabbage Tree Road for egress from the Precinct. Mona Vale Road to the west is the only option to move out of the Precinct in a westerly direction. All other evacuation options egress to the east and south-east which is commensurate with the scale of landscape-level hazard to the west, allowing residents to evacuate in a direction that is away from the largest extent of hazard.

Tumburra Street, which is an existing road connection from Mona Vale Road to Wirreanda Valley is intended to be closed under the draft Structure Plan. This closure effectively isolates the western pocket of Wirreanda Valley from the balance of the Precinct, requiring residents in this location to traverse bushland through what is intended to be a revegetated corridor, to reach either Addison Road or Chiltern Road. Whilst Mona Vale Road itself is subject to risk exposure, the closure of an existing evacuation network route is not considered desirable. Tumburra Street should ideally incorporate a left in / left out turning arrangement at its intersection with Mona Vale Road to maximise network opportunities which are available in the event of emergency. Roadside vegetation along all three of the routes exiting this pocket should be treated to remove hazardous vegetation.

From North Ingleside, evacuation is intended to be facilitated either via Mona Vale Road, Minkara Road or Cabbage Tree Road. Each of these routes will require significant design upgrades to enable them to function in an emergency given their existing design, grade and construction. From Bayview Heights and that area to the north of Cicada Glen Road, these same evacuation routes are intended to service these locations, in addition to an existing fire trail linking Bayview Heights directly with the suburb of Bayview, to the north.

The figure below illustrates the core evacuation network proposed for Ingleside.

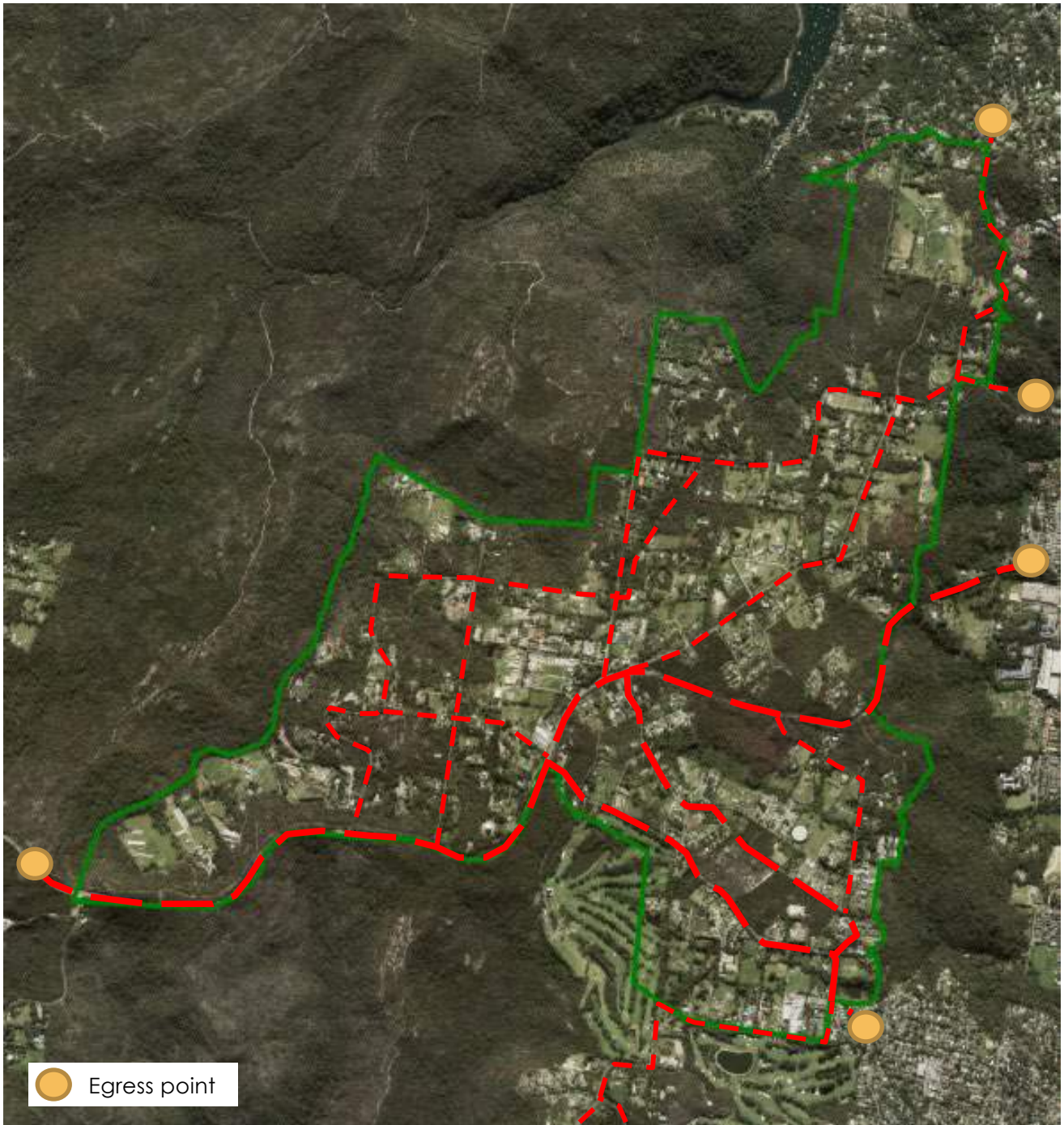


Figure 26 - Proposed core evacuation network options (Source: Aerial from Northern Beaches Council, 2016)

It is necessary to note that due to topography, waterways and ecological constraints, it is difficult to identify suitable locations for additional evacuation options from Ingleside to adjoining suburbs. That is not to say such opportunities do not exist however, it would likely be the case that any such opportunities would be subject to extensive negotiation.

9.3.1 Evacuation centres and neighbourhood safer places (alternative evacuation models)

In the instance that timely evacuation within the desired (and mutually agreed) evacuation window for a FFDI 100 design fire scenario of the entire Precinct presents a challenge, alternative evacuation models could be considered via neighbourhood safer places (NSPs) and emergency evacuation

centres located within Ingleside, mitigating the need to evacuate the entirety of the population to locations outside of the Precinct. There remain several locations which, based upon the risk exposure mapping exercise, might present possible lower risk options for evacuation centres. These centres would need to be built to the standards required by relevant planning, building and emergency management provisions.

As noted previously in this report, whilst it is the preference of emergency and disaster managers in Australia that persons evacuate to the home of friends or family to reduce system burden – which is certainly not contested by this risk assessment – it is the role of land use planning to allocate land and identified planning-based measures to enable strategic decisions to be made in the future with regard to evacuation facilities and NSPs. Thus, whilst such formalised evacuation locations may not be the preference of emergency and disaster managers, land use planning should not inadvertently void the option or require retrofitting to community infrastructure at a later date as a result of limited-range strategic planning.

9.3.1.1 Cascading risk considerations

Alternative models elsewhere in Australia, including the concept of 'community fire refuges' in Victoria are provided on the premise of being a 'Plan C' option however, there do remain challenges in terms of community messaging and their understanding of how evacuation processes are ideally supposed to occur. This has been raised in Victoria in response to the community fire refuge program, where residents' fire plans identify immediate evacuation to the refuge instead of a) having a well-prepared and maintained property b) having a bushfire survival plan and household evacuation plan. Thus, the plan of last resort becomes Plan A as residents defer their own individual responsibility and instead rely on evacuation to designated evacuation centres.

A further challenge relates to the ultimate capacity of the centres themselves. Should community attitudes align with the above, it could be the case the capacity of the centres becomes overwhelmed by persons undertaking late evacuation rather than leaving early as per emergency management messaging, believing the centres are a safe haven and easier to possibly travel to than undertake full evacuation. This is a common problem for emergency managers, irrespective of hazard.

Over-reliance upon evacuation can also further ingrain the cycle of government reliance and perceived responsibility for individuals during times of emergency and disaster, thus the designation of evacuation centres can ultimately have the reverse effect on community resilience and can further perpetuate the cycle of individual / household responsibility versus perceived government responsibility.

Additionally, whilst the risk exposure mapping (proposed scenario) identifies pockets of lower risk areas throughout Ingleside in terms of exposure to flame contact and radiant heat, ultimately the suburb in its entirety continues to remain at substantial risk, having regard to the extent of key fire runs, the upper extent of urban house loss recorded by CSIRO, the vegetation to be retained throughout the Precinct, and noting that all property within Ingleside remains within 700m of hazard.

At present, there are no neighbourhood safer places (NSPs) within Ingleside itself. NSPs are a place of last resort, if a fire plan has failed or evacuation measures do not go to plan. Thus, there is no guarantee of safety in these locations. At present, an NSP in Ingleside may not offer a significant benefit given the risk profile which may partly explain why an NSP is not currently in place. However, moving forward, NSPs may offer an ancillary option for consideration as part of a broader suite of resilience measures for Ingleside.

9.4 Emergency services and disaster management

Emergency services and the Local Emergency Management Committee are the lead agencies during a bushfire emergency. Warnings are authorised and released by the NSWRFs and the Police are the lead agency for evacuation in NSW.

Table 4.2.1 of PBP 2018 requires consideration of potential increased demand placed on emergency services and the ability for emergency services to carry outfire suppression during and emergency.

The draft Structure Plan envisages the relocation of the existing rural fire brigade station further to the north on Chiltern Road within the Wirreanda Valley Sub-Precinct. This proposed location is surrounded by hazard to the north, west and south however, it is understood NSWRFs was consulted on the revised brigade station location.

The question of increased demand is a challenging one in a strategic land use planning context. On the one hand, the proposed development of Ingleside effectively increases exposure of people, property and infrastructure, including increased exposure of firefighting personnel. However, the intent of this risk assessment process seeks to rationalise the strategic land use planning approach to mitigate this extent of risk exposure, acknowledging (in accordance with the ALARP principle) that not all risk can be avoided, and thus residual risk will remain and be transferred to others (emergency services, the community, insurers, etc.).

9.5 Infrastructure

Despite the above, and with specific regard to water supply, it noted that current reporting identifies that North Ingleside is unable to be serviced by reticulated services until 3 years after any rezoning occurs. The provision of water supply to North Ingleside is further identified to be at an elevated cost due to the extent of new infrastructure required, with specific aspects of the network located in highly exposed areas which could place them at risk of loss or failure. This can present a substantial risk if such infrastructure is impacted during an event, at a time when it is being drawn upon the most.

Based upon existing infrastructure servicing reporting, it is also understood the current electricity network is aboveground, and would transition to an underground arrangement, with gas and telecommunications services also located below ground as part of the draft Structure Plan. This is of course with exception to telecommunications towers. It is recommended that an investigation into the potential vulnerability of the network tower adjacent to Mona Vale Road between Ingleside and Terrey Hills be undertaken to determine the potential resultant impacts of its loss before, during and after an event and the ability for residents to receive information and warnings as they are issued. This could be performed as part of a future update to the Pittwater Warringah Bush Fire Risk Management Plan which is understood to be due for revision.

9.6 Adjoining land

With respect to adjoining land, the largest landholder is the State, represented by the National Parks and Wildlife Service (NPWS) which manages the National Parks, as well as Northern Beaches Council. Fire Management Strategies are currently in place by NPWS which identifies a series of strategic objectives and strategies within the National Parks, as does Northern Beaches Council in its fire management plans for Ingleside Chase Reserve and Katandra Bushland Sanctuary. Given that development already exists in this location, and that fire management strategies are also driven by ecological fire thresholds which dictates how regularly they can be burnt before fire frequency and/or intensity changes its ecological and biodiversity values, it may or may not be the case that NPWS and Northern Beaches Council might alter its existing fire management strategies to account for exposure adjacent to these parks.

9.7 Summary of evaluation

From a strategic land use planning perspective, the issue of property risk is relatively able to be addressed via a suite of strategic mitigation measures and alterations to the draft Structure Plan to increase the physical and land use resilience of the development design. This is on the premise that property loss, despite mitigation efforts, may still occur.

Addressing risk to life is more complex. Firstly, the same suite of mitigation measures identified to address physical and land use risk equally applies to threat of life loss, particularly given the current

increasing trend of fatalities inside structures over recent decades. Secondly however, is role of the evacuation network and reliance upon it from a land use planning perspective in deriving 'acceptable risk'.

The community expectation of new development in Australia is that land use planning avoids risk to life from natural hazard (to that extent which is foreseeable), which in addition to the above land use planning measures, places a significant expectation on the design and performance of the road network to facilitate evacuation – including last minute evacuation.

However, evacuation traffic modelling (for any natural hazard, let alone bushfire) is an emerging field. It is imprecise and challenging to undertake in terms of the assumptions and scenarios to be used. Notwithstanding this and based upon mutually agreed assumptions in terms of resident evacuation behaviour which can be derived alongside NSWRFSS and Northern Beaches Council, it does offer the opportunity to gain a better understanding of the potential performance of the proposed road network in evacuation situations – using various design densities and different fire weather and event scenarios. Whilst it cannot provide a guaranteed view of its performance in every single situation which may prevail during an event, it can provide a useful strategic planning tool. It can also help to identify unforeseen vulnerabilities across the road network as a result of evacuation processes.

In acknowledging the above however, it is also important to acknowledge there remain limited to no examples of true integration of 'ability to evacuate' into land use planning decisions in NSW to date. Studies are ongoing in parts of the Hawkesbury Nepean floodplain in relation to flood risk evacuation however, the context of flood evacuation is markedly different to that of bushfire evacuation. This is mostly associated with the unknowns associated with point of ignition and rate of spread.

The existing road network between Ingleside and surrounding suburbs is intended to be upgraded, but no new road connections are proposed. In locations where new connections could present a possibility, these equally present bottleneck risks, with motorists potentially trapped in bushland in an attempt to escape. This remains the case for four of the five existing evacuation routes out of Ingleside, at present.

Overall, evacuation is a challenging issue in a land use planning context, as it is generally pre-supposed that the destination of evacuation and the pathway to reach it are ultimately less risk-exposed than where a person may be travelling from, which is often not the case. Thus, the role of land use planning is primarily about ensuring multiple network opportunities exist. Testing its performance thus remains challenging.

This however, does not answer the question regarding what is an acceptable 'ability' to evacuate. If community expectation is for zero life loss for new development, the ability to evacuate the entire population of Ingleside within what are often very narrow evacuation timeframes is likely considered to be the benchmark for acceptability. In many peri-urban areas which extend from existing conurbations and settlements, multiple opportunities for direct and immediate egress in a direction away from hazard exists. This is not the case for Ingleside. Ingleside remains almost entirely surrounded by hazard. Whilst a fire front may emanate from one direction, the effects of spotting, intense ember attack, smoke, gusting winds, fallen trees, road accidents and catastrophic fire conditions can easily confuse evacuees as to the direction of the main fire front. Four of the fire evacuation routes out of the Precinct traverse bushland, not to mention the high number of internal roads within the Precinct which remain exposed to ember attack and radiant heat – in both the existing and proposed scenarios.

Quite separately to the issue of evacuation is the exposure of a large part of the Precinct to potential fire run impact emanating from an ignition in Ku-ring-gai Chase National Park. The vegetated corridors and re-vegetation approach adopted by the draft Structure Plan integrates hazard within the Precinct, introducing the potential for fire front intrusion into Wirreanda Valley, Bayview Heights and North Ingleside.

10 Bushfire Risk Treatment Options

A suite of risk mitigation options is available to respond to bushfire risk, at a general level. These measures exist on a spectrum which reflects the level of relative 'strength' of each measure, illustrated below.



Figure 27 - Influence of bushfire risk mitigation measures

The following suite of mitigation measures are identified for consideration on a spectrum of risk treatment. From a land use planning perspective, the transfer or acceptance of risk without mitigation or avoidance is not an appropriate planning response. Thus, these elements are not capable of consideration outside the bounds of residual risk management.

The mitigation measures outlined below represent varying levels of effectiveness, are strengthened by multiple measures acting in concert to reduce risk exposure, and have not been tested from a cost benefit analysis perspective.



Figure 28 - Spectrum of risk treatment relevant to land use planning

10.1 Strategic planning measures

The suite of strategic-level bushfire resilience measures available in response to bushfire risk (generally) includes:

- Arresting further development to avoid increased life and property risk exposure

- Identify and express a settlement / land use pattern and structure which responds to bushfire risk
- Identification of an appropriate development density which enables community evacuation
- Identification of alternative evacuation models for consideration including the role of evacuation centres within Ingleside
- Avoidance of vulnerable land uses in higher risk locations (SFPP)
- Reconsideration of the balance between urban development and environmental conservation, noting a general incompatibility between the two intents in Ingleside having regard to the extent of landscape-scale risk
- Infrastructure servicing which is resilient to impact of bushfire having regard to both location and installation.

This risk assessment has primarily focused on the above, and having regard to the intersection of these matters with other associated disciplines such as disaster and emergency management, ecology and land management, etc. Aside from the key point around ability to evacuate, the second issues of relative significance include the likelihood of urban fire intrusion (which relates back to urban density and settlement pattern arrangement) and also the balance between environmental conservation and revegetation of identified areas and corridors internal to the Precinct. This is particularly the case for Wirreanda Valley and Bayview Heights. Whilst limited development is contemplated in these locations, the proposed revegetation intent is largely at odds with the risk profile of the community, both existing and proposed. Thus, careful consideration must be given to the scale of conservation proposed and the parallel increase in risk exposure they may inadvertently introduce for existing residents.

A possible trade-off in this regard may be the introduction of walking / mountain bike trails and periodic fire trails and fire breaks within these areas to disrupt fuel connectivity and enhance opportunities for fuel management. This may require careful management however, given the potential for degradation of environmental values and also, from an ignition management perspective. Increasing access to bushland areas can also see increased ignition activity as people deliberately and accidentally ignite fires in such locations.

10.2 Design-based measures

The suite of bushfire protection measures applicable at the site-based scale include:

- Asset protection zones (defendable space) (including to essential infrastructure items)
- AS3959 building construction standards
- Building design
- Site-based access to reticulated water supply, where possible, and sufficient static supplies (or both)
- Site-based landscaping
- Site-based access and egress (driveway design and distance from public road).

These design-based measures are largely enshrined in existing policy provisions, and thus already mandated. However, some merit exists in potentially expanding these measures beyond the identified '100m from hazard' zone. Noting that not one area of the Precinct is more than 700m from a hazard source, which represents the upper extent of urban house loss from forest fire in Australia, implementation of ember-protection construction throughout the entirety of the Precinct could be a valuable protection measure, worthy of consideration. Whilst from a policy perspective, this represents some challenges, it is also an inexpensive opportunity to upgrade built form to the threat of ember attack and some level of increased radiant heat exposure protection.

10.3 Fuel management and emergency management arrangements

A range of fuel and emergency management opportunities exist, which include:

- Identification of an appropriate development density which enables community evacuation
- Identification of alternative evacuation models for consideration including the role of evacuation centres within Ingleside
- Pending demonstration of 'ability' to evacuate, preparation of an emergency evacuation plan for Ingleside. The focus of such a plan must be on the community (communicating residents' roles and what they need to be aware of to plan and prepare, and their relevant options) rather than agency roles and responsibilities as this is already covered by relevant local, regional and state-wide emergency management plans
- Potential application of Strategic Fire Advantage Zones or Land Management Zones, recognised bushfire land management treatments under NSWRFs bush fire risk management plan processes;
- Updates to relevant emergency management documents:
 - Pittwater Warringah Bush Fire Risk Management Plan
 - Regional / local emergency management plan
 - Community protection plans
- Fire trails and fire breaks
- Static water supply tanks for Wirreanda Valley and Bayview Heights.

Essential infrastructure servicing reports to date indicate that neither Wirreanda Valley or Bayview Heights maintain the ability to be easily or affordably serviced by reticulated water connection. In the Yarra Ranges in Victoria, municipal water supply tanks are located in road reserves to bolster water supplies throughout the community. This may be benefit to local residents in these locations which may benefit from the ability to draw water from such facilities in lower-scale emergencies. These concrete tanks cost an estimated \$7,000 each and depending upon rainfall, may need to be topped up prior to and during each annual fire season.



Figure 29 - Roadside static water supplies for firefighting purposes in the Yarra Ranges, Victoria
(Source: Yarra Ranges Council, 2013)

10.4 Supplementary measures

In addition to the above, there remain several supplementary measures relevant to the development of Ingleside worthy of consideration:

- Establishment of an interim governance arrangement to coordinate the strategic assessment and implementation of bushfire protection matters in Ingleside (i.e. an 'Ingleside Bushfire Development Committee) which would include a multi-disciplinary team of planners, emergency managers, policy officers, community awareness officers, etc. from DPE, NSWRFs and Northern Beaches Council. This could couple in with an existing governance arrangement as a sub-committee informing a broader project team
- Prepare a whole-of-Precinct fire and fuel management strategy for all public land within the Ingleside Precinct
- A fit-for-purpose community awareness program. Such a program might include published communications like flyers and fact sheets, digital and social media communications, open days and stalls at community events, door knocks, etc. Local community champions are also a solid method of bolstering community interest in preparedness
- Support any existing community bushfire protection groups (or work to establish one if one does not currently exist) to grow with the community, and foster community-led messaging and action to build grassroots community bushfire resilience

- Throughout any development assessment processes, ensure Council's emergency managers form part of the assessment team to derive a holistic review process which will also include NSWRFs in most cases, pursuant to the provisions of the EP&A Act
- Preparation of a Guidance Manual for conducting strategic land use planning risk assessments / bushfire strategic studies as an addendum / appendix to PBP 2018 to ensure consistency in process, approach and evidence-based reporting is conducted moving forward across NSW (similar to the NSW Floodplain Development Manual).

These measures seek to supplement land use planning, building construction, land management and infrastructure measures etc. by facilitating a well-rounded and holistic approach to bushfire protection. Whilst strategic land use planning is a strong and influential form of risk mitigation, the broader bushfire risk management forms an important consideration in land use planning and other decisions.

Should mitigation of existing risk be pursued, which is the recommendation of this assessment, several baseline requirements exist and should be expanded upon by targeted locally-led resilience building processes. These baseline requirements include the following:

1. Completion of upgrades to Mona Vale Road to the east and west;
2. Provision of suitable water supply;
3. Address the nature of existing vegetation in the Precinct (i.e. land management and fuel management studies) to mitigate existing risk exposure; and
4. Avoidance of additional vulnerable persons in the area, including avoidance of new aged care and child care facilities, for example.

11 Testing Mitigation for Risk Acceptability

Whilst mitigation options exist, the overall ability of these measures to reasonably reduce the risk profile to an acceptable or tolerable level must be explored. As discussed at Section 7.4, responsibility ultimately rests with governments (state and local) to articulate risk appetite (Productivity Commission, 2014).

11.1 Development scenario testing

A draft risk assessment report was prepared for DPE, NSWRFs and Northern Beaches Council and distributed in July 2018 for stakeholder consideration. That draft report identified six (6) potential development scenario options moving forward for the Ingleside Precinct, derived from the observations, analysis and evaluation pursuant to the risk assessment process.

The development scenarios were identified on a spectrum from lower exposure to higher exposure, to assist in testing and guiding an informed decision-making process.

Exploratory scenario-based approaches are widely applied to complex and uncertain socioenvironmental system problems (Riddell et al. 2018). A variety of development scenarios in this case not only present a spectrum-range of potential pathways moving forward for consideration but help to inform a rigorous analysis process to inform 'risk acceptability' and the nature of residual risk which each scenario involves.

The identified development scenarios for the Ingleside Precinct are summarised below and at **Appendix F**, which examines the combination of measures, the complexity of implementation, contribution to potential risk 'acceptability' and residual risk likely to be transferred to others.

Lower exposure options

1. **Avoid** increased risk and/or exposure of persons, property and infrastructure

Further development of the Ingleside Precinct does not proceed. Irrespective, the suite of strategic mitigation measures identified at Section 10 are adopted to treat existing risk to the current community, including the Caladenia and Dendrobium precinct to the south-west.

2. **Mitigate** – development of South Ingleside

Avoidance of further development in higher risk areas of the Precinct (north of Mona Vale Road) is adopted, with a development focus on the lower exposure area, being South Ingleside. Conduct evacuation traffic modelling for extent of development / density proposed under the draft Structure Plan for South Ingleside only, including the balance of the Precinct as it currently exists, to confirm 'acceptability of risk' for the development of the South Ingleside Precinct, including a specific re-investigation of the intersection of Wilga Street and Powderworks Road to ensure evacuation opportunity for residents of Caladenia Close and Denbrobium Crescent is not adversely impacted by the density proposed on land between Wilga Street and Wilson Street. This option contemplates development of South Ingleside only, on balance of the ability for risk mitigation and ability to be serviced by infrastructure. The suite of strategic mitigation measures identified at Section 10 are also adopted.

Moderate exposure options

3. **Mitigate** – development of South Ingleside and maximum circa one into two lot subdivisions in North Ingleside

Conduct evacuation traffic modelling for extent of development / density proposed under the draft Structure Plan for South Ingleside plus exploration of circa one into two lot subdivision of existing landholdings in North Ingleside to inform potential 'acceptability of risk' for the development of the South Ingleside Precinct plus a marginal density increase in North Ingleside. The suite of strategic mitigation measures identified at Appendix G and relevant measures identified at Section 10 are also adopted.

4. **Mitigate** – development of South Ingleside and very low urban residential density in North Ingleside (10 dwellings per hectare)

Conduct evacuation traffic modelling for extent of development / density proposed under the draft Structure Plan for South Ingleside plus a reduced density (approximately 10 dwellings per hectare) in North Ingleside to inform potential 'acceptability of risk' for the development of the South Ingleside Precinct plus a moderate density increase in North Ingleside. The suite of strategic mitigation measures identified at Section 10 are also adopted.

Higher exposure options

5. **Transfer** – adopt mitigation measures and implement current draft Structure Plan

Develop the Precinct as per the draft Structure Plan but including strategic mitigation measures identified at Section 10.

6. **Transfer** – implement current draft Structure Plan as is

Proceed with the draft Structure Plan as is without any change and without any investigation into the evacuation capacity of the proposed road network.

As per Figure 28 of this report, transfer and acceptance of risk (unless relating only to residual risk after avoidance or mitigation of highest risk) does not represent an appropriate land use planning response. This being the case, the highest exposure options (options 5 and 6 above) are not acceptable pathways based upon the evidence of this risk assessment. The balance options (options 1 to 4 above) were considered (at length and in detail) by the key government stakeholder group following the issue of the draft report in July 2018. Refer to Table 1 of this report at Section 5.3 which outlines the dates and details of key stakeholder meetings. This is noting that additional meetings between those stakeholder groups also occurred, in the absence of Meridian Urban.

11.1.1 Stakeholder assessment

Upon issue of the draft report to the key stakeholder group in July 2018, each stakeholder was individually briefed on the process of the draft risk assessment and the subsequent issues identified. This process is reflected by Table 1 at Section 5.3 of this report. These meetings sought to provide an overview of the draft report content. A larger full-day workshop was subsequently scheduled for 13 August 2018 where the key stakeholder group (including multiple representatives of each stakeholder organisation) met to discuss the preliminary observations of the risk assessment and the identified development scenarios.

Each of the development scenarios were discussed in a great detail with an agreed understanding that options 5 and 6, being the two highest risk options, were not appropriate on balance of the magnitude of residual risk associated with both options. Throughout the workshop, the complexity with regard to the pathway forward for North Ingleside remained, largely associated with significant reliance on evacuation required (representing a potential single point of failure) and the apparent challenges in enhancing the road network to compensate. Property and infrastructure loss in an FFDI 100 event emanating from Ku-ring-gai Chase National Park would be certain in almost (if not all) development scenarios, acknowledging a significant increase in residential development and infrastructure investment associated with options 3 and 4.

In addition to the complexities discussed in relation to North Ingleside, the ability for development to withstand bushfire attack in South Ingleside was also considered. In 1994, the Cottage Point fire breaches the two golf courses which flank the western and southern portions of South Ingleside to impact upon property in this area, resulting in loss and damage. The extent of ember attack from the west, based upon stakeholder accounts and also reflected by the 1995 Coronial Inquiry report and other sources, was 'extreme'. Thus, the relevance of the secondary loss extent for Ingleside is relevant, noting previous fire activity has seen member attack lead to property damage and loss in this location, beyond that recognised by AS3959.

The above breach of the golf courses gave rise to a detailed consideration of the proposed school in South Ingleside. Aside from the population required to support the opening of a new school, concerns were raised by the stakeholder group in relation to the behavioural aspects of students and parents in a bushfire emergency, aside from the ability for property and occupant survival. Whilst from a locational perspective, the school site may satisfy the provisions of PBP 2018, its position on Powderworks Road, nestled between two key evacuation routes through South Ingleside, could present certain issues for the broader evacuation network despite trying to alleviate them by locating on a key corridor.

Not isolated to North Ingleside, the evacuation network supporting South Ingleside was also highlighted as a key issue. The likelihood of timely evacuation in an emergency, in a situation where most residents may adopt a 'wait and see' approach or deliberately wait for an emergency / evacuation warning from NSWRF, remains tenuous even with proposed road and intersection upgrades. Concerns with bottlenecks remain, in locations where spot fires could develop immediately adjacent to the road network.

11.2 Benchmarks for risk acceptability

Risk acceptability is a challenging area of practice given the environment for subjectivity which exists. Thus, the use of benchmarks against which to 'test' risk acceptability or tolerance is necessary. In this regard, PBP 2018 includes provisions which denote the nature of 'inappropriate' development. These criteria are outlined below and adopted as the performance benchmark against which this assessment is undertaken and were the benchmark against which stakeholder considerations were framed.

11.2.1 PBP exclusion of 'inappropriate' development

The 2018 version of PBP introduces a range of strategic planning provisions regarding those instances where 'inappropriate' development should be avoided. These include:

- a) when the bush fire risk makes it inappropriate for new development to occur;
- b) for development that is likely to be difficult to evacuate during a bush fire when the siting in the landscape, fire history, size and scale of a development is likely to be difficult to evacuate and/or protect during a bush fire. Some specific locations have significant fire history and are recognised as known fire paths, these areas may require more strategic assessment. Understanding the fire history of an area is important during early planning and may require the provision of more stringent protection measures for development that will adversely affect other bush fire protection strategies or place existing development at increased risk;
- c) for development that will adversely affect other bush fire protection strategies or place existing development at increased risk;
- d) for development that is within an area of high bush fire risk where density of existing development may cause evacuation issues for both existing and new occupants; and
- e) where environmental constraints to the site cannot be overcome.

Whilst evacuation traffic modelling has not been undertaken, evacuation is just one element of the overarching range of risk exposure issues relevant to the Precinct (item (a) above). Given the nature of these criteria, none can be considered in isolation and as such, the above matters are discussed holistically below.

Ahead of the consideration of evacuation, it is noted the entirety of the Precinct is subject to the secondary loss extent, and 73 per cent of the proposed post-development Precinct will remain subject to the primary loss extent (91 per cent in the existing scenario). This represents a particularly high proportion of the existing and proposed communities, located within the primary loss extent. Whilst land use mitigation measures (i.e. reducing density, altering the structure/settlement pattern, etc.) may reduce this, it is the case this will be of marginal benefit/impact given the extent of

landscape-scale risk exposure relating to the Ingleside Planned Precinct, being located amongst Ku-ring-gai Chase and Garigal National Parks, Katandra Bushland Sanctuary and Ingleside Chase Reserve. To this end, the extent of property and life risk remains significant, acknowledging that:

- an extreme event occurring in adjoining bushland is almost certain to threaten the community of Ingleside, including catastrophic-scale events;
- the likelihood of property and infrastructure loss and damage is high; and
- the ability for land use planning and built form measures to mitigate this threat to a point that is acceptable is constrained by a multitude of challenges which have been identified throughout this assessment.

One of the defining aspects of the above is understanding exactly what defines 'acceptable risk'. As previously highlighted, this is characterised for the purposes of this risk assessment by:

- a) risk to property; and
- b) risk to life.

As demonstrated by the evidence base presented by this assessment, acceptance of a level of property loss or damage would be necessary if development is to proceed. Due to the nuances of bushfire behaviour and impact, it is difficult to determine the exact extent of possible property loss. The 100m primary loss extent reflects that area where 80 per cent of property loss might occur from a bushfire event impacting upon Ingleside. With 73 per cent of the Precinct (proposed scenario) subject to the primary loss extent and 100 per cent within the secondary loss extent, the majority of new dwellings proposed as part of the draft Structure Plan would be placed at risk. Whilst a level of property loss could be theoretically accepted, the following must be considered:

- the draft Land Use and Infrastructure Strategy for the Ingleside Precinct identifies approximately 3,400 new homes. 73 per cent of these is 2,482 dwellings, with 80 per cent of these (1,986 dwellings) estimated as subject to potential loss based upon event history. This represents a significant portion of the proposed housing stock within the Precinct.
- the above equates to a proposed population of almost 5,000 people (existing and proposed residents) who could expect to potentially lose their home in a bushfire event based on the spatial relationship of dwelling location and proximity to hazard.
- over the period of a 30-year mortgage, there is an estimated 45 per cent probability of a 1:50 year (FFDI 100+) fire weather event occurring. Whilst this may not necessarily involve an ignition, the probability of fire weather of a catastrophic scale is high, noting that five approximate-FFDI 100 days have occurred in this region since 2010 and the Precinct has previously endured fire.
- the frequency of elevated fire danger days is increasing (observed) and is likely to continue to do so as a result of climate change impact.

Whilst acceptance of potential property loss following mitigation could be considered, the extent of potential loss in this case is significant. Coupling in the fact that 30 per cent of the Precinct is earmarked for conservation purposes and 30 per cent will remain unchanged (including considerable areas of vegetation), approximately 60 per cent of the Precinct will retain a level of vegetation (via patches and corridors) which may introduce fire front or spotting into the Precinct, giving rise to fire front intrusion. This accounts for the high extent of the proposed draft Structure Plan which is subject to the primary loss extent, and also the extent of the secondary loss area which accounts for 100 per cent of the Precinct, in both the existing and proposed scenarios. The draft Structure Plan does not reduce the extent of the Precinct subject to the secondary loss extent. That is to say, every property in the Precinct is located within 700m of hazardous vegetation (either landscape or localised) and the draft Structure Plan does not change this. Within 700m, some form of bushfire attack in a catastrophic event could occur – whether it be from direct flame contact, radiant heat exposure, house-to-house ignition, the combined effects of wind or radiant heat and ember attack, etc.

With only five routes in/out (one of which is likely to close to evacuation traffic early on in an event – being Mona Vale Road heading west) and no new roads proposed, significant question marks remain with regard to existing capacity, design and bottlenecks, and the performance of the existing evacuation road network in an emergency with an additional 8,000 persons traversing bushland areas both within and surrounding the Precinct attempting to evacuate. 25 per cent of the Mona Vale Road corridor is identified as subject to potential flame contact. The ability for some of these roads to function in a bushfire emergency cannot be guaranteed. There is also a pre-supposition attached to evacuation that the route from which a person is travelling is safe, or safer than where they are coming from or travelling to. Even at a lower density (which raises infrastructure provision and servicing cost/benefit issues), the prevailing risk regarding ability to evacuate remains.

The evacuation issues remain the 'tip of the iceberg' (one element which forms part of a much larger, complex and serious issue), noting the complex array of competing, compounding and cascading risks to life, and to property, which are demonstrated by this risk assessment process. In this regard, the scale and extent of risk embodied by the current draft Structure Plan, as evidenced by this assessment, is seemingly beyond the realm of reasonable risk tolerance noting that mitigation measures are unlikely to reconcile the magnitude of observed risk.

The application of strategic fuel management measures such as Strategic Fire Advantage Zones and Land Management Zones throughout surrounding National Parks and across the Precinct has been considered. Both the NSW National Parks and Wildlife Services and NSWRFSS, in conjunction with Northern Beaches Council as well as some individual property owners, already undertake a great deal of strategic and site-based fuel management, including fire management plans for the National Parks and strategic bushfire management measures identified by the Warringah Pittwater BFRMP. Whilst fuel management can and does reduce fire intensity, its effectiveness in Catastrophic conditions is less reliable. Though land management activities could be implemented, the ongoing cost and difficulty will be significant and is heavily resource dependant (cost, time and labour). The role of effective land use planning is to avoid onerous and resource intensive transfer of risk in perpetuity. Taking into consideration the value of the natural assets adjoining the Ingleside Precinct, which are already subject to various fire and fuel management practices to mitigate current risk, the potential additional impact on these assets as a direct impact of population and development increase must be considered as an inherent trade-off. There are also various ownership / jurisdictional matters, etc. which would need to be overcome to enable further activities and impact and the cascading issues associated with such matters. Stakeholder discussions undertaken throughout the period of this study did not offer any immediate solutions, but rather magnified the scale of challenges associated with fuel management in immediate proximity to urban areas, including smoke impacts, etc.

It is the summation of this assessment that an evacuation plan, as a mitigating measure to support further development within Ingleside, could not be reasonably relied upon to save lives, again given the scale and extent of risk factors described above. If risk tolerance levels could accept property loss, but not life loss, the level of reliance upon evacuation in this situation likely represents a 'single point of failure'. Given the nature of the existing and proposed road network, a single tree fall across one key road, or a traffic accident due to poor visibility, is likely to compromise the evacuation ability of residents and create compounding issues across the balance of the evacuation network. The extent of existing and proposed vegetation within the Precinct means that some residents may not be able to access the higher order road network to evacuate in an extreme or catastrophic event, becoming isolated, getting stuck or becoming disoriented by the effects of radiant heat, smoke, and/or panic. Thus, the risk management conversation is more than just the ability to evacuate, as demonstrated by the 'inappropriate' development benchmarks identified in PBP 2018.

With regard to risk to life, whilst 85 per cent of observed historical fatalities have occurred within the first 100m from the hazard source, this does not mean that 85 per cent of persons within this area may lose their life. Rather, this is where most people are located at their time of death. With 73 per cent of the draft Structure Plan remaining within the primary loss extent (91 per cent in the existing scenario), the risk is elevated. This, coupled with the likelihood of dwelling loss (relevant if people are actively or passively sheltering inside) and increasing trends of fatalities in structures in higher

intensity bushfire events, the extent of exposure is high. Given the environmental values in and around the Precinct, the ability to substantially mitigate primary loss exposure is limited.

Based upon the CSIRO data collated for bushfire related fatalities from 1901 to 2011 for 260 events, the majority of fatalities occurred within a structure (passively sheltering or actively defending) or in the process of late evacuation. In the case of Ingleside, the magnitude of landscape-scale risk exposure deems either passive sheltering or active defence to be inappropriate in elevated fire weather conditions, likewise late evacuation is not adequately supported by the physical context of the area, or the existing or proposed road network. The context of the surrounding area also seemingly limits the ability for alternatives to be explored to change this.

11.3 Summary of mitigation testing analysis

At the conclusion of the relevant stakeholder briefings and workshops, and in consideration of the evidence compiled by this report, there was no clear mitigation pathway identified by the key stakeholder group to reduce risk to an acceptable level.

In consideration of the full suite of mitigation options available and the combined nature of those measures, the stakeholder group found (without disagreement) the risk profile of Ingleside is such that a revised draft Structure Plan cannot be prepared to effectively mitigate life and property risk to a tolerable level ('tolerable' being the ability of emergency services, the community and insurers to effectively mitigate and/or accept and endure residual site-based risk after appropriate strategic mitigation).

The capacity of the road network and the potential 'single point of a failure' reliance upon it remains a fundamental issue for the Ingleside Precinct, which is compounded by a complex range of associated cascading risk issues.

This being the case, the risk to life posed by further development/population within the Ingleside Planned Precinct is unable to be satisfactorily mitigated without some form of substantial change to the current context which is beyond the scope of this assessment.

The risk profile of Ingleside as it currently exists is a separate matter which requires investigation, mitigation and management.

Overall and having regard to the 'inappropriate' development benchmarks of PBP 2018, the scale and complexity of the competing, compounding and cascading risks to life and property, supported by the quantified and qualified evidence base presented by this risk assessment, determines that current available mitigation measures are unable to reduce the risk profile to a level which is universally acceptable to DPE, NSWRFs or Northern Beaches Council insofar as the current draft Structure Plan relates.

12 Key Observations, Options and Recommendations

This section summarises the key observations and recommendations of this risk assessment.

12.1 Key observations

The key observations derived from this risk assessment process include:

Risk identification and evaluation

- The Ingleside Precinct is exposed to potentially extreme existing bushfire risk, noting the Precinct has been previously impacted by fire events and extreme-scale event exposure is likely again based on recorded daily Forest Fire Danger Index (FFDI) captured since 1976.
- The proposed Structure Plan seeks to introduce a nine-fold increase in population, largely occurring via density increases in the Sub-Precincts of North Ingleside and South Ingleside (from approximately 1,080 persons at present to 9,000 persons).
- The proposed Structure Plan identifies important ecological communities which exist within the Precinct. Land use planning measures have thus been identified to maintain and enhance these values within the Precinct. It is the case however, these measures are at odds with the scale of potential risk exposure relevant to the Precinct and introduce strategic planning issues relating to the potential intrusion of landscape-scale fire risk into the Precinct
- Among others there are two primary aspects relevant to the consideration of bushfire risk for the Ingleside Precinct:
 - Risk to property; and
 - Risk to life.
- Risk treatment to property is considered possible through the application of a wide range of mitigation measures, specified in Section 10, consistent with the draft *Planning for Bushfire Protection 2018*. However, such property mitigation measures do not guarantee against property loss (or a large extent of property loss) having regard to the broad range of factors which contribute to building ignition during bushfire events. Further, the application of any treatment measures is likely to result in substantial impacts on the intended settlement pattern, and subsequently result in issues of overall development feasibility.
- Risk treatment to life is concordantly more complex and based on interlinked relationships between density/settlement pattern, human behaviour, evacuation capability and the potential for urban fire intrusion and house-to-house ignition. The ability to adequately treat life safety risk remains the core criteria which drives development acceptability.

Risk context

- Existing statutory planning and building frameworks either tacitly or explicitly result in acceptance of bushfire risk by government for property – house loss has and can still occur despite the combination of planning, building and other bushfire protection measures and this is acknowledged by the relevant instruments in place. These mitigation approaches seek to balance the trade-off often required between development and risk exposure, acknowledging that development can still occur in risk-exposed locations provided the magnitude of risk is mitigated to a level that is as low as reasonably practicable (i.e. tolerable or acceptable risk).
- From a property risk perspective, amendments to the draft Structure Plan combined with the suite of statutory planning and building (and other) mitigation measures is capable of mitigating, to an extent, property risk issues, acknowledging that despite this combination of measures some considerable property loss may still occur in higher magnitude events. In the

case of Ingleside, almost 2,000 dwellings (5,000 occupants) could be expected to be lost. This represents a significant portion of the proposed housing stock within the Precinct.

- Despite the above, the issue of risk acceptability in relation to the Ingleside Planned Precinct is largely about risk to life, and the identified need to examine the broader consideration of holistic bushfire risk management sought by governments and communities. Thus, the key to risk acceptability in this regard is ensuring from a government perspective that all necessary risk treatment measures are considered and applied to minimise risk.
- Bushfire fatality data for 260 events from 1901 to 2011, analysed by the CSIRO, shows that whilst late evacuation represents the primary activity undertaken at the time of death, there is a rising trend of fatalities occurring within structures (sheltering in place) – particularly in more extreme-scale events.
 - This emerging trend may be symptomatic of:
 - Residents which are reluctant to act upon a ‘leave early’ warning;
 - Lack of situational awareness (i.e. people caught off-guard);
 - Residents attempting to stay and defend in fire weather conditions which are not conducive to doing so; and/or
 - Residents adopting a ‘wait and see’ attitude and then leaving it too late to safely evacuate.
- The behavioural response of residents to bushfire emergency and evacuation warnings, studied by the Bushfire and Natural Hazards CRC, is a necessary input when contemplating evacuation as part of strategic risk-based land use planning.
- There is a strong relationship between built form, density, evacuation and resident behaviour.
- In Australia, ‘acceptable’ risk in instances of new land release and development is characterised by a general community expectation of zero life loss for design scenario events (which in this case is FFDI 100), thus loss of life represents unacceptable risk (i.e. community expectation is that sufficient information and capability exists today to make risk-informed decisions to avoid exposure where serious potential for life loss exists).
- Following disaster events, public dialogue with regard to the role of land use planning in allowing development to proceed in higher risk locations is common, and growing.
- From a strictly land use planning perspective, whilst evacuation is an emergency management process, risk-based land use planning must deliver route network options and design that facilitate safe and efficient evacuation but acknowledging the scale of unknown and unforeseeable situations which may translate on the day a fire event might occur.
- With regard to the Ingleside Precinct and the issue of risk to life, the topographic context and important ecological values in and surrounding the Precinct constrains the road network. Whilst upgrades to existing roads are proposed, no new roads are proposed and the upgraded network is insufficient to service the proposed population density (up from 1,080 to over 9,000 people) in an emergency, given the serious ‘single point of failure’ issues which exist. This is acknowledging:
 - Ingleside is completely surrounded by hazard, every evacuation route with the exception of Powderworks Road requires residents and fire services to traverse bushland to enter or evacuate. Powderworks Road is likely to bottleneck in an emergency, compounded by evacuees entering the network from Elanora Heights moving south;
 - no new road connections from Ingleside to surrounding suburbs is proposed. Notwithstanding, upgrades to four roads (offering five evacuation options) are

- proposed. 25 per cent of the Mona Vale Road corridor is identified as subject to potential flame contact. The ability for some of these roads to function in a bushfire emergency cannot be guaranteed;
- the Coronial Inquiry following the 1994 Cottage Point fire identified potential challenges with the road network as it existed at that time, with regard to the facilitation of evacuation and that this should be a core consideration in contemplating new development within Ingleside into the future;
 - evacuation of approximately 9,000 people from the Precinct, assuming 12 per cent would leave early, is likely to take hours and require substantially longer warning than that which might be available once an emergency situation is apparent, this is particularly the case if rate of spread/intensity is significant or catastrophic;
 - there are safety issues with the location of 'neighbourhood safer places' or evacuation centres, when coupling these facilities with the nature of the proposed road network and population density; and
 - more generally, there is a broader focus on the ability to evacuate as part of strategic land use planning dialogue in Australia and internationally, in recognising the role of land use planning in disaster risk reduction.
- it is accepted that as a general rule in planning in response to natural hazard, level of exposure can increase, but not the level of risk; and
 - the existing community of Ingleside is exposed to existing bushfire risk (addressed throughout this report). Despite some clearing that would be required as part of development in Ingleside, risk exposure to persons/potential for life loss is increased.

Consideration of key risk issues

Subsequent to the above, the key risk issues were considered, workshopped and deliberated in detail amongst all key stakeholders involving officers from DPE, NSWRFs and Northern Beaches Council across June, July and August 2018.

During stakeholder meetings to workshop and discuss the multitude of risk issues at play, there could be no clear mitigation pathway identified to reduce risk to an acceptable level.

Following extensive exploration of key risk issues, the risk to life as a key criterion/benchmarks for risk acceptability is unable to be satisfactorily mitigated either via strategic land use planning and/or other mitigation/management approaches.

This process involved the analysis of:

- the existing risk profile of Ingleside versus the proposed draft Structure Plan;
- changes to development and population densities;
- structure and settlement patterns;
- evacuation networks and alternative evacuation models (i.e. neighbourhood safer places and evacuation centres);
- the ecological values and topography in and surrounding the Precinct;
- the element of human behaviour in preparing for and responding to bushfire emergency;
- the transfer of risk to emergency services and risk to frontline firefighting personnel; and
- the impact of the 1994 bushfires on Ingleside and surrounding areas and the transition of fire which occurred irrespective of low fuel buffer areas.

Overall and having regard to the 'inappropriate' development benchmarks of PBP 2018, the scale and complexity of the competing, compounding and cascading risks to life and property, supported by the evidence base presented by this risk assessment, determines that available mitigation measures are unable to reduce the risk profile to a level which is universally acceptable to DPE, NSWRFs or Northern Beaches Council insofar as the current draft Structure Plan.

12.2 Recommendations

Moving forward, several key recommendations are identified:

1. The planning pathway forward for Ingleside should be clearly identified. If appetite for further development or certain types of development is low, appropriate planning instruments should be implemented to avoid potential for ad hoc and incremental risk increase over time via discrete planning proposals.
2. The existing risk profile of Ingleside must be addressed with a combined range of measures to strengthen community resilience to bushfire. This could be undertaken via a resilience workshopping process to identify key mitigation opportunities and built-in to a revised Warringah Pittwater Bush Fire Risk Management Plan and Local Emergency Management Plans.
3. Avoid the introduction of any new Special Fire Protection Purposes within the Ingleside Precinct into the future.
4. Consider the preparation of a Guidance Manual for conducting strategic land use planning risk assessments / bushfire strategic studies as an addendum / appendix to PBP 2018 to ensure consistency in process, approach and evidence-based reporting is conducted moving forward across NSW (similar to the NSW Floodplain Development Manual).

As bushfire protection planning policy has changed since the planning process for Ingleside first commenced, and new methodologies have emerged, it is now expected that new master planning processes would inherently consider the magnitude of potential bushfire risk as a precursor and build-in bushfire resilient land use planning approaches throughout design processes, where appropriate.

13 Conclusions

This risk assessment considers the extent of potential bushfire risk relevant to the existing and proposed community of Ingleside, having particular regard to the draft Structure Plan and draft Land Use and Infrastructure Strategy prepared for the Ingleside Planned Precinct.

This risk assessment has been undertaken through the lens of risk-based land use planning in order to critically analyse the extent of bushfire risk exposure in both existing and potential future (based upon the current draft Structure Plan) contexts. On the basis of the NERAG framework, this risk assessment report has analysed the extent of both landscape-scale and localised fire risk to evaluate the quantum of risk issues of relevance from a strategic land use planning perspective.

Overall and having regard to the 'inappropriate' development benchmarks of PBP 2018, the scale and complexity of the competing, compounding and cascading risks to life and property, supported by the evidence base presented by this risk assessment, determines that available mitigation measures are unable to reduce the risk profile to a level which is universally acceptable to DPE, NSWRFSS or Northern Beaches Council.

In recognition of the above, several recommendations are identified for consideration to resolve the planning pathway for Ingleside moving forward, with a focus on avoiding ad hoc and incremental risk increase over time.

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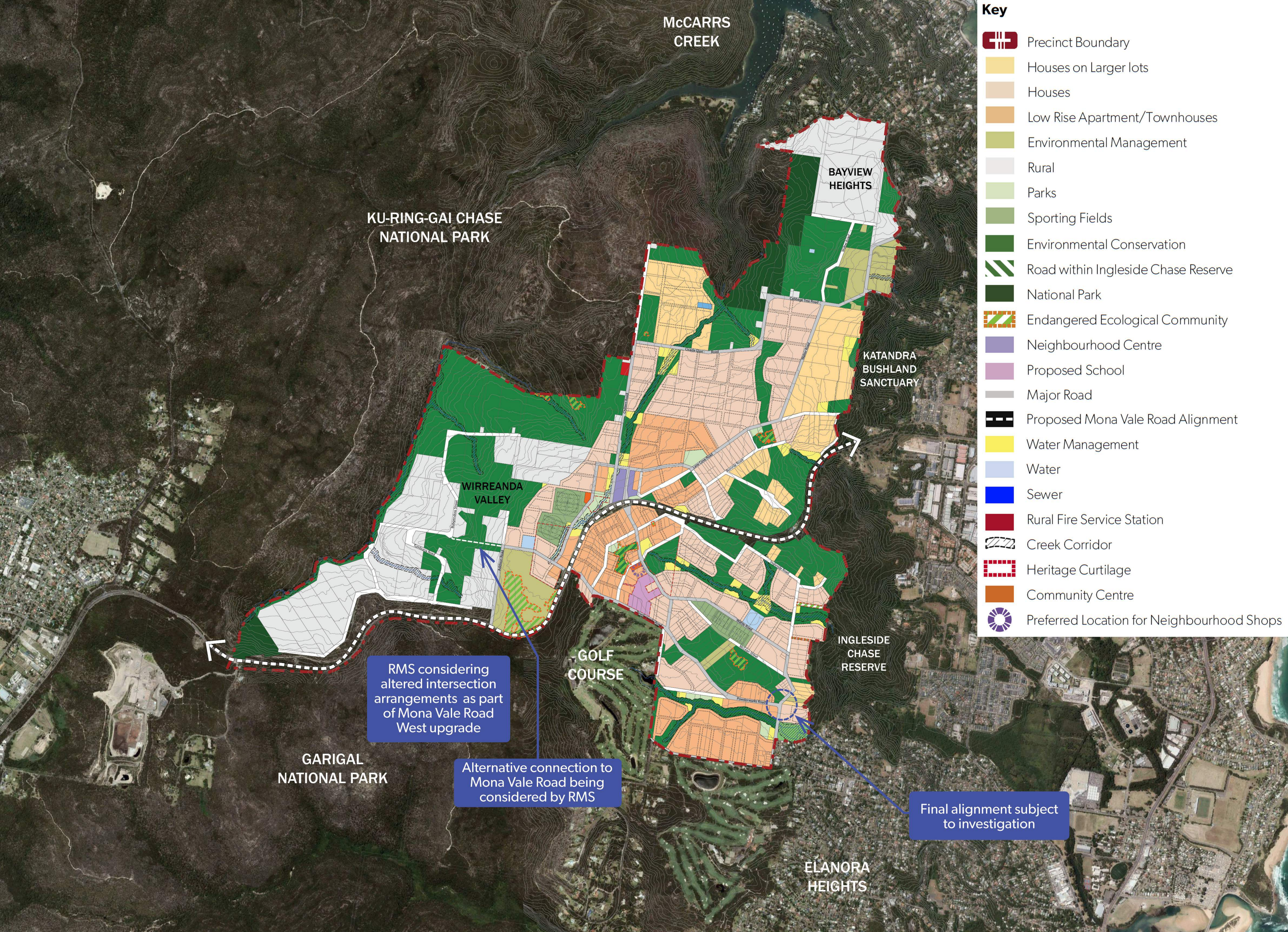
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APPENDICES



Appendix A Draft Structure Plan for the Ingleside Precinct



McCARRS CREEK

KU-RING-GAI CHASE NATIONAL PARK

BAYVIEW HEIGHTS

KATANDRA BUSHLAND SANCTUARY

WIRREANDA VALLEY

GOLF COURSE

INGLESIDE CHASE RESERVE

GARIGAL NATIONAL PARK

ELANORA HEIGHTS

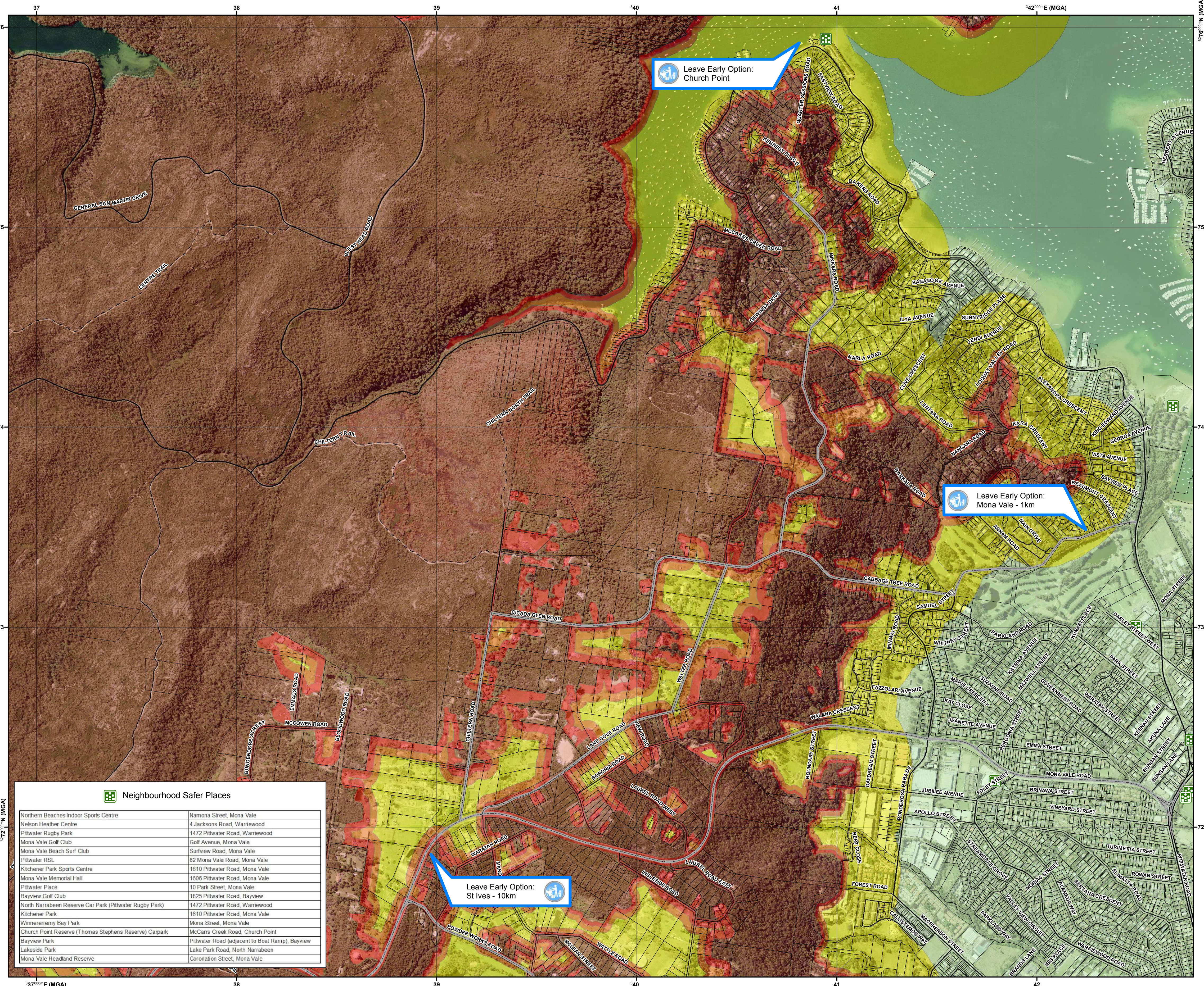
- Key**
-  Precinct Boundary
 -  Houses on Larger lots
 -  Houses
 -  Low Rise Apartment/Townhouses
 -  Environmental Management
 -  Rural
 -  Parks
 -  Sporting Fields
 -  Environmental Conservation
 -  Road within Ingleside Chase Reserve
 -  National Park
 -  Endangered Ecological Community
 -  Neighbourhood Centre
 -  Proposed School
 -  Major Road
 -  Proposed Mona Vale Road Alignment
 -  Water Management
 -  Water
 -  Sewer
 -  Rural Fire Service Station
 -  Creek Corridor
 -  Heritage Curtilage
 -  Community Centre
 -  Preferred Location for Neighbourhood Shops

RMS considering altered intersection arrangements as part of Mona Vale Road West upgrade

Alternative connection to Mona Vale Road being considered by RMS

Final alignment subject to investigation

Appendix B NSWRFS Bush Fire Survival Map for Bayview, Ingleside and Elanora Heights



Neighbourhood Safer Places

Northern Beaches Indoor Sports Centre	Namona Street, Mona Vale
Nelson Heather Centre	4 Jacksons Road, Warriewood
Pittwater Rugby Park	1472 Pittwater Road, Warriewood
Mona Vale Golf Club	Golf Avenue, Mona Vale
Mona Vale Beach Surf Club	Surfview Road, Mona Vale
Pittwater RSL	82 Mona Vale Road, Mona Vale
Kitchener Park Sports Centre	1610 Pittwater Road, Mona Vale
Mona Vale Memorial Hall	1606 Pittwater Road, Mona Vale
Pittwater Place	10 Park Street, Mona Vale
Bayview Golf Club	1825 Pittwater Road, Bayview
North Narrabeen Reserve Car Park (Pittwater Rugby Park)	1472 Pittwater Road, Warriewood
Kitchener Park	1610 Pittwater Road, Mona Vale
Winnereremy Bay Park	Mona Street, Mona Vale
Church Point Reserve (Thomas Stephens Reserve) Carpark	McCarrs Creek Road, Church Point
Bayview Park	Pittwater Road (adjacent to Boat Ramp), Bayview
Lakeside Park	Lake Park Road, North Narrabeen
Mona Vale Headland Reserve	Coronation Street, Mona Vale

Bush Fire Survival Map

Bayview & Ingleside (Nth)

What is Your Bush Fire Threat?

- Flame Impact** (Red): You and your property are likely to be directly impacted by flame, deadly levels of radiant heat, significant embers and smoke from a bush fire. The risk of death and property destruction from bush fire is greatest in this area. Leaving early is your safest option.
- Radiant Heat Impact** (Orange): You and your property are likely to be impacted by deadly levels of radiant heat, significant embers and smoke from a bush fire. You and your property must be well prepared if you choose to stay and defend.
- Ember Impact** (Yellow): You and your property are likely to be impacted by lower levels of radiant heat, significant embers and smoke from a bush fire. You and your property must be well prepared if you choose to stay and defend.
- Be Aware** (Green): Embers can cause fires kilometres from the main fire and can impact on houses up to one hour before the fire arrives and several hours after the fire has passed. It only takes one ember to ignite your house and property. Ensure that you and your property are well prepared and monitor your property carefully during a bush fire.

Extreme Fire Danger Rating. Information provided on this map is not to be used for building / planning purposes.

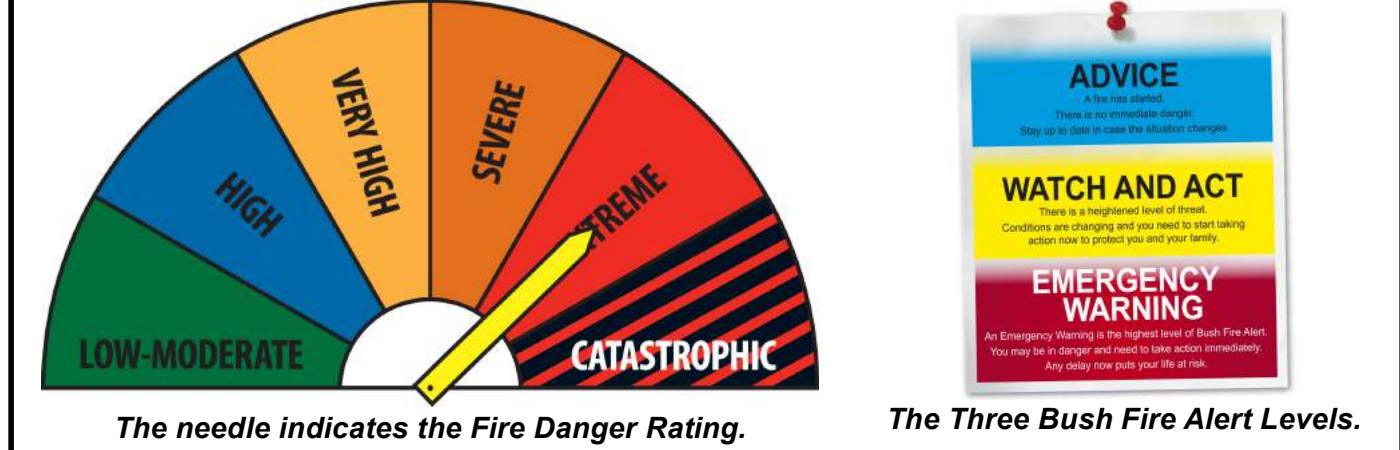
A well designed and prepared building will provide more protection against bush fire.

- Neighbourhood Safer Place**: Neighbourhood Safer Places are a Place of Last Resort during a bush fire. Have you identified a Neighbourhood Safer Place and Other Safer Locations in your Bush Fire Survival Plan? See attached List.
- Main Road**: Roads may become impassable during a bush fire. Your safest option is to Leave Early.
- Leave Early**: Leaving early means leaving LONG before a bush fire is in your area. On days of Catastrophic fire danger you should leave early in the morning or even the night before.

Your Bush Fire Survival Options



Stay informed about local fire conditions. Check the NSW RFS website or listen to the local emergency radio broadcaster for information on the Fire Danger Rating and Bush Fire Alert Level.



PREPARE. ACT. SURVIVE.

KEEP YOURSELF INFORMED
 Emergency Local Broadcaster
 ABC Local Radio 702 AM
 ABC National Radio 576 AM
 RTA Traffic Info Line: 132 701
www.facebook.com/nswrfs
www.twitter/nswrfs

BUSH FIRE INFORMATION LINE
1800 NSW RFS
 1 8 0 0 6 7 9 7 3 7
www.rfs.nsw.gov.au

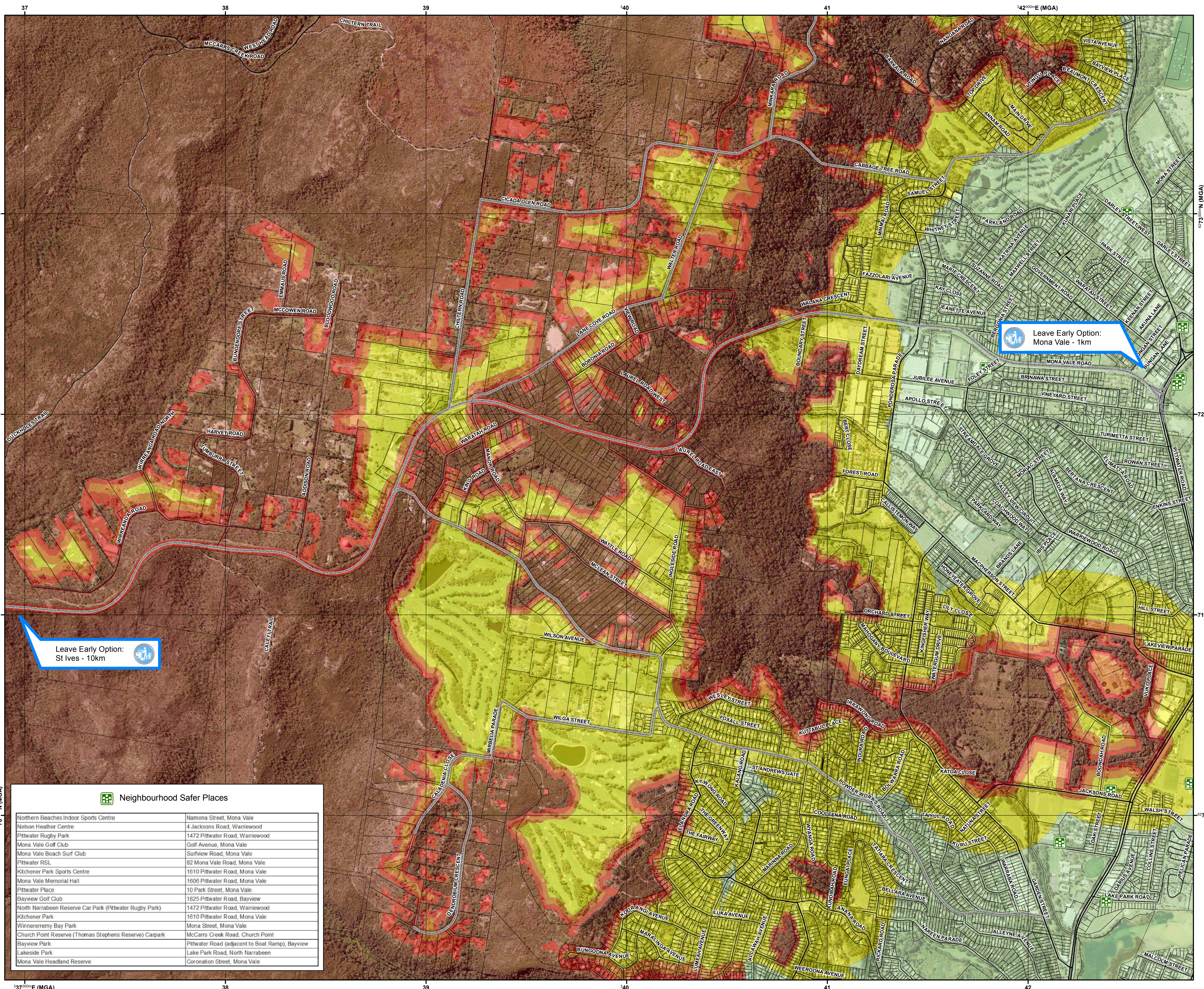
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 Base Data: LPMA Casastre and Topo Database
 Map Projection: GCS_GDA_1994
 Re-Print Date: 7 January 2015
 Produced by: Sarah Kemble
 1 grid square = 1 km² Scale: 1: 10,000
 BFMC Approval: 3 December 2013

WARNING INFORMATION

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FIRE HAS A PLAN DO YOU?

Get prepared for the Bush Fire Season and make your Bush Fire Survival Plan Now.
 Go to www.myfireplan.com.au and discuss with your family what to do if a fire starts near you.



Neighbourhood Safer Places

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Bayview Park	Pittwater Road (adjacent to Boat Ramp), Bayview
Lakeside Park	Lake Park Road, North Narrabeen
Mona Vale Headland Reserve	Coronation Street, Mona Vale

Bush Fire Survival Map

Elanora Heights & Ingleside (Sth)

What is Your Bush Fire Threat?

- Flame Impact**
 You and your property are likely to be directly impacted by flame, deadly levels of radiant heat, significant embers and smoke from a bush fire. The risk of death and property destruction from bush fire is greatest in this area. Leaving early is your safest option.
- Radiant Heat Impact**
 You and your property are likely to be impacted by deadly levels of radiant heat, significant embers and smoke from a bush fire. You and your property must be well prepared if you choose to stay and defend.
- Ember Impact**
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- Be Aware**
 Embers can cause fires kilometres from the main fire and can impact on houses up to one hour before the fire arrives and several hours after the fire has passed. It only takes one ember to ignite your house and property. Ensure that you and your property are well prepared and monitor your property carefully during a bush fire.

Extreme Fire Danger Rating. Information provided on this map is not to be used for building / planning purposes.

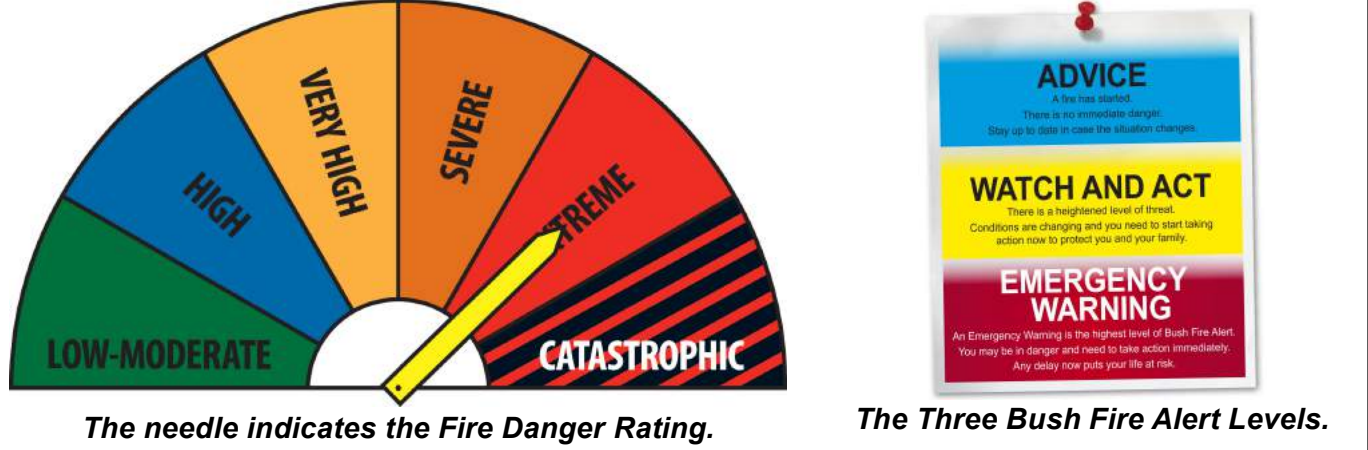
A well designed and prepared building will provide more protection against bush fire.

- Neighbourhood Safer Place**
 Neighbourhood Safer Places are a Place of Last Resort during a bush fire. Have you identified a Neighbourhood Safer Place and Other Safer Locations in your Bush Fire Survival Plan?
 See attached List.
- Main Road**
 Roads may become impassable during a bush fire. Your safest option is to Leave Early.
- Leave Early**
 Leaving early means leaving LONG before a bush fire is in your area. On days of Catastrophic fire danger you should leave early in the morning or even the night before.

Your Bush Fire Survival Options



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PREPARE. ACT. SURVIVE.

KEEP YOURSELF INFORMED
 Emergency Local Broadcaster
 ABC Local Radio 702 AM
 ABC National Radio 576 AM
 RTA Traffic Info Line: 132 701
www.facebook.com/nswrfs
www.twitter/nswrfs

BUSH FIRE INFORMATION LINE
1800 NSW RFS
 1 8 0 0 6 7 9 7 3 7
www.rfs.nsw.gov.au

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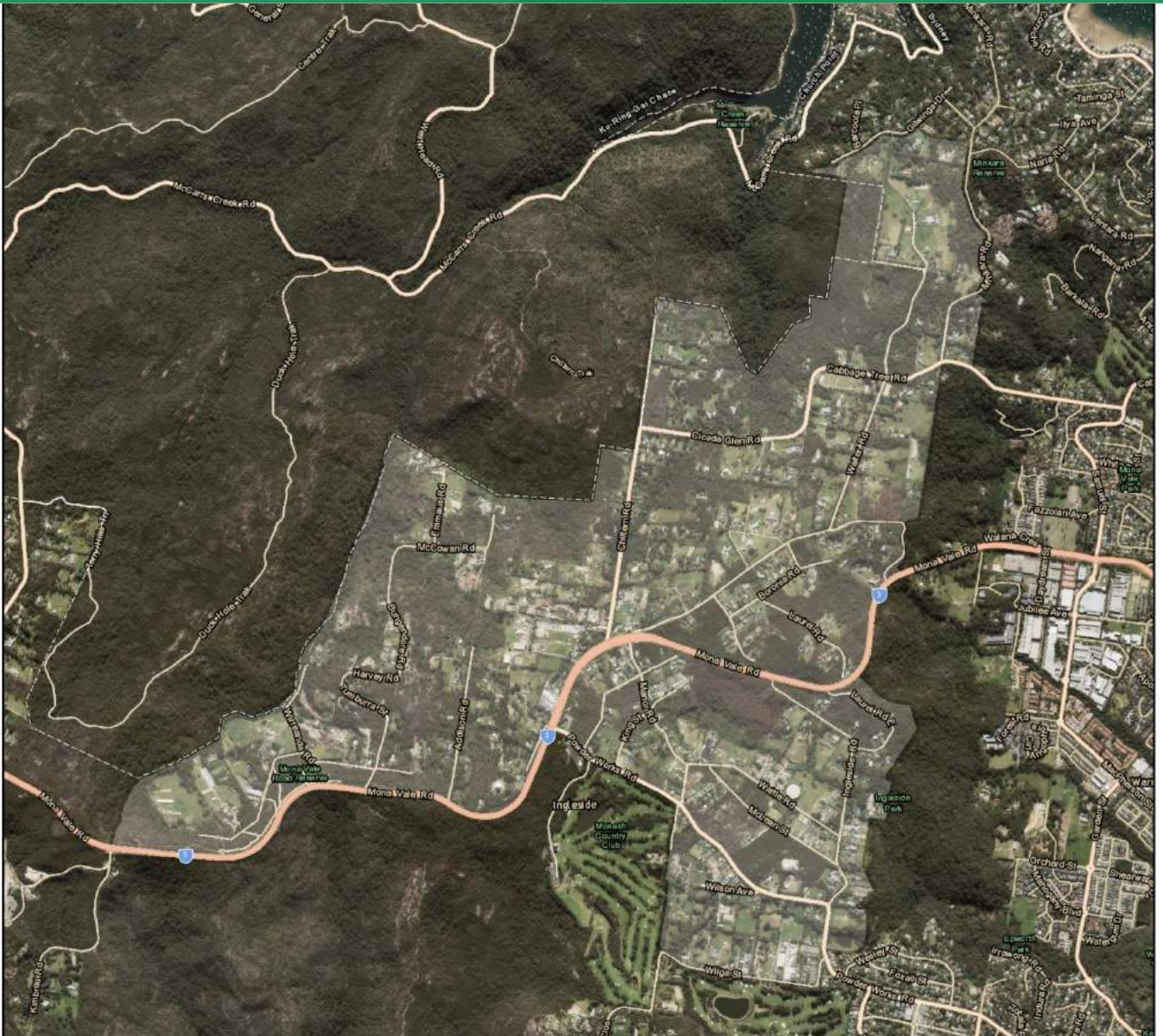
Appendix C ELA Bushfire Intensity Modelling Report

Bushfire Intensity Modelling

Ingleside Precinct

Prepared for
NSW Department of Planning & Environment

May 2018



DOCUMENT TRACKING

Item	Detail
Project Name	Bushfire Intensity Modelling – Ingleside Precinct
Project Number	17SYD-9493
Project Manager	Nathan Kearnes 02 8536 8614 / 0423 191 725 L1, 101 Sussex Street Sydney NSW 2000
Prepared by	Peter Hawke
Reviewed by	Nathan Kearnes, Bruce Horkings
Approved by	Nathan Kearnes
Status	DRAFT
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1 Introduction

1.1 Background

The Department of Planning & Environment (DPE) is in the process of reviewing its draft structure plan for the Ingleside Precinct (**Figure 1**). The aim of this study was to prepare bushfire intensity models for a number of bushfire scenarios to provide context to the potential bushfire risk that the precinct is exposed to.

To meet this aim, the agreed project approach was to:

1. Assess the bushfire hazard relevant to the Ingleside Precinct (specified for this study as being the precinct and the surrounding landscape out to a distance of 5km); and
2. Prepare models within a GIS of the potential bush fire intensity across the study area for an agreed set of bushfire scenarios.

1.2 Study Area

The Ingleside Precinct is the focus of this study (**Figure 1**), however the area surrounding the Precinct (to a distance of 5 km) is also included in the study area, in order for the landscape bushfire risk to be assessed.

The Ingleside Precinct is located along Mona Vale Road on Sydney's Northern Beaches and within the Local Government Area of the newly amalgamated Northern Beaches Council. The Precinct is located between Ku-ring-gai Chase National Park to the northwest, Katandra Bushland Sanctuary and Ingleside Chase Reserve to the east, and Garigal National Park to the southwest. Existing urban and rural/urban development and other landuses are located within the Precinct as well as surrounding the Precinct to the north, east, southeast and in part to the west in the Terrey Hills area.



Figure 1: Ingleside Precinct Location & Study Area

2 Bushfire Intensity Modelling

The bushfire intensity modelling undertaken for this project is outlined in Section 2.2 and relied on a series of inputs representing various elements of the bushfire hazard setting for the landscape across the study area, outlined in Section 2.1 below.

2.1 Bushfire Hazard

The assessment of bushfire hazard for this study leverages on a classification of topography (slope and aspect) and vegetation formations / fuel across the study area. The assessment leveraged off the draft guidelines *Planning for Bushfire Protection* (PBP) (RFS 2017).

2.1.1 Slope

Slope (in degrees) has been derived across the study area from a 10 m grid cell Digital Elevation Model (DEM) and provides an overview of the terrain within the study area. It shown in **Figure 2** in the following slope classes (as per PBP):

- Upslope and flat;
- >0° – 5° downslope;
- >5° – 10° downslope;
- >10° – 15° downslope;
- >15° – 20° downslope;
- >20° downslope.

2.1.1 Aspect

Aspect (in degrees) has been derived across the study area from a 10 m grid cell Digital Elevation Model (DEM). It is shown in **Figure 3** and is a relevant input into the intensity models in combination with wind direction and slope given the influence on intensity of fire burning uphill (faster and hotter) downhill (cooler and slower) or on flat ground.

2.1.2 Vegetation / Fuel

Vegetation types present across the study area have been compiled from best available vegetation mapping, then classified into Keith Formations and Keith Class (Keith 2004) and then assigned a potential total fuel load (tonnes / hectare) using Table A1.11.21 from PBP (RFS 2017).

Two different vegetation/fuel layers were developed as follows:

- Existing vegetation, based on extant vegetation mapping;
- Potential future vegetation, based on the above for areas outside the precinct and the potential future vegetation inside the precinct given the proposed land uses presented in the draft structure plan. That is, extant vegetation in areas identified in the Ingleside Precinct Draft Structure Plan for development were removed and conversely, areas marked as environmental conservation or high constraint were retained / added.

The vegetation/fuel classification (existing) is presented in **Figure 4** with the allocation of formations, classes and assignment of fuel load as per **Table 2**. The vegetation/fuel datasets were generated from a compilation of the following:

- Sydney Metro Catchment Management Area Vegetation Mapping (OEH 2016)
- Ingleside Precinct Validated Vegetation Mapping (ELA 2016)

Table 1: Vegetation formation, class and fuel allocation for the study area

Keith Formation	Keith Class	Overall Fuel (t/ha)*
Rainforest	Littoral Rainforests	13.2
	Northern Warm Temperate Rainforests	
Wet Sclerophyll Forests (Grassy)	Northern Hinterland Wet Sclerophyll Forests	33.1
Wet Sclerophyll Forests (Shrubby)	North Coast Wet Sclerophyll Forests	35.98
	Southern Lowland Wet Sclerophyll Forests	32.8
Dry Sclerophyll Forests (Shrubby)	Sydney Coastal Dry Sclerophyll Forests	27.3
	Sydney Hinterland Dry Sclerophyll Forests	27.42
	Coastal Dune Dry Sclerophyll Forests	31.1
Forested Wetlands	Coastal Swamp Forests	34.1
Heathlands (Tall Heath)	Sydney Coastal Heaths ^{##}	15
	Coastal Headland Heaths	36.9
	Low Hazard [#]	13.2
Freshwater Wetlands	Coastal Heath Swamps	15.0
	Coastal Floodplain Wetlands	15.1
	Coastal Freshwater Lagoons	4.4
Grasslands	Maritime Grasslands	6.0

*Overall fuel as per Bark and Canopy field in Table A1.11.21 from PBP (RFS 2017)

[#] 'Low Hazard' vegetation as per PBP, Rainforest Fuel used.

^{##} Short Heath fuel used given abundance of rock outcrops.

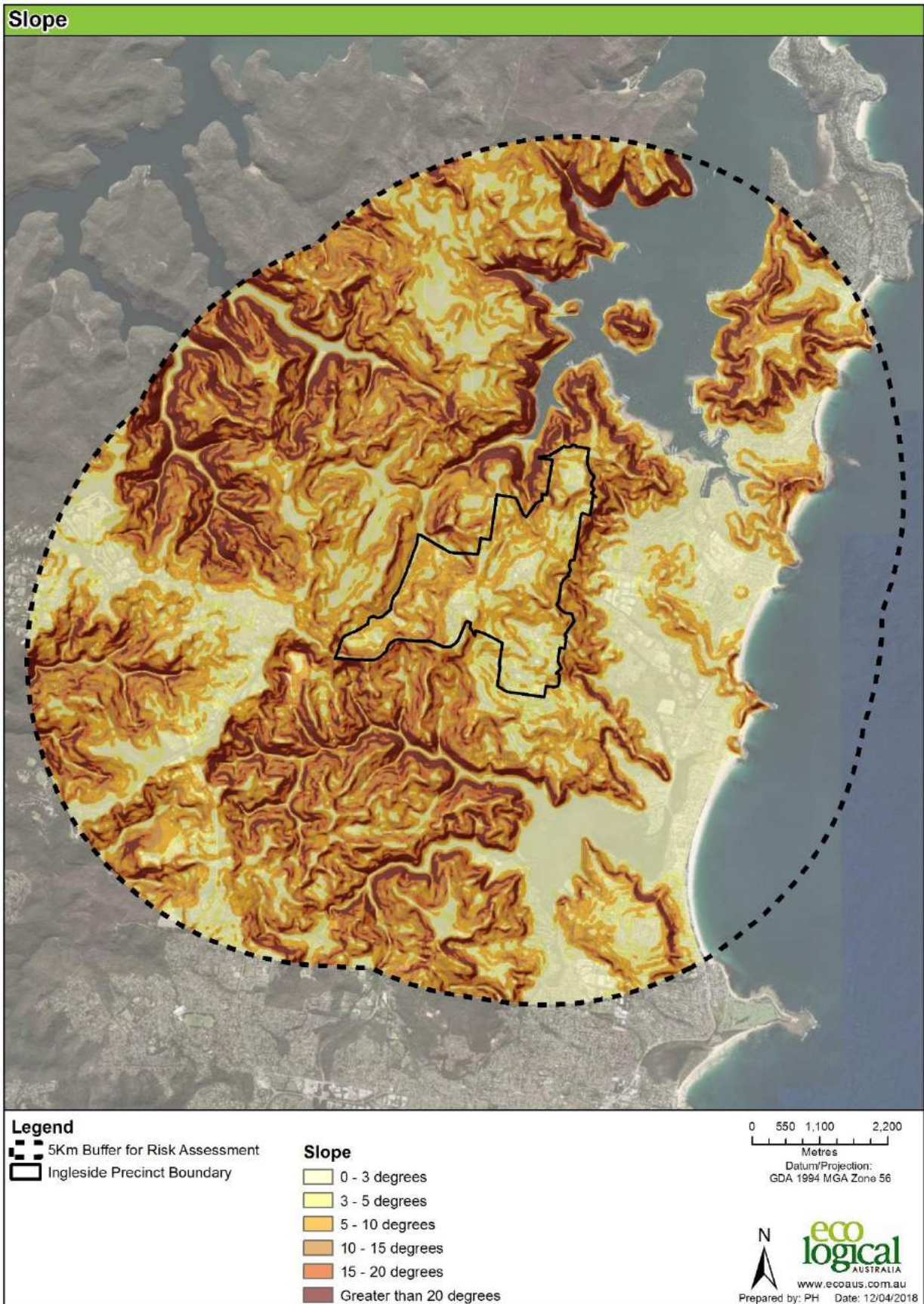


Figure 2: Slope across the study area

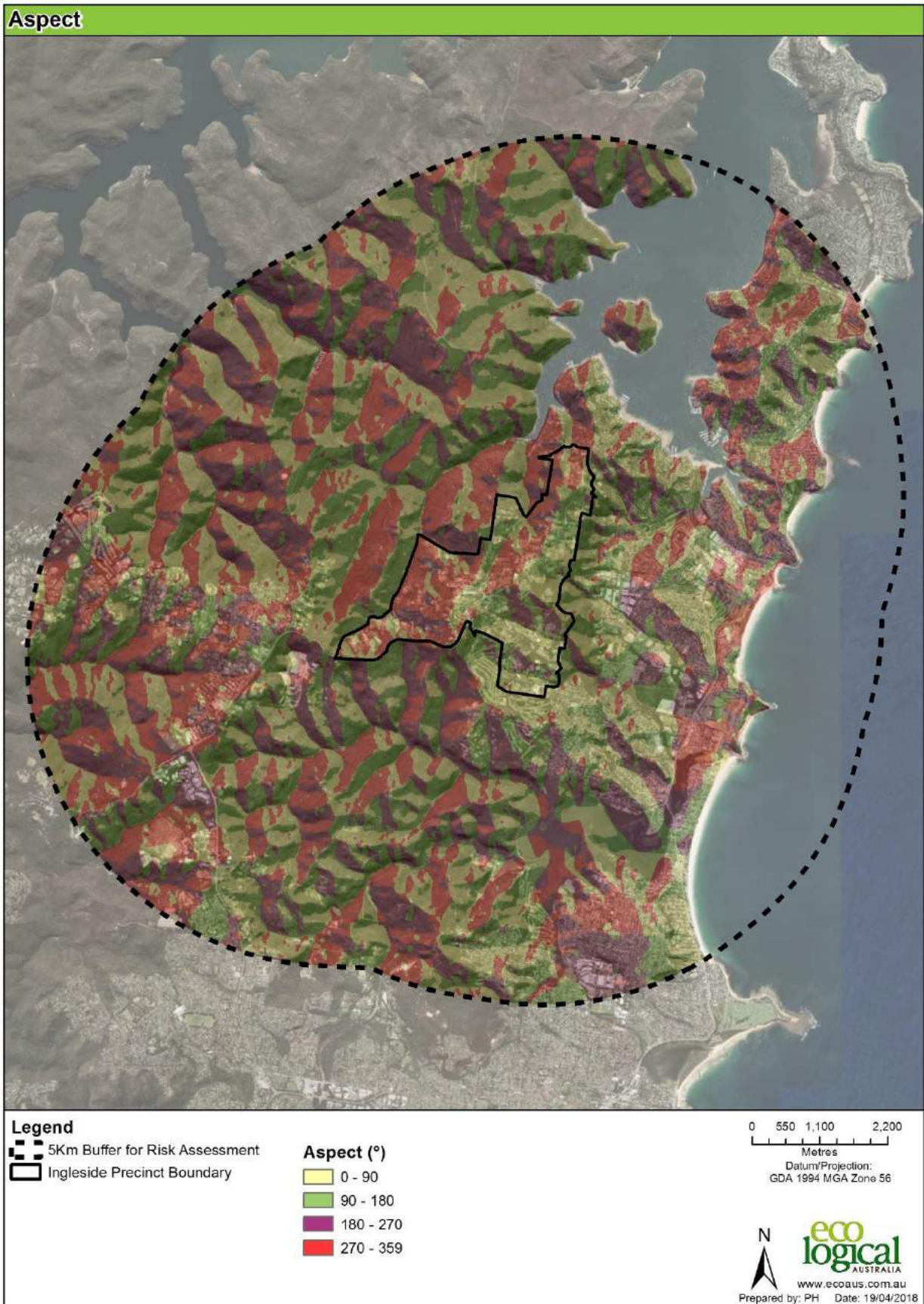


Figure 3: Aspect across the study area

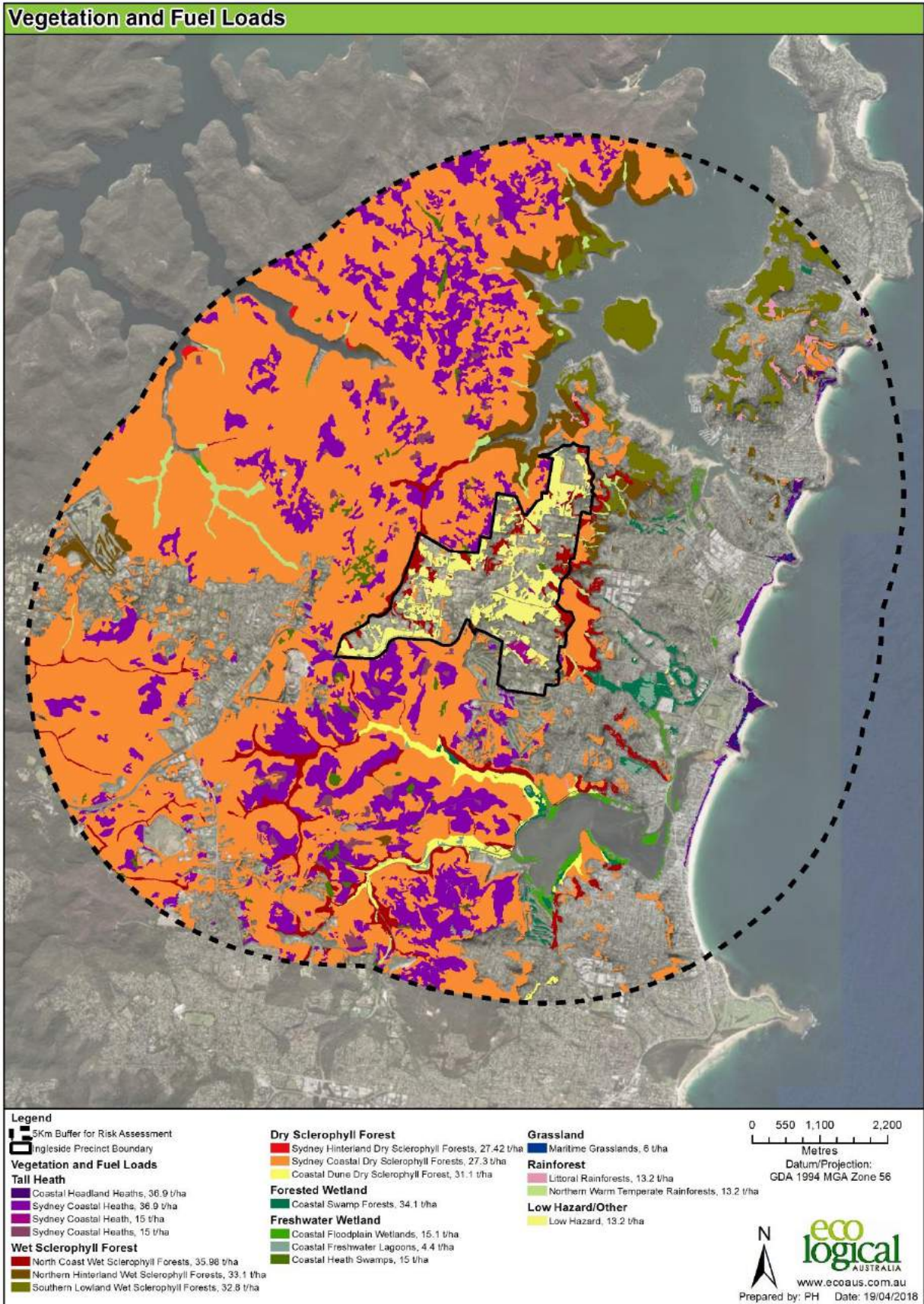


Figure 4: Current vegetation formation / fuel classification of the study area

2.2 Bushfire Intensity Modelling

A series of bushfire intensity models were prepared based on the approach and scenarios outlined below and the inputs outlined in Section 2.1 above. The models provide an indication of the potential head fire intensity from the direction of attack for the scenario's being modelled, with intensities greater than 4,000 kW/m generally considered uncontrollable in all weather conditions.

The models were generated spatially for the entire study area utilising the bushfire hazard data (as detailed in Section 2.1) and in light of an analysis of bushfire weather (documented in Section 2.2.1 below). These models use the following parameters to identify the potential bushfire intensity:

- Terrain (slope and aspect);
- Fuel (vegetation);
- Likely bushfire weather scenarios including the Forest Fire Danger Index (FFDI) and wind direction.

The modelling approach calculates potential head fire intensity using established fire intensity formulae documented in Cheney et al 2012 (for Forest and Woodland), Anderson et al 2015 (for Heath and Shrubland), and Cheney et al 1998 (for Grassland). Three core models were prepared for the following bushfire attack scenarios:

- Bushfire attack from the north to south-east direction (clockwise) at FFDI 63 (**Figure 5 & 12**);
- Bushfire attack from the south-east to south-west direction (clockwise) at FFDI 47 (**Figure 6 & 13**);
- Bushfire attack from the south-west to north direction (clockwise) at FFDI 116 (**Figure 7 & 14**).

The three core models have been compiled together to provide an overall “average” intensity from all directions (**Figure 8 & 15**).

In addition, models were run to simulate bush fire attack from the south-west to north direction (clockwise) at FFDI 62, representing the likely conditions experienced on 8th of January 1994 (**Figure 9 & 16**), and also south-west to north direction (clockwise) at FFDI 134, representing a scenario for potential climate change conditions (**Figure 10 & 17**). Lastly, final models were run at FFDI 100, following stakeholder requests (**Figure 11 & 18**).

Each of the above model intensity scenarios were modelled to represent the existing vegetation environment, and in addition; each model scenario was run for the potential future vegetation fuel loads based on the Draft Structure Plan. **Table 3** summarises the scenarios modelled and the resultant figures (presented in Section 3).

Table 2: Bush fire intensity models run in this study

	Item	Bushfire Scenario	Existing vegetation	Proposed vegetation (based on draft Structure Plan)
Core Models	1	N to SE wind - FFDI 63	Figure 5	Figure 12
	2	SE to SW wind - FFDI 47	Figure 6	Figure 13
	3	SW to N wind - FFDI 116	Figure 7	Figure 14

	Item	Bushfire Scenario	Existing vegetation	Proposed vegetation (based on draft Structure Plan)
	4	Average intensity from all scenario's above	Figure 8	Figure 15
Additional Models	5	SW to N wind - FFDI 62 (representing the likely conditions experienced on 8th January 1994)	Figure 9	Figure 16
	6	SW to N wind - FFDI 134 (representing potential climate change conditions)	Figure 10	Figure 17
	7	SW to N wind - FFDI 100	Figure 11	Figure 18

2.2.1 Bushfire Weather Analysis

Weather data developed by Lucas (2010) under the National Historical Fire Weather Dataset (1972-2015) incorporates the daily Forest Fire Danger Index (FFDI), where suitable inputs are available, from over 70 weather stations across Australia. Data from the Sydney Airport and Richmond weather stations (station numbers 66037 and 67033/67105 respectively) was analysed to determine the maximum FFDI for a 1 in 50-year event, being the accepted recurrence period for land use planning (RFS 2006).

The dataset for each site was split into subsets based on wind directions including:

- All directions;
- North to south-east (clockwise);
- South-east to South-west (clockwise);
- South-west to North (clockwise).

To determine the 1:50 recurrence value, a Generalised Extreme Value (GEV) analysis method was undertaken to calculate the FFDI value within each data subset (**Table 4**). Although the GEV model has been used in other disciplines for analysing extreme events (i.e. flooding recurrence values), it is only in recent times to have been considered appropriate for bushfire weather analysis (Douglas 2017). The GEV methodology and its use to analyse bushfire weather data is discussed in a number of papers by Douglas et al (2014; 2016).

Table 3: FFDI for a 1 in 50-year event

Weather Station	Max Recorded FFDI	All directions	N to SE	SE to SW	SW to N
Sydney Airport	116	116	63	47	116
Richmond Airport	96	105	52	45	105

The FFDI values for Sydney Airport are worse (higher) than those for Richmond Airport, so the former was considered more appropriate for consideration as 'worst case'.

3 Results

The models show that the greatest intensities are possible on the western facing slopes containing forest and heath vegetation, which are present in the surrounding National Parks areas to the west and south. The areas to the east are modelled as generally having lower potential levels of intensities.

It is noted that each bushfire event is different, responding to changes in fuel, weather conditions and FFDI. Thus, the models are an indication of what could be experienced under the bushfire weather scenario modelled provided the fuel and terrain are similar to the input data used in the model.

It is important to note that the models of potential fire intensity do not provide an indication of ignition risk or the rate of spread of a bushfire. It is specifically noted that, although the grassland areas will not carry a fire of the same intensity as the forested areas, these areas potentially have the highest risk of ignition and rate of spread. Conversely, fires within the grassland areas are potentially more controllable under certain weather conditions given the lower potential fire intensities in these locations.

It is lastly noted that the above intensity modelling approach does not account for events under extreme fire behaviour / weather including such phenomena as:

- Spotting/Fire storm;
- Fire tornado/whirls;
- Lateral vortices;
- Junction zones (Jump fires);
- Eruptive fires;
- Conflagrations;
- Downbursts;
- Pyro-convective events;



Figure 5: Potential Fire Intensity (north to south-east wind, FFDI 63, existing vegetation)



Figure 6: Potential Fire Intensity (south-east to south-west wind, FFDI 47, existing vegetation)

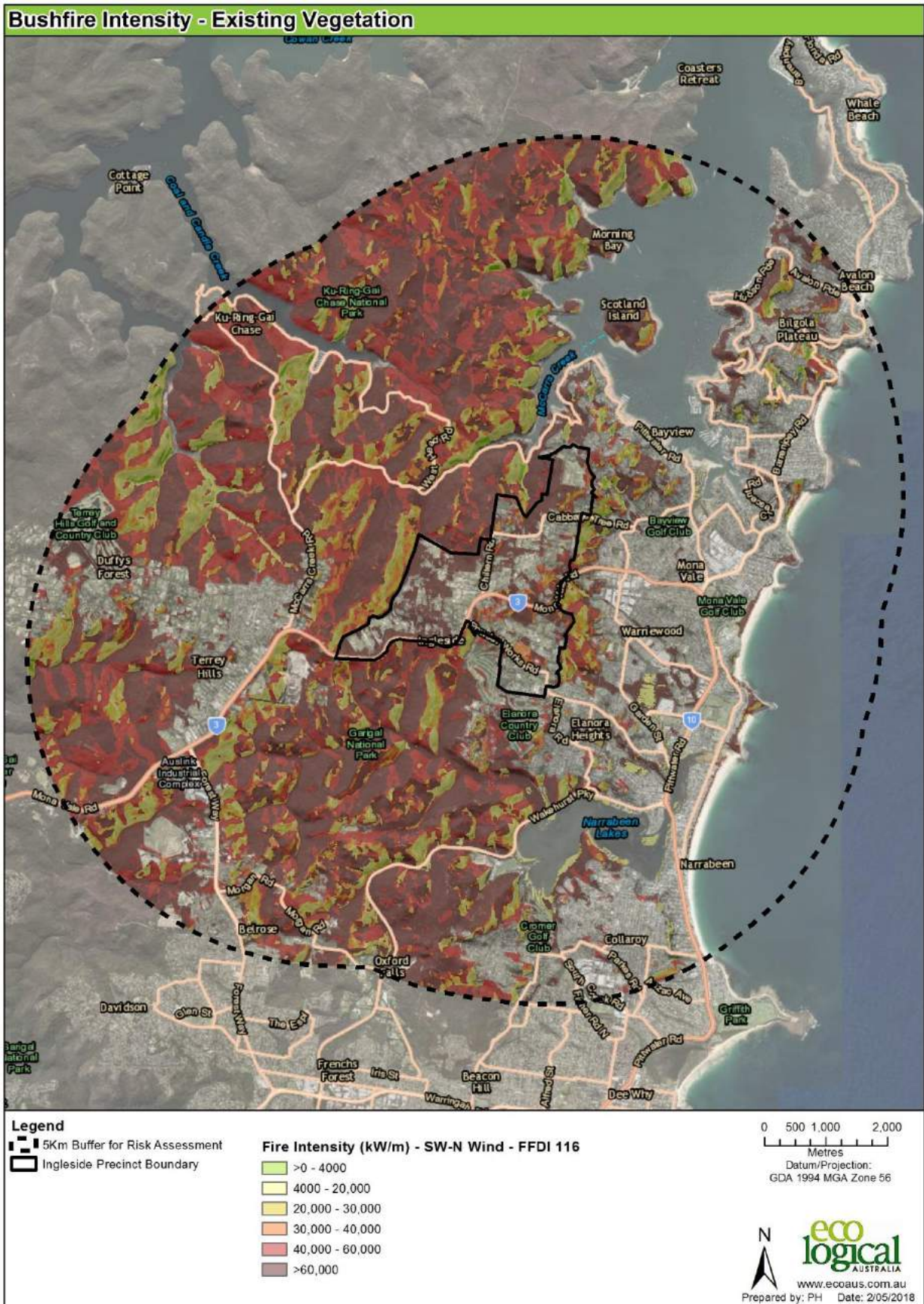


Figure 7: Potential Fire Intensity (south-west to north wind, FFDI 116, existing vegetation)

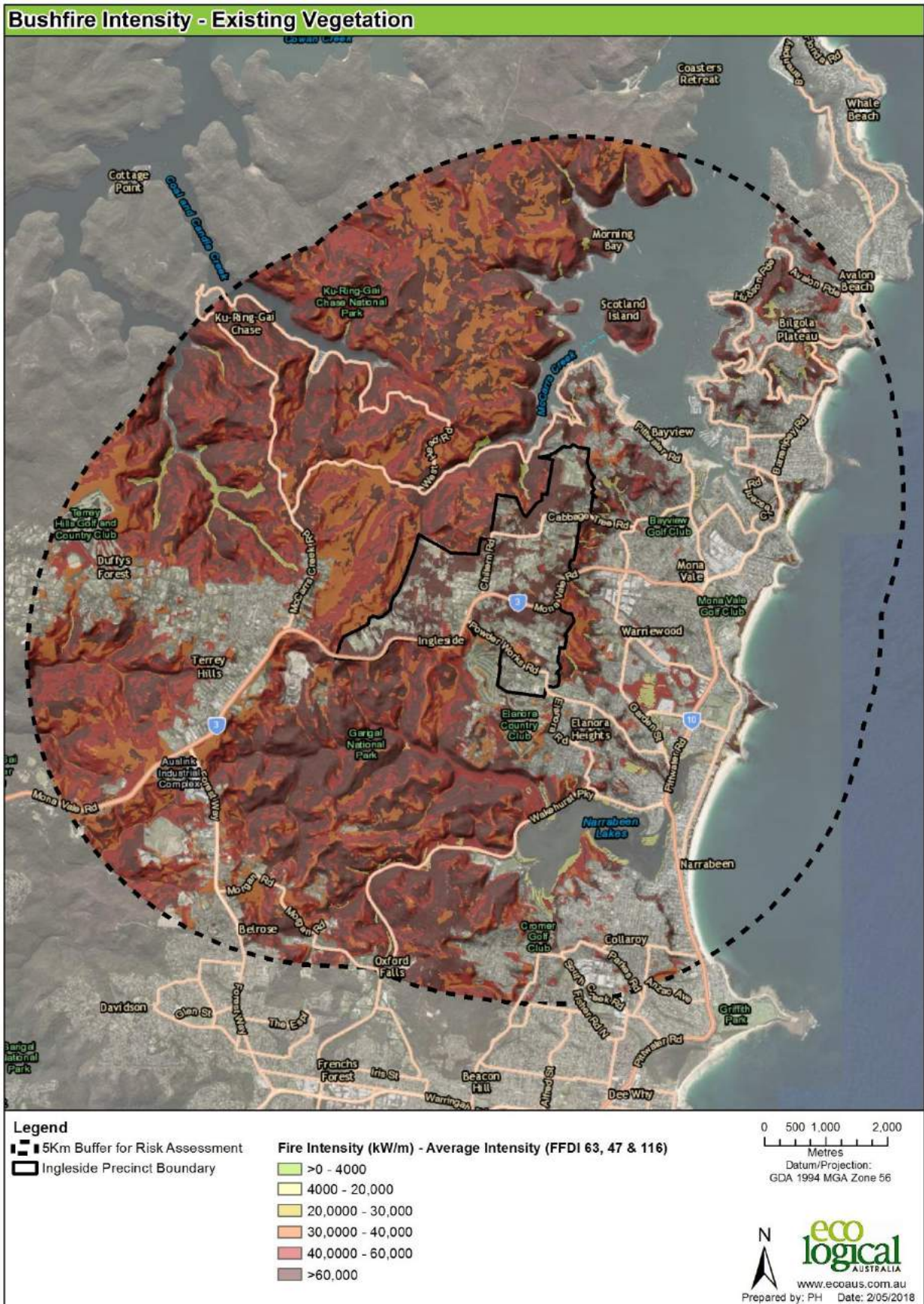


Figure 8: Potential Fire Intensity (average of all directions, existing vegetation)



Figure 9: Potential Fire Intensity (south-west to north wind, FFDI 62, existing vegetation)

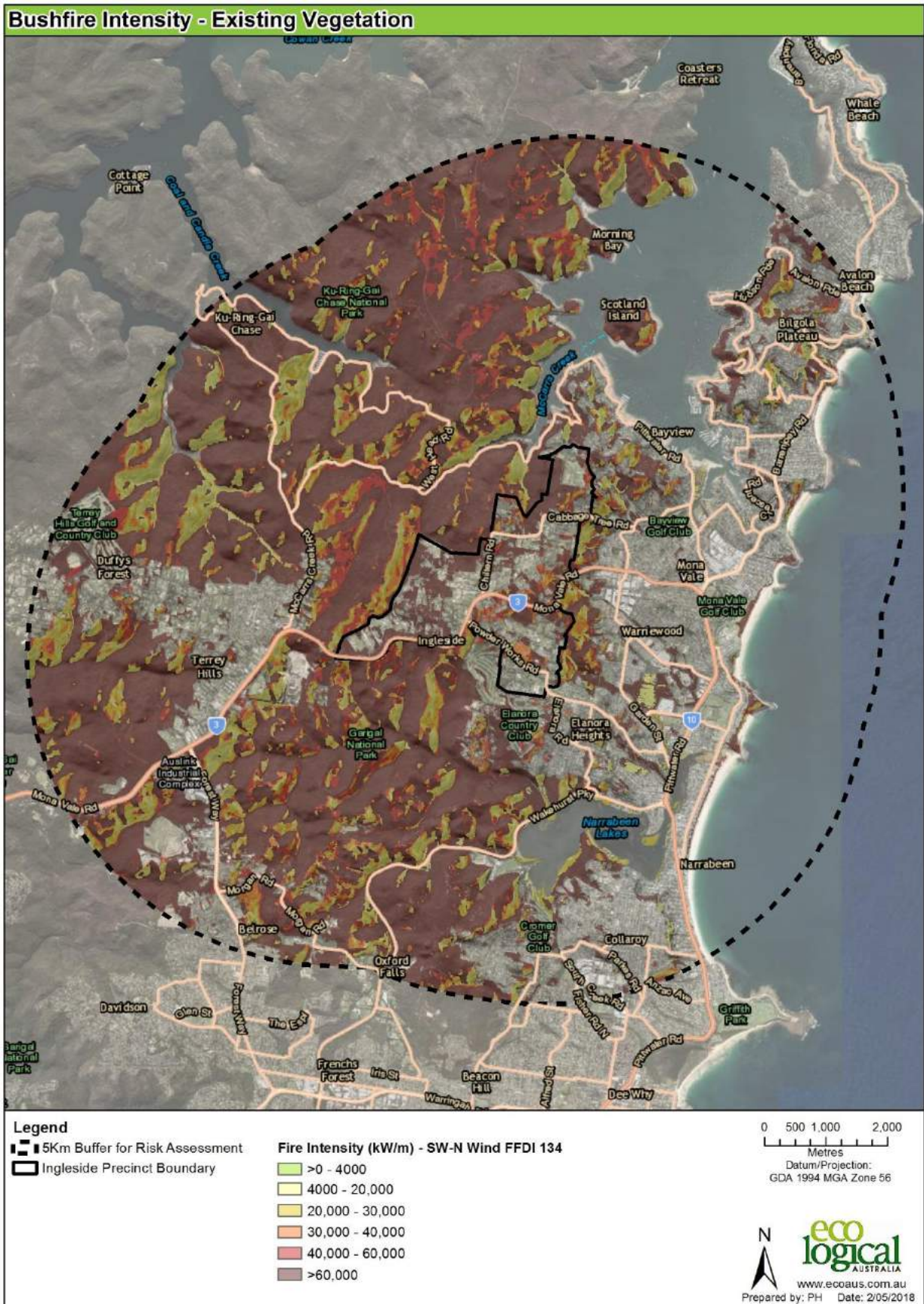


Figure 10: Potential Fire Intensity (south-west to north, FFDI 134, existing vegetation)

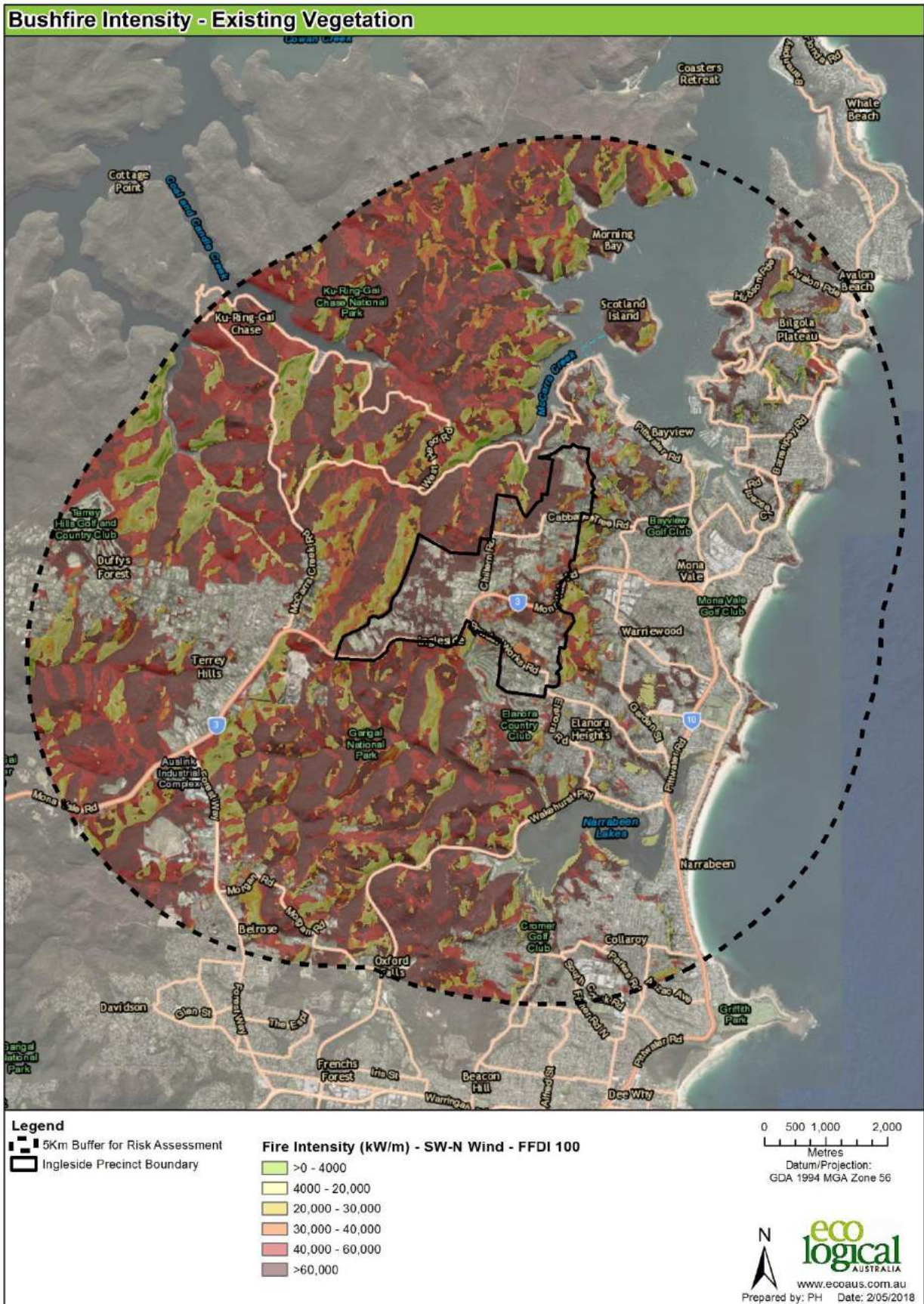


Figure 11: Potential Fire Intensity (south-west to north, FFDI 100, existing vegetation)



Figure 12: Potential Fire Intensity (north to south-east wind, FFDI 63, proposed vegetation)



Figure 13: Potential Fire Intensity (south-east to south-west wind, FFDI 47, proposed vegetation)

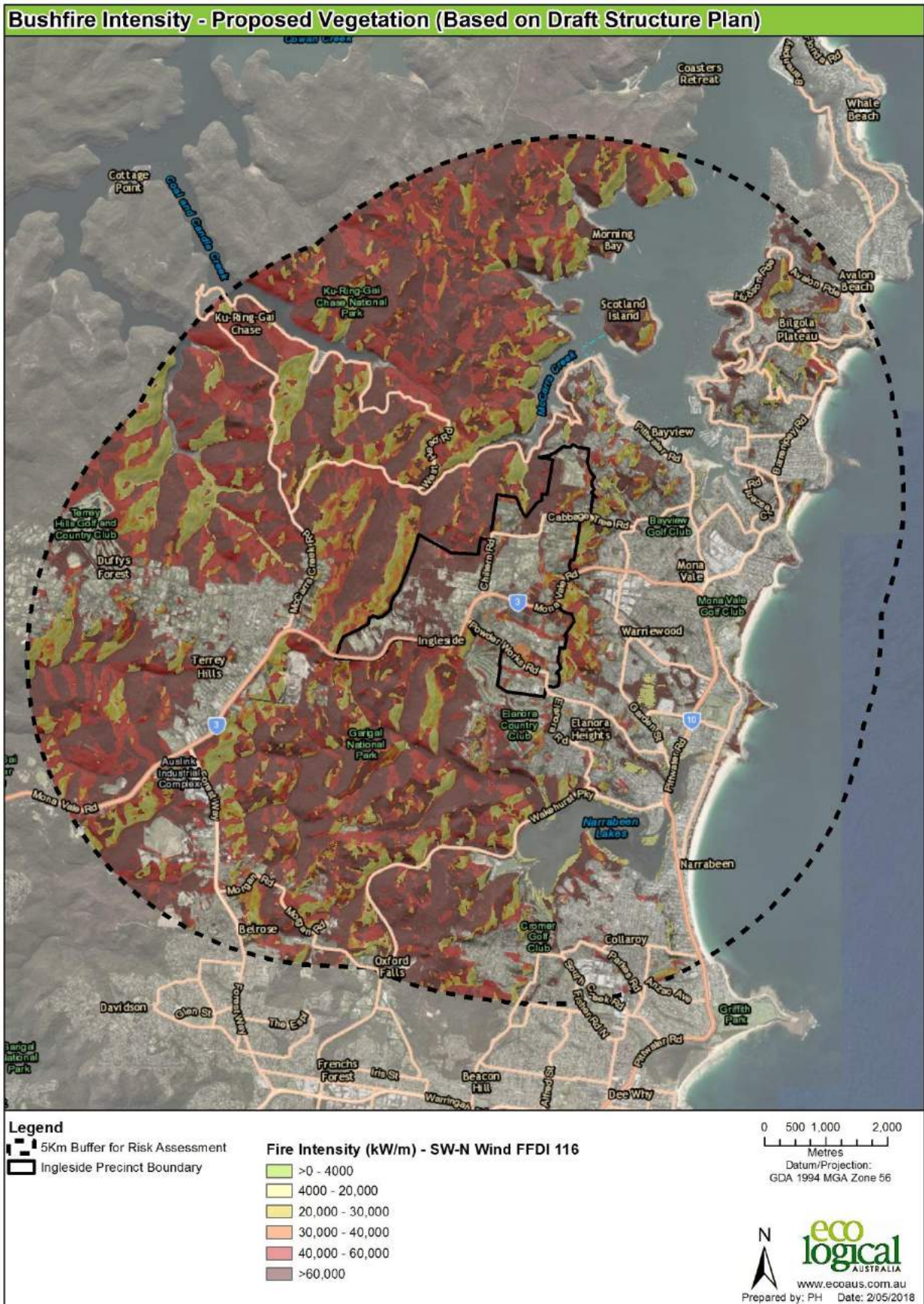


Figure 14: Potential Fire Intensity (south-west to north wind, FFDI 116, proposed vegetation)

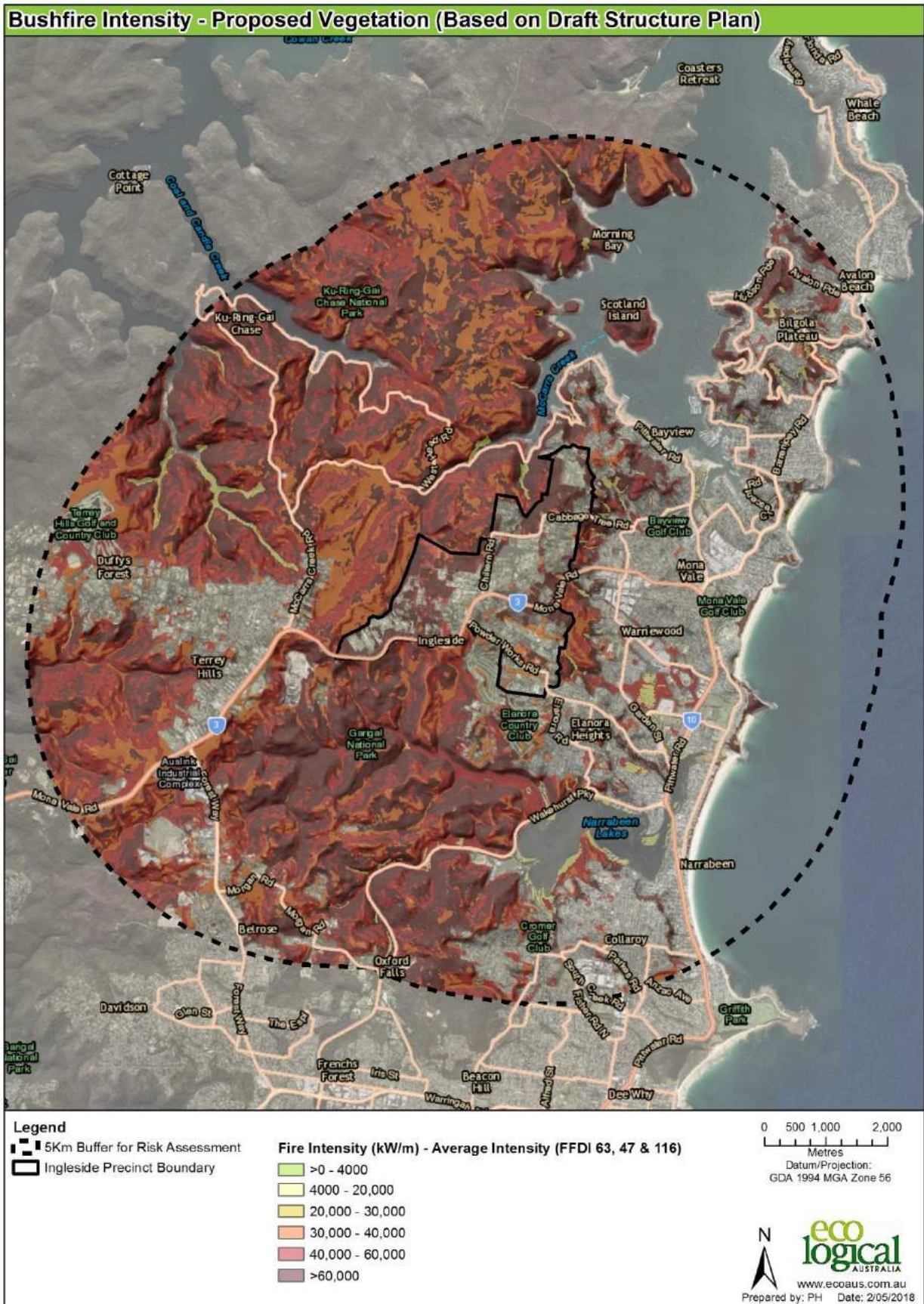


Figure 15: Potential Fire Intensity (average of all directions, proposed vegetation)

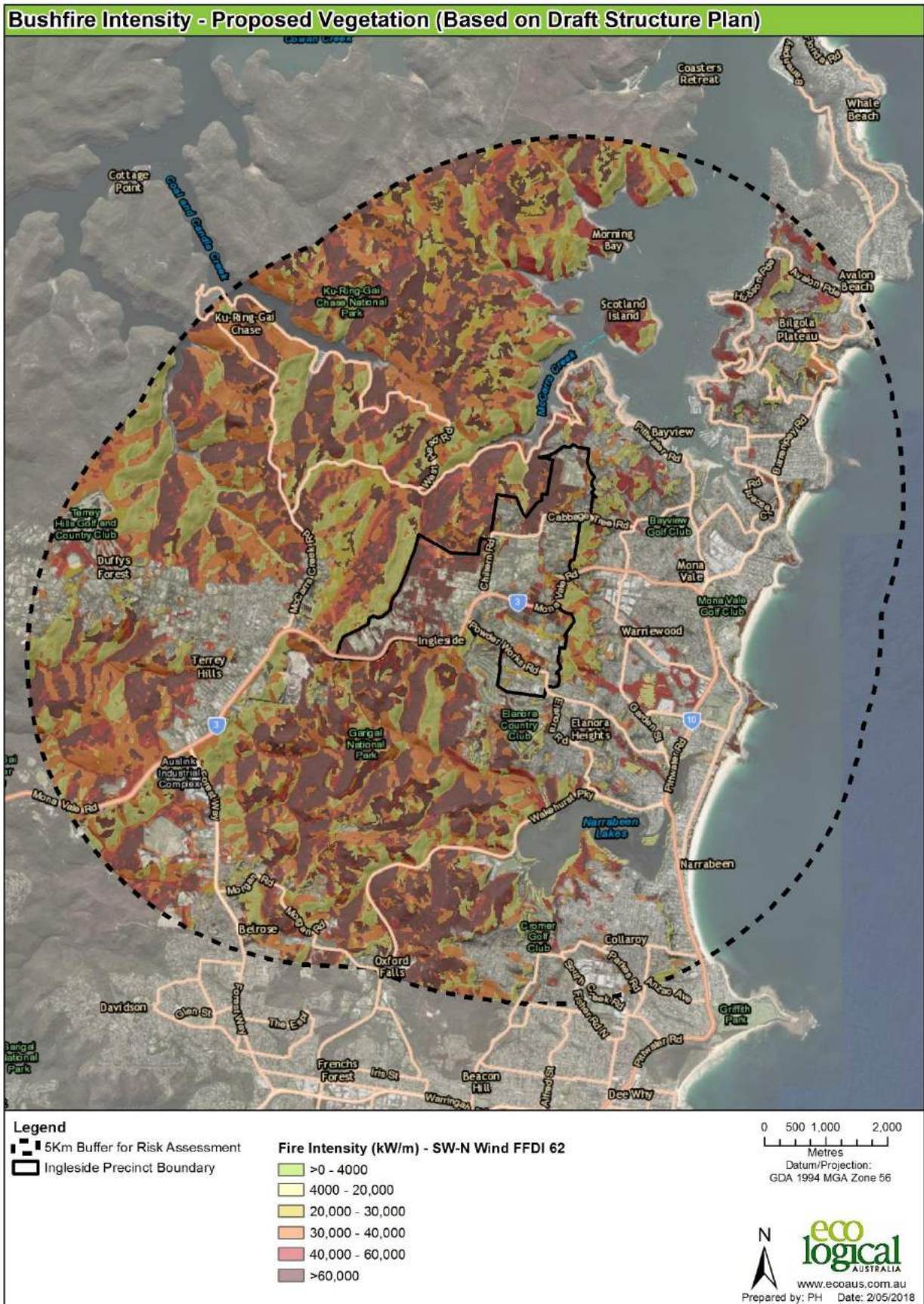


Figure 16: Potential Fire Intensity (south-west to north wind, FFDI 62, proposed vegetation)

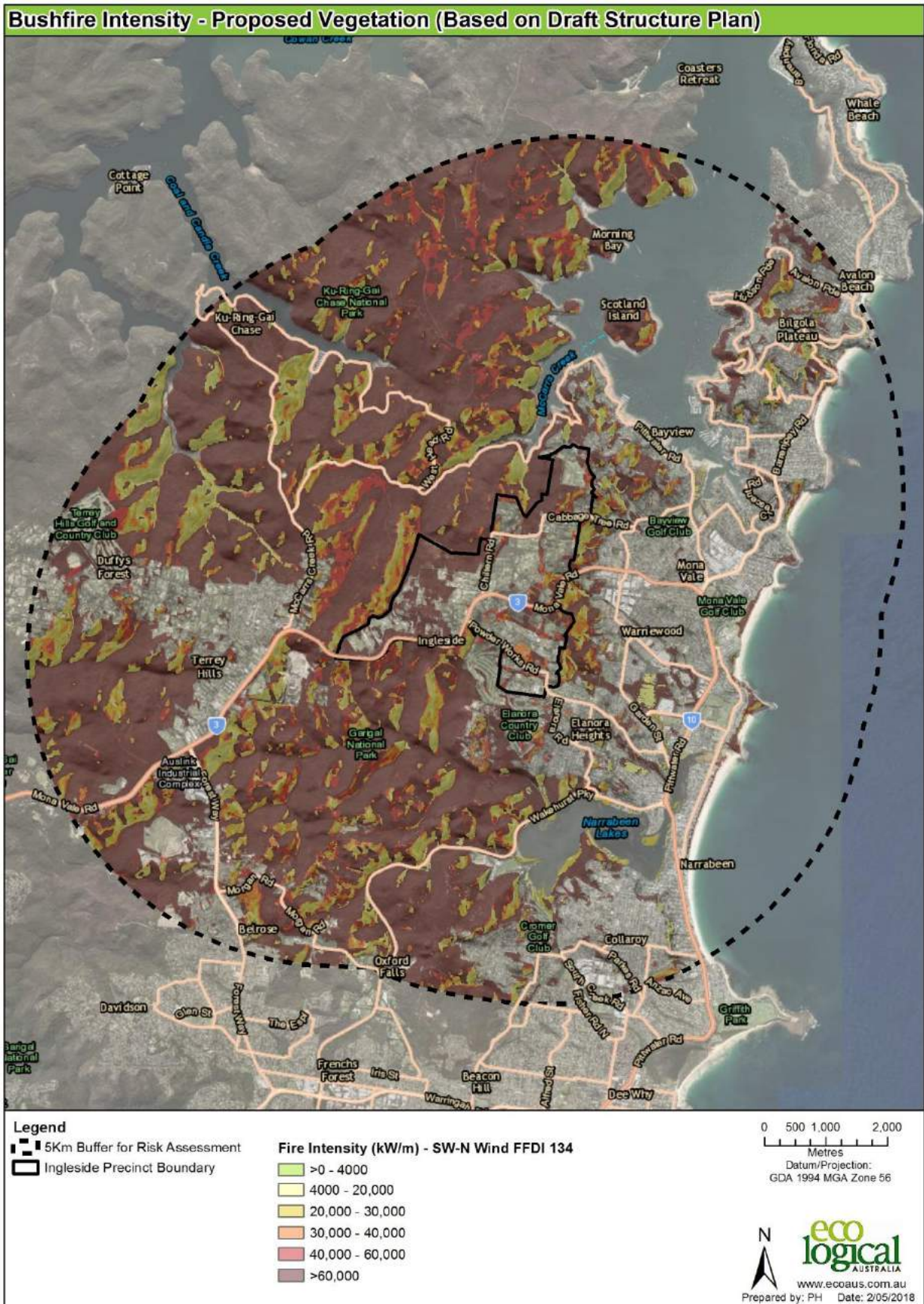


Figure 17: Potential Fire Intensity (south-west to north wind, FFDI 134, proposed vegetation)

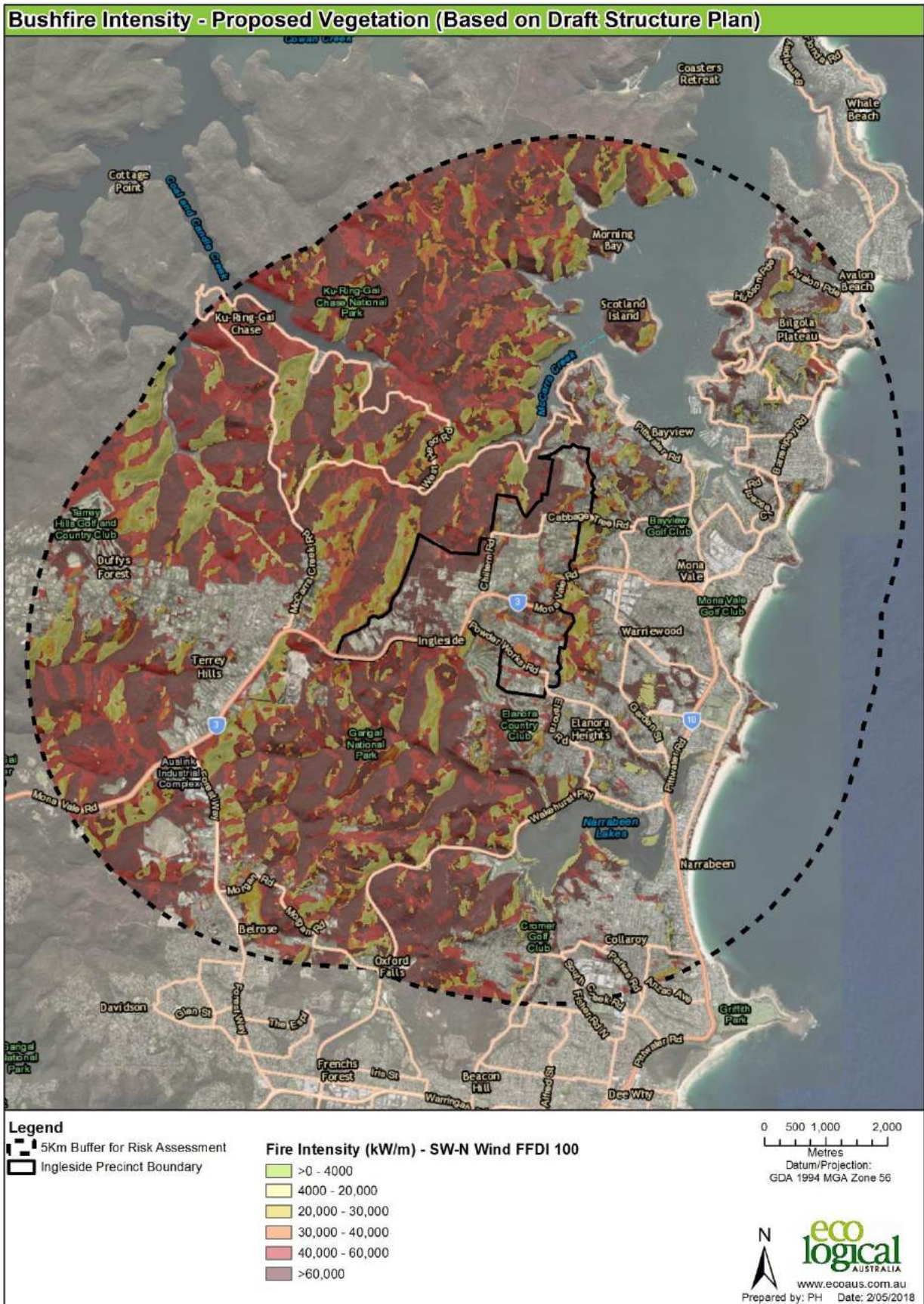


Figure 18: Potential Fire Intensity (south-west to north wind, FFDI 100, proposed vegetation)

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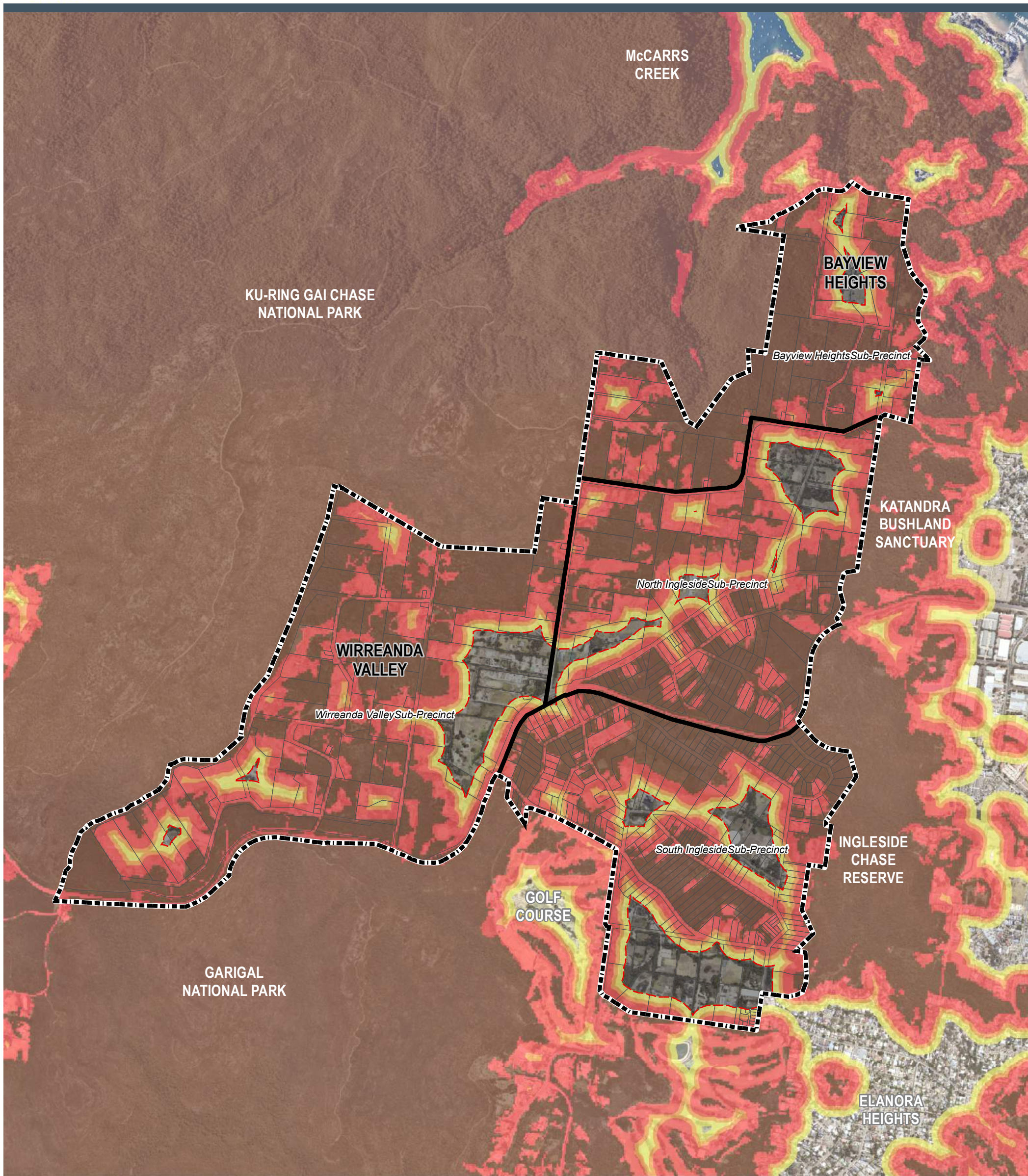
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Appendix D Mapping of Existing and Proposed Risk Exposure



Precinct boundary

Sub-Precinct Boundaries

Landscape Risk - Current (IntCurSWN100 - FFDI100)

Fire intensity - bushfire hazard area

Bushfire attack contours

Flame contact 0 - 50m buffer

Radiant heat exposure 0 - 70m buffer

Ember attack 0 - 100m buffer

Primary loss extent and extent of statutory planning and building controls 100m buffer

Secondary loss extent 700m buffer

Cadastral boundary

Original bushfire intensity modelling supplied by Ecological Australia, May 2018

3/09/2018

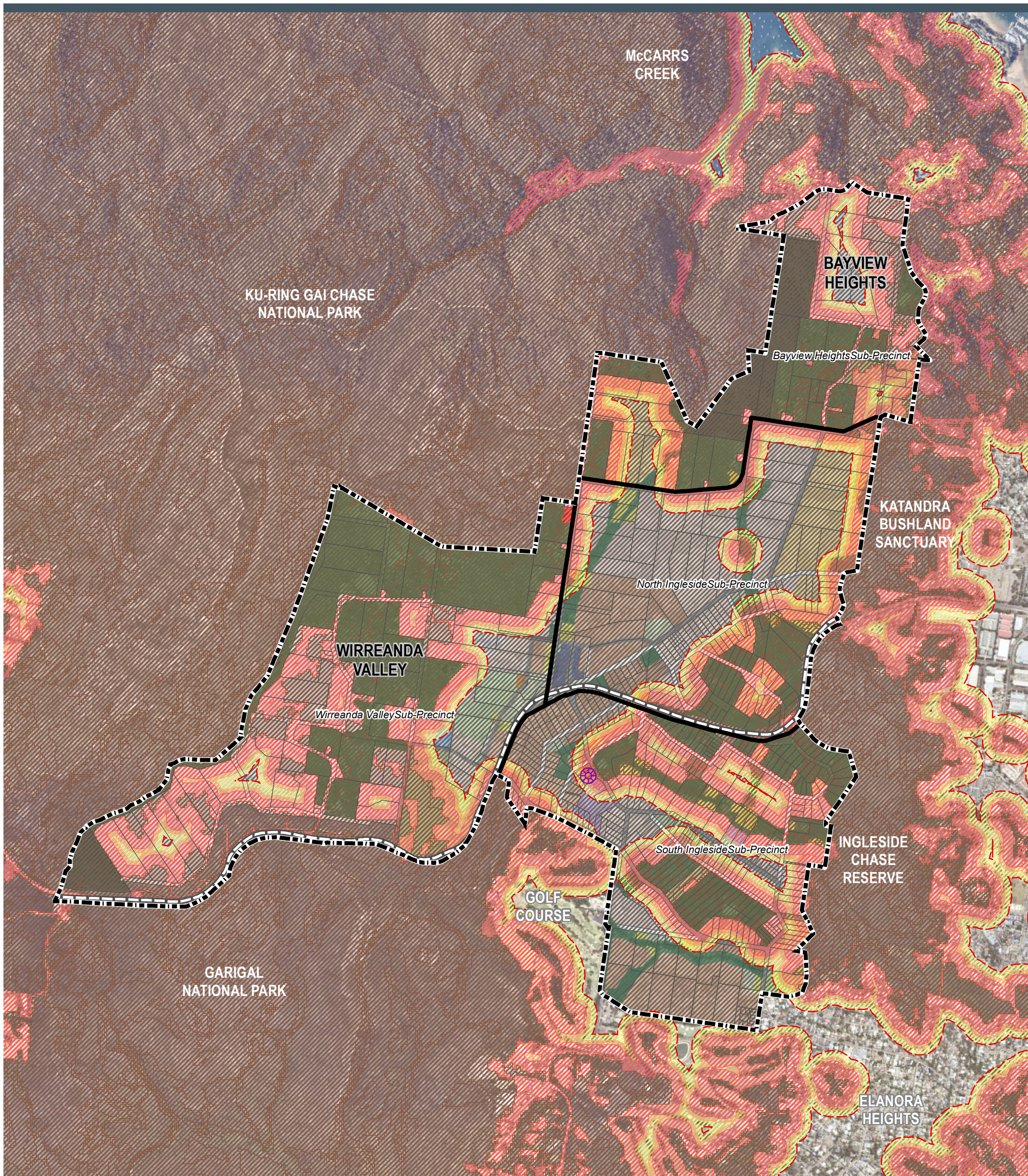
GDA 94 Zone 56

Data Source: Cadastre sourced from NSW State Government 2018, Nearmaps 20/1/18

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- Precinct boundary
- Sub-Precinct Boundaries
- Preferred Location for Neighbourhood Shops
- Proposed Mona Vale Road Corridor
- Structure Plan - Land use**
- Houses on Larger Lots
- Houses
- Low Rise Apartment /

- Village Centre
- Community Centre
- Proposed School
- Park
- Sporting Fields
- Environmental Management
- Environmental Conservation
- National Park
- Rural
- Rural Fire Service Station
- Sewer Pump Station
- Water Management
- Water Reservoir
- Existing Road
- Major Road

- Landscape Risk - Proposed (IntPropSWN100 - FFDI100)**
- Bushfire hazard area
 - Flame contact 0 - 50m buffer
 - Radiant heat exposure 0 - 70m buffer
 - Ember attack 0 - 100m buffer
 - Cadastral boundary
 - Primary loss extent and extent of statutory planning and building controls 100m buffer
 - Secondary extent loss 700m buffer

Bushfire intensity modelling supplied by Ecological Australia, May 2018

3/09/2018

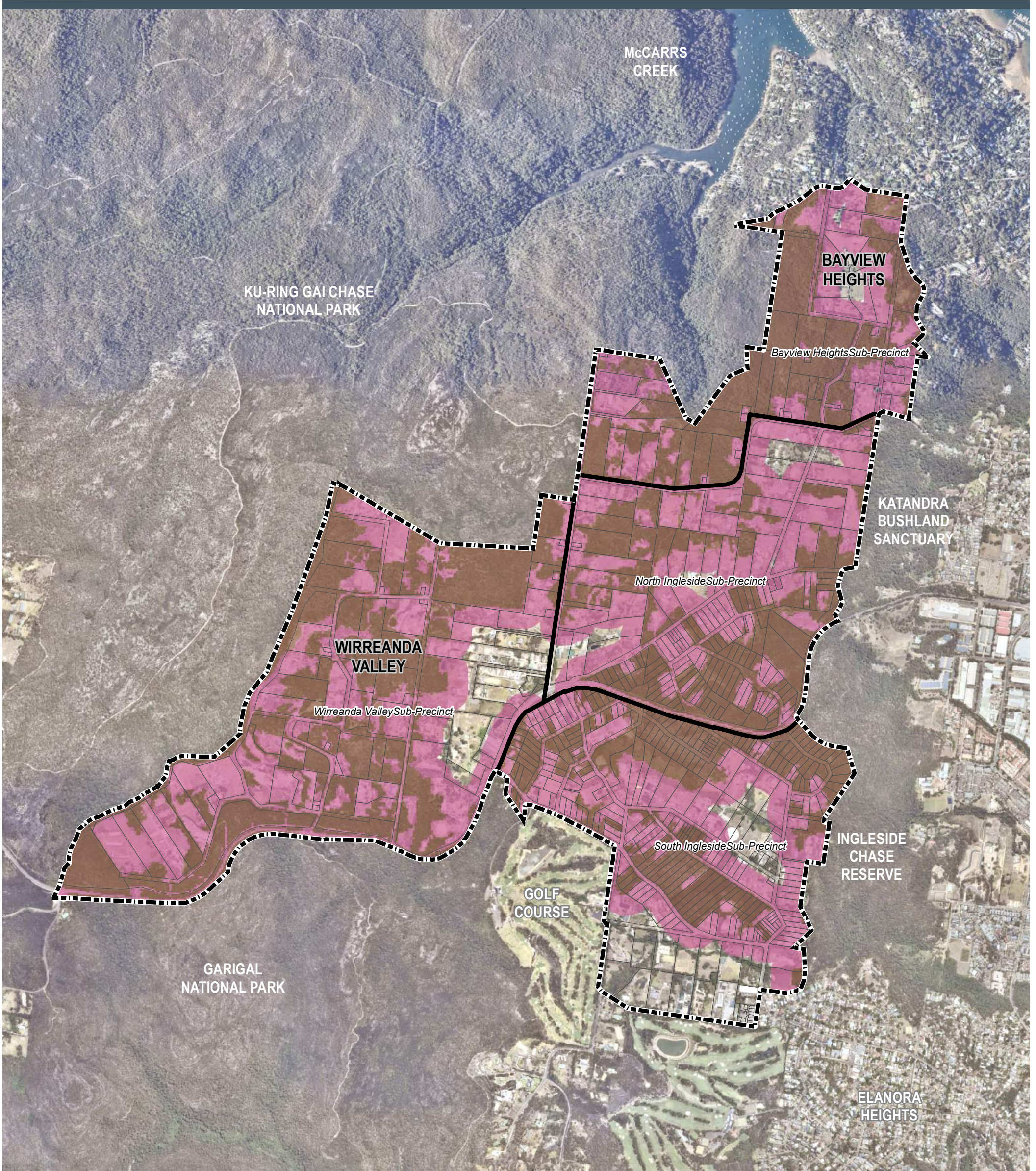
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Data Source: Cadastre sourced from NSW State Government 2018, Nearamaps 20/1/18

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-  Precinct boundary
-  Sub-Precinct Boundaries

Localised Risk - Current (IntCurSWN100 - FFDI100)

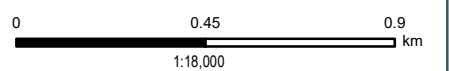
-  Bushfire hazard area
-  Primary loss extent
-  Cadastral boundary

Original bushfire intensity modelling supplied by Ecological Australia, May 2018

15/05/2018

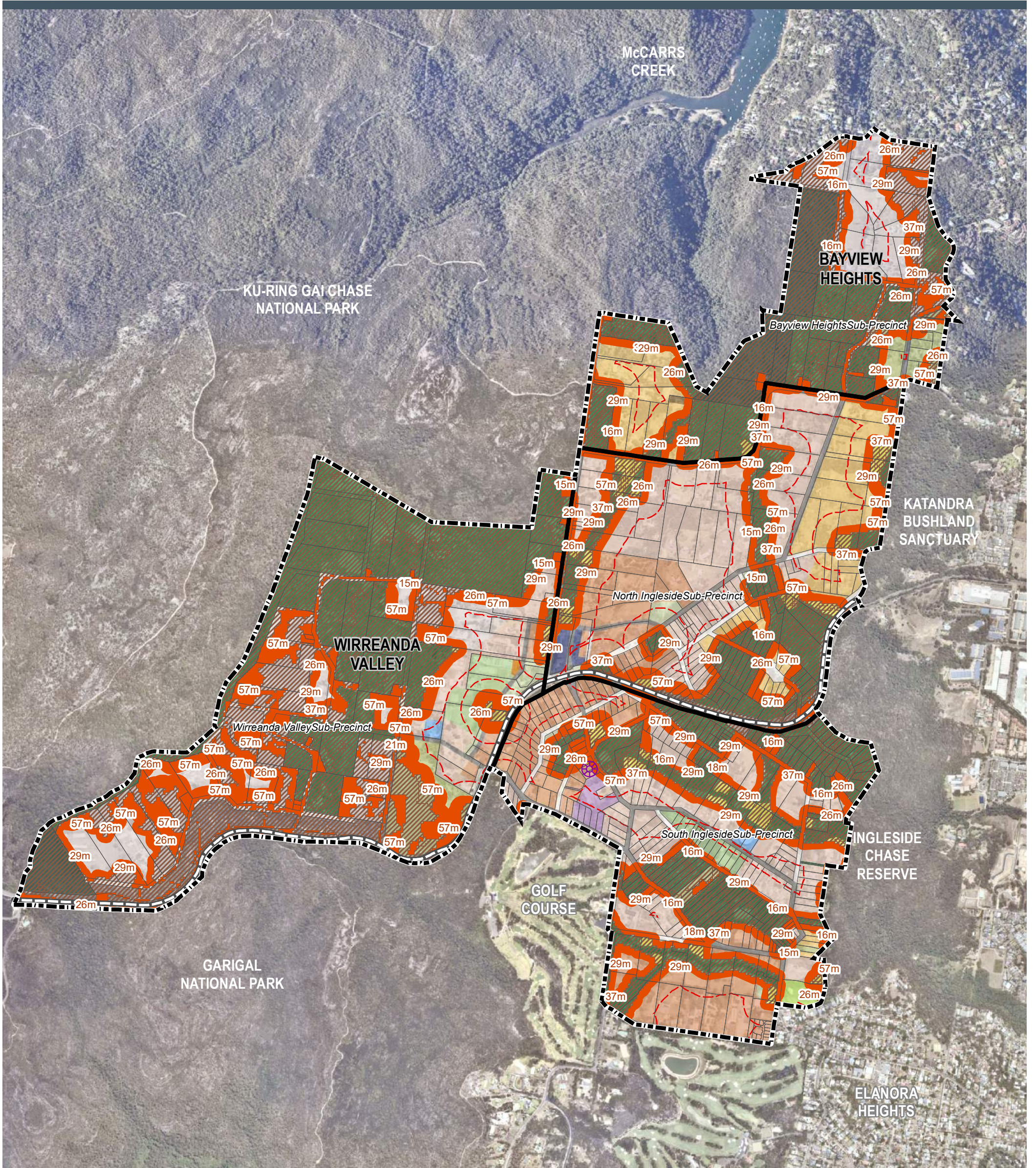
GDA 94 Zone 56

Data Source: Cadastre sourced from NSW State Government 2018, Nearmaps 20/1/18



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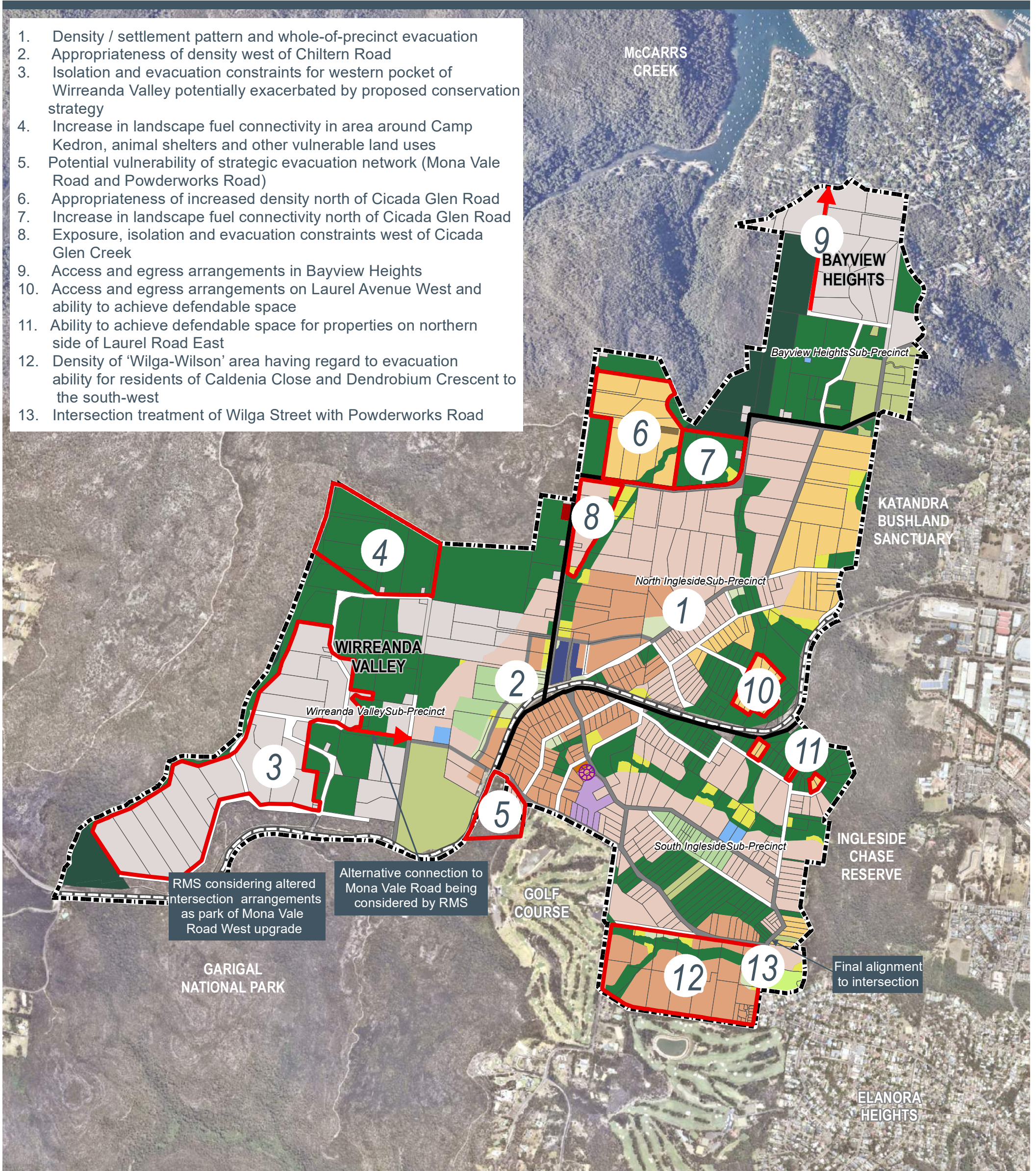
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<ul style="list-style-type: none"> Precinct boundary Sub-Precinct Boundaries Bushfire hazard area Minimum asset protection zone (indicative only) Primary loss extent & extent of statutory planning & building controls Cadastral boundary Preferred Location for Neighbourhood Shops Proposed Mona Vale Road Corridor 	<p>Structure Plan - Land use</p> <ul style="list-style-type: none"> Houses on Larger Lots Houses Low Rise Apartment / Townhouses Village Centre Community Centre Proposed School Park Sporting Fields Environmental Management 	<ul style="list-style-type: none"> Environmental Conservation National Park Private Open Space Rural Rural Fire Service Station Sewer Pump Station Water Management Water Reservoir Existing Road Major Road 	<p>10/05/2018</p> <p>GDA 94 Zone 56</p> <p>Data Source: Cadastre sourced from NSW State Government 2018, Nearmaps 20/11/18</p> <p>0 0.4 0.8 km</p> <p>1:16,614</p> <p>INDICATIVE ONLY NOT FOR STATUTORY PURPOSES</p> <p>Buffer labels provide a sample distance only</p> <p>Original bushfire intensity modelling supplied by Ecological Australia, May 2018</p> <p>Disclaimer This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. The map layers displayed are compiled from various sources. Therefore, no warranty is given relation to the data displayed on this map (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data.</p>
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Appendix E Strategic Bushfire Issues Map

1. Density / settlement pattern and whole-of-precinct evacuation
2. Appropriateness of density west of Chiltern Road
3. Isolation and evacuation constraints for western pocket of Wirreanda Valley potentially exacerbated by proposed conservation strategy
4. Increase in landscape fuel connectivity in area around Camp Kedron, animal shelters and other vulnerable land uses
5. Potential vulnerability of strategic evacuation network (Mona Vale Road and Powderworks Road)
6. Appropriateness of increased density north of Cicada Glen Road
7. Increase in landscape fuel connectivity north of Cicada Glen Road
8. Exposure, isolation and evacuation constraints west of Cicada Glen Creek
9. Access and egress arrangements in Bayview Heights
10. Access and egress arrangements on Laurel Avenue West and ability to achieve defensible space
11. Ability to achieve defensible space for properties on northern side of Laurel Road East
12. Density of 'Wilga-Wilson' area having regard to evacuation ability for residents of Caldenia Close and Dendrobium Crescent to the south-west
13. Intersection treatment of Wilga Street with Powderworks Road



Precinct boundary	Village Centre	Private Open Space
Sub-Precinct Boundaries	Community Centre	Rural
Strategic Exposure and Risk Areas	Proposed School	Rural Fire Service Station
Structure Plan - Land use	Park	Sewer Pump Station
Houses on Larger Lots	Sporting Fields	Water Management
Houses	Environmental Management	Water Reservoir
Low Rise Apartment / Townhouses	Environmental Conservation	Existing Road
	National Park	Major Road

Preferred Location for Neighbourhood Shops
Proposed Mona Vale Road Corridor
Cadastral boundary

28/05/2018

GDA 94 Zone 56

Data Source: Cadastre sourced from NSW State Government 2018, Nearthmap 20/1/18

0 0.45 0.9 km
1:18,000

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Appendix F Development Scenario Analysis

Development scenario analysis – Ingleside Planned Precinct

Scale of Risk Tolerance/Appetite	Type of Risk Treatment	Potential Development Scenario	Combined Risk Reduction Mitigation/Treatment Measures	Contribution to Risk 'Acceptability'	Complexity of Implementation	Likely Transfer of Residual Risk
Lower exposure options	Avoid	No further development but implement full suite of strategic mitigation measures to mitigate existing risk	To avoid any increase in life or property risk exposure, avoid future development of Ingleside by arresting development and maintaining current settlement pattern but with the consideration of relevant measures contained at Section 10. This represents the strongest form of risk treatment, by avoiding any further population or property risk exposure whilst seeking to mitigate existing risk.	Existing risk is acknowledged and sought to be mitigated to that extent possible by physical intervention (i.e. land management and land use measures), without introducing additional population, property and infrastructure exposure.	<ul style="list-style-type: none"> • Immediate and ongoing costs of implementation of mitigation measures • Physical limitation in implementation (i.e. topographical constraints etc. which preclude certain treatments from taking place) • Collaborative approaches between land managers and emergency management representatives • Annual mitigation implementation, reliant on government budgets, resources and suitable weather windows of opportunity • Strong reliance on community responsibility 	Existing settlement pattern which has emanated since Ingleside was first established is subject to certain vulnerabilities from bushfire. Without change to the existing settlement pattern, the onus is on community awareness, transferring risk considerations on to local government, NSWRFs, local residents and the insurance industry to mitigate and recover from an event.
	Mitigate	Avoid further development north of Mona Vale Road and assuming evacuation traffic study supports, development of South Ingleside but not North Ingleside and with property-based mitigation measures and consideration of suite of measures contained at Section 10	Assuming support from an evacuation traffic study, development of South Ingleside is subject to comparably lower risk exposure than other Sub-Precincts and can be mitigated via: <ul style="list-style-type: none"> • Settlement pattern • Evacuation route network options provided by Mona Vale Road (fully upgraded as a precondition to any development), Powderworks, Manor and Ingleside Roads • Suitable intersection treatments at the above intersections as well as Powderworks Road and Wilga Street • Investigation into potential use of new school for evacuation centre purposes • Reduction of fuel in proximity to Powderworks Road intersection with Mona Vale Road 	These measures, in combination, contribute to a land use rationale for South Ingleside which logically extends upon existing development in Elanora Heights, addressing primary fire run risk and establishing the primary evacuation route network, including the address of its vulnerabilities as relevant to the Sub-Precinct. In combination, these measures seek to mitigate the life and property loss risk exposure to Ingleside as low as reasonably practicable whilst balancing the desire for development in this location. A level of risk is acknowledged and accepted by stakeholders, which subject to additional mitigation measures (i.e. implemented by NSWRFs, Council, etc.) is identified as representing 'acceptable' risk.	<ul style="list-style-type: none"> • Process to undertake evacuation traffic modelling likely to require stakeholder workshopping and agreement • Determination of fit-for-purpose evacuation window is required (i.e. based on bushfire behaviour modelling) • Cost-benefit equation of infrastructure provision based on density of South Ingleside alone • Immediate and ongoing costs of implementation of mitigation measures • Physical limitation in implementation (i.e. topographical constraints etc. which preclude certain treatments from taking place) • Collaborative approaches between land managers and emergency management representatives • Annual mitigation implementation, reliant on government budgets, resources and suitable weather windows of opportunity 	Other agencies will be required to implement mitigation measures including fuel and land management annually – with budget and resourcing available to do so, increased exposure to people, infrastructure and property for which Council, emergency services, the community, infrastructure providers and insurance industry are required to mitigate. Should the new school be identified as an evacuation centre, its ability to operate as such may require annual maintenance, etc. Ember attack is unlikely to be mitigated beyond that required by AS3959 which may not reflect the extent of property loss/damage which occurred in 1994 when the Cottage Point fire breached the golf courses. Interim risk may be higher than the completed risk exposure level, which will also require appropriate mitigation.
Moderate exposure options	Mitigate	Assuming evacuation traffic study supports, development of South Ingleside and eventually North Ingleside, but only to a doubling of existing density (i.e. one into two lot expansion) and with property-based mitigation measures and consideration of suite of measures contained at Section 10	Assuming support from an evacuation traffic study, development of South and North Ingleside (to an extent) can be mitigated via: All of the dot points above, plus – <ul style="list-style-type: none"> • Settlement pattern 	These measures, in combination, contribute to a land use rationale for South Ingleside which logically extends upon existing development in Elanora Heights, addressing primary fire run risk and establishing the primary evacuation route network, including the address of its vulnerabilities as relevant to the Sub-Precinct. In combination, these	<ul style="list-style-type: none"> • Process to undertake evacuation traffic modelling likely to require stakeholder workshopping and agreement • Determination of fit-for-purpose evacuation window is required (i.e. based on bushfire behaviour modelling) 	A moderate level of risk is transferred to Council, emergency services, community and infrastructure and insurance providers. This is largely associated with ongoing management processes and suppression and evacuation requirements during events.

			<ul style="list-style-type: none"> • Land use allocation • Density limited to an approximate one into two lot subdivision (i.e. double in density) • Upgrade to design of existing evacuation route network • Revision of the re-vegetation intent internal to the Precinct 	<p>measures seek to mitigate the life and property loss risk exposure to Ingleside as low as reasonably practicable whilst balancing the desire for development in this location.</p> <p>For North Ingleside, the capacity of the road network in times of evacuation is not overloaded by the doubling of existing density. The settlement pattern and land use rationale of the Sub-Precinct are revised to reduce landscape risk exposure and limit potential urban fire intrusion. Density is deliberately limited a) in response to evacuation network capacity and b) to adequately separate dwellings and reduce risk of house-to-house ignition.</p> <p>A level of risk is acknowledged and accepted by stakeholders, which subject to additional mitigation measures (i.e. implemented by NSWRFSS, Council, etc.) is identified as representing 'acceptable' risk.</p>	<ul style="list-style-type: none"> • Cost-benefit equation of infrastructure provision based on density of South Ingleside and only marginal increase in density in North Ingleside • Immediate and ongoing costs of implementation of mitigation measures • Physical limitation in implementation (i.e. topographical constraints etc. which preclude certain treatments from taking place) • Collaborative approaches between land managers and emergency management representatives • Annual mitigation implementation, reliant on government budgets, resources and suitable weather windows of opportunity 	<p>If an alternative evacuation model is selected, potential to perpetuate a cycle of reliance upon all levels of government before, during and after and event rather than individual or household responsibility.</p> <p>Ember attack is unlikely to be mitigated beyond that required by AS3959 which may not reflect the extent of property loss/damage which occurred in 1994 when the Cottage Point fire breached the golf courses.</p> <p>Evacuation networks may become a single point a failure, if no other options for resident safety can be provided.</p>
Mitigate		<p>Assuming evacuation traffic study supports, development of South Ingleside and eventually North Ingleside, but only to a maximum density of 10 dwellings per hectare and with property-based mitigation measures and consideration of suite of measures contained at Section 10</p>	<p>Assuming support from an evacuation traffic study, development of South and North Ingleside (to an extent) can be mitigated via:</p> <p>All of the dot points above, plus –</p> <ul style="list-style-type: none"> • Settlement pattern • Land use allocation • Density limited to an approximate 10 dwellings per hectare (circa 900m² per lot) • Upgrade to design of existing evacuation route network • Revision of the re-vegetation intent internal to the Precinct 	<p>These measures, in combination, contribute to a land use rationale for South Ingleside which logically extends upon existing development in Elanora Heights, addressing primary fire run risk and establishing the primary evacuation route network, including the address of its vulnerabilities as relevant to the Sub-Precinct. In combination, these measures seek to mitigate the life and property loss risk exposure to Ingleside as low as reasonably practicable whilst balancing the desire for development in this location.</p> <p>For North Ingleside, the capacity of the road network in times of evacuation is not overloaded by the very low urban residential density. The settlement pattern and land use rationale of the Sub-Precinct are revised to reduce landscape risk exposure and limit potential urban fire intrusion. Density is deliberately limited a) in response to evacuation network capacity and b) to adequately separate dwellings and reduce risk of house-to-house ignition.</p> <p>A level of risk is acknowledged and accepted by stakeholders, which subject to additional mitigation measures (i.e. implemented by</p>	<ul style="list-style-type: none"> • Process to undertake evacuation traffic modelling likely to require stakeholder workshopping and agreement • Determination of fit-for-purpose evacuation window is required (i.e. based on bushfire behaviour modelling) • Cost-benefit equation of infrastructure provision based on density of South Ingleside and very low urban residential density of North Ingleside • Immediate and ongoing costs of implementation of mitigation measures • Physical limitation in implementation (i.e. topographical constraints etc. which preclude certain treatments from taking place) • Collaborative approaches between land managers and emergency management representatives • Annual mitigation implementation, reliant on government budgets, resources and suitable weather windows of opportunity 	<p>A moderate level of risk is transferred to Council, emergency services, community and infrastructure and insurance providers. This is largely associated with ongoing management processes and suppression and evacuation requirements during events.</p> <p>If an alternative evacuation model is selected, potential to perpetuate a cycle of reliance upon all levels of government before, during and after and event rather than individual or household responsibility.</p> <p>Ember attack is unlikely to be mitigated beyond that required by AS3959 which may not reflect the extent of property loss/damage which occurred in 1994 when the Cottage Point fire breached the golf courses.</p> <p>Evacuation networks may become a single point a failure, if no other options for resident safety can be provided.</p>

				NSWRFS, Council, etc.) is identified as representing 'acceptable' risk.		
Higher exposure options	Transfer	Develop the Precinct with property-based mitigation measures (including evacuation centres and NSPs)	<p>Limited to relevant measures which include:</p> <ul style="list-style-type: none"> • Fire trail and fire break network • Changes to land use intents in specific locations • Static water supply opportunities • Road network access and egress options to enhance evacuation resilience • Revision to corridor network and extent of environmental management • Intersection treatments • Land management in Garigal National Park. 	The level of risk is considered acceptable by relevant stakeholders without any discernible need for further investigation with regard to the performance of the road network using an event scenario-based approach.	Focus is placed on mitigation measures which are demonstrated by the attached report to be insufficient to lower risk profile to a tolerable level. The measures may incorporate cost implications both immediate and long term. Longer term management may also be required from relevant lead agencies.	<p>Majority of risk is transferred to Council, emergency services, the community and infrastructure and insurance providers on the assumption the road network will facilitate evacuation as required and evacuation centres will perform as desired.</p> <p>If an alternative evacuation model is selected, potential to perpetuate a cycle of reliance upon all levels of government before, during and after and event rather than individual or household responsibility.</p>
	Transfer	Development of the current draft Structure Plan with no changes	Nil	The level of risk is considered acceptable by relevant stakeholders without any discernible need for land use planning mitigation measures.	Negligible, reliance on existing measures in place (i.e. fire management strategies and emergency management strategies is considered sufficient to accommodate increased development and population.	Majority of risk is transferred to Council, emergency services, the community and infrastructure and insurance providers.

