Peer review of Report "Risk Implications of Dynamic Fire Propagation: A case study of Ginninderry region." dated June, 2017 by Jason Sharples, UNSW, Canberra.

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This peer review has been undertaken by Dr Grahame Douglas, Senior Lecturer and Academic Course Advisor (Post-graduate Bushfire program) at Western Sydney University in the School of Computing, Engineering and Mathematics. Grahame is a bushfire scientist, having worked in the area of bushfire risk assessment, bushfire planning and development control, environmental assessment and community safety with the NSW RFS for 15 years, and more recently with Western Sydney University for approximately 5 years. He is a member of the FP-020 Committee for AS3959-2009 representing the interests of fire protection and chairs working group A concerned with site assessment.

Introduction.

This peer review has been commissioned by EcoLogical Aust on behalf of developers of land at Ginninderry near Yass, NSW. The purpose of the review is to consider the merits of the discussion within the Sharples report (the Report). I make no comment on the merits or otherwise of the report by EcoLogical Australia in relation to the proposed subdivision in the Ginnindery Region, which I have not had access to.

Jason Sharples is an Associate Professor of Applied Mathematics in the School of Physical, Environmental and Mathematical Sciences at UNSW, Canberra. He has both practical firefighting experience (since 2003) as well as a significant contribution to fire science, and dynamic wind propagation arising from bushfire events in particular. He holds two ARC grants and is widely published in a number of areas, including aspects of fire dynamics.

The Report.

In addressing the central tenants of the Report, it is worth noting the main conclusions of the Report and then analysing the evidence for each concluding contention. The main conclusions relate to the perceived shortcomings of the Australian Standard AS3959-2009 (the Standard or AS3959) and can be summarised in 4 main points being, the Standard:

- is based entirely on the assumption that fires propagate in quasi-steady manner;
- is predicated on the notion that the main cause of house loss is radiant heat exposure;
- factors in the effect of embers in an over-simplistic way via an assumed relationship with radiant heat exposure;
- offers no consideration of the potential effects of pyrogenic winds.

On this basis it is contended that the Standard does not adequately address current state of knowledge of fire science and is likely to under-predict the level of risk from bushfire attack under extreme conditions. Therefore the Standard (AS 3959-2009) may not be adequate for design and construction. However, at the outset, it is not appropriate to use AS3959 as the basis of assessing risk, which is not its purpose or intent. Any assessment of risk should be based on ISO 31000.

Assoc. Professor Sharples has also reiterated the issues in a paper entitled: *Reassessing the validity of AS3959 in the presence of dynamic bushfire propagation*, presented at the 22nd International Congress on Modelling and Simulation, Hobart, Tasmania, 3-8 December 2017. In effect, this is response to both documents.

In reviewing these questions, it will be necessary to consider the evidence presented in the report and consider the requirements of the Standard, as well as the National Construction Code (ABCB, 2016).

Role of the National Construction Code (NCC).

As a general observation, the report fails to contextualise the nature of the Standard within the broader framework of the National Construction Code and the performance requirements for bushfire protection of different classes of building under that Code. This is an important consideration, as the criticisms of the Standard may in fact be a product of the NCC rather than any particular shortcomings of the Standard, which is a deemed-to-satisfy provision. In fact, many of the challenges levelled at the Standard could be addressed as part of a performance assessment. In addition, it appears that the report is directed in the context of a future sub-division and as such, the requirements under the planning system and *Planning for Bush Fire Protection (2006)* may be more relevant.

The NCC performance requirement GP5.1 applies to Class 2-3, 4 part and some Class 9 buildings as well as associated Class 10a in NSW (it also applies to Class 1 buildings in Vol 2 of the NCC) is as follows:

<u>GP5.1</u>

A building that is constructed in a designated bushfire prone area must, to the degree necessary, be designed and constructed to reduce the risk of ignition from a bushfire, appropriate to the—

> *(a) potential for ignition caused by burning embers, radiant heat or flame generated by a*
>
> *bushfire; and*
>
> *(b) intensity of the bushfire attack on the building.*

It can be seen from the performance requirement that the relevant conditions are to <u>reduce risk</u> of ignition, <u>arising from burning embers, radiant heat or flame</u>, and the <u>intensity of bushfire attack</u>. In addition, in 2014, the ABCB proposed a verification method GV5 which proposed a 1:25 fire weather event and 20% ignition criteria. Due to intense lobbying by fire agencies and fire protection industry, this appears to have been amended to a 1:50 year bushfire event and a 10% ignition criteria (Douglas and He, 2017). This specifically excludes pyrogenic winds or lateral spread or fire generated vortices.

It is indeed unfortunate that the NCC and the Australian Building Codes Board, do not see the importance of fire generated winds and pyrogenic conditions more generally as a suitable condition for bush fire safety and construction practice.

Fire Propagation based of quasi-steady State.

As discussed in the report, the Standard relies heavily on the Macarthur Mark 5 Fire Danger Meter equations developed by Noble et al (1980) in relation to forest fires. Since 2009, further research has been forthcoming and in 2007, Gould et al (2007) published its final report on the outcomes of Project Vesta. However, a challenge in the use of Project Vesta has been the availability of data in relation to fuel hazard score assessments and calculation of the 1:50 design bushfire conditions. Douglas et al (2016) has recently illustrated a methodology for undertaking such a performance assessment using Project Vesta and NSW data for north coast vegetation. In the Douglas et al (2016) study, it was found that for the north coast flame heights were larger but comparable to that of the Macarthur Mark Meter 5 equations.

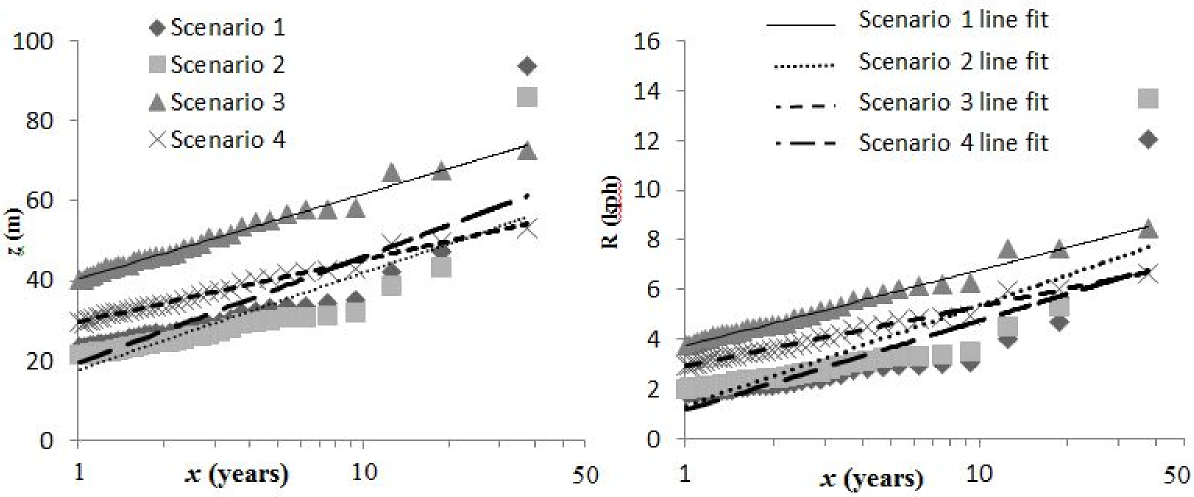

Figure 1. Flame height (z) and forward rate of spread (R) for 4 scenarios of North Coast vegetation comparing Macarthur Mark 5 (Scenario 1 and 2) and Project Vesta equations (scenario 3 and 4) (from Douglas et al, 2016). X-axis is recurrence period.

However, this does not address the central question posed by the report, being the use of quasi-steady state equations. In addressing fire science based on 'eruptive fire behaviour' the conditions described in 2.2.1 of the report are relevant, and notes '*during eruptive fire events, means that fire fighters could be exposed to intensive convective heat fluxes, which are not accounted for in the BAL calculations*'. Firstly, BAL are in no way designed for fire fighter considerations, but solely for buildings based on a design bush fire. Reference is also made to slopes in excess of 20 degrees and it should be noted that for slopes in excess of 20 degrees other assumptions must be made as recognised by AS3959-2009 in Appendix B. The suggestion from the CFD analysis is that attachment of the plume for a slope of 26 degrees (i.e.>25 degrees) represents a new benchmark in terms of convective heat exposure. How is this to be quantified? For negative slopes the use of the Sullivan et al (2014) equation has already been identified to be implemented as part of the review of AS3959.

The pre-conditions for considering eruptive fire behaviour (including vorticity-driven lateral spread are relevant and relate strongly to the consideration of what is commonly referred to as landscape fire effects. It is generally accepted that pyro-convection and pyrogenic winds causes a significant plume, and as described can rise several kilometres into the air and rain down large amounts of burning debris and embers. It is also clear that the reports by McRae et al (2012) in relation to the

Canberra fire are both observable and devastating. The challenge is how this applies quantitatively in the context of building practice and the Standard. This question has also been considered by Kwok et al (2012) and the challenge is to convert these environmental conditions into a site assessment methodology with application to land use planning and construction practice. This is not advanced in the Sharples report. It is suggested by the reviewer that at this point in time this is not available.

The main cause of house loss is radiant heat.

The report considers that AS3959 focusses too much on radiant heat modelling at the expense of other bush fire attack mechanisms, notably embers. Figure 5 cites Leonard and Blanchii (2005) in relation to the causes of house loss/damage from Duffy during the Canberra 2003 fires. Firstly, the citation of 45 kph within the Standard has no bearing of forest fire behaviour, but relates solely to design conditions for grasslands and shrub/heath/mallee models. There is no intended relationship between wind speeds of 45 kph and FFDI settings of 80 or 100. Rather, it is in fact likely that ambient 10 m average wind speeds would approach 60 kph for most FFDI 80-100 conditions.

It cannot be ascertained that the Standard is based on FFDI and forward rate of spread alone. The flame height calculations are in fact halved for effective flame length, so as to allow for discontinuities and barriers within the 'view' of the fire. Using the flame temperature, flame contact in fact can be expected to be made at BAL-40 and possibly BAL 29 not just BAL-FZ which is often a mistaken assumption by those not experienced in the development of the Standard.

Before any assumptions can be made about the relationship between radiant heat and loss, one needs to consider the performance of materials under conditions of radiant heat exposure and whether there is any conservatism or not within the construction elements, not just arising from the site assessment.

Rather than the Standard predicated on radiant heat exposure, the BAL levels provide a common benchmark which is aligned to construction practice and materials science in relation to exposure. The reference to the comments of Leonard and Blanchii (2005) are also problematic, as the major mechanism identified for house loss in Duffy and Chapman arose from house to house exposure, irrespective of the original source of establishing a burning building. None of the houses lost in Duffy in 2003 were constructed to any Standards for construction practice, and to attempt to correlate losses for non-protected dwellings with questionable landscaping is not a rationale for deficiencies in the current Standard or its predecessors. The ACT Government had not implemented any effective planning controls (other than perimeter roads) or construction practice in Duffy or any other area of Canberra prior to 2003.

The effect of embers is overly simplistic.

On page 15, the report suggests that for conditions of extreme-catastrophic fire danger rating, that embers will travel from between 6 km and 20 km ahead of the fire front. There appears to be a confusion (by the report) between embers travelling ahead of a fire front and its ability to ignite new fires in the landscape, versus embers travel ahead of the fire and burning down buildings. To date, for all fires, the greatest distance for a building loss ahead of a fire has been observed at just under 700 metres at Penrith in December 2001 from the Mulgoa Nature Reserve at conditions what are now describe as 'catastrophic' (Douglas et al, 2006). Similarly, the example given for Canberra given at 3.3 of the report is informative as this represents a limit for house loss (745 metres) (see also Penman et al, 2015). These matters are not in dispute.

However, again, the relationship between site assessment and construction practice is not understood or appreciated. With the exception of grasslands, the relationship between generated embers and fire intensity is fairly understood for forest fires and shrublands (heath). As embers travel from the fire front they will progressively consume the burning debris as a fuel until it is either extinguished or burns out. Some debris is larger than other and will burn for longer and travel further downwind.

A study of NSW house losses by Douglas et al (2009) confirmed previous studies that approximately 80-85% of cumulative losses of buildings occur within 100 metres of the interface. This is not a universal finding for all major fires however (see McAneney et al, 2007 in relation to Duffy). For whatever reason, the ABCB has taken 100 metres as the regulatory limit for implementing the Standard. It is of interest to note that the Victorian variation to the NCC provides a BAL-12.5 for all bushfire prone land irrespective of distance from the interface. This is in line with the findings of the Victorian Bushfire Royal Commission (2010) which identified that 140 metres may be a more appropriate but did not recommend a regulatory limit.

The real issue is that ember protection is intended to be inherent in all BAL levels, and that ember protection is achieved as a result of the inherent characteristics of construction practice. It would be fair to say these assumptions are under some question within the Committee responsible for developing the Standard, however, the simplicity does not arise in the site assessment but in the construction practice used. In NSW, *Planning for Bush Fire Protection* provides for additional protection measures to address ember attack in concert with the Standard and in accordance with recommendations of the VBRC (2010). There is no assumed relationship between embers and radiant heat for construction practice, just the fact that embers are likely to have a higher density closer to the fire front than further away.

No consideration of pyogenic effects.

The statement that pyrogenic winds are not addressed in AS3959 is true. However, it is the view of the ABCB that the correct place for the consideration of wind loads, is within the relevant wind Loadings Codes (AS/NZS 1170 series or AS 4055).

The ABCB has for a significant period of time, rejected the inclusion of wind loading provisions arising from pyrogenic sources (including Pyro-cumulous and Vorticity Lateral Spread events) based on the cost-benefit requirements of the COAG agreement in relation to developing building codes.

It would appear that although the report's author and the current reviewer share a common concern about this issue, there is little prospect for addressing these concerns until a comprehensive site assessment methodology can be developed, and that this is subject to cost-benefit assessment. Kwok et al (2012) presented a preliminary risk matrix based on the environmental conditions identified within the report. While it may be appropriate to include wind load measures to protect against F2 tornado scale events as per McRae et al (2012), the question is how far and how deep into a residential area.

Penman et al (2015) suggests that only a distance of 40 metres, or possibly 65 metres would be warranted for protecting buildings based on proportion of houses lost at this distance. Prof Ross Bradstock (per comm.) has suggested that hazard reduction at depth of <1 kilometre would provide sufficient protection against major house loss.

Overall comments and conclusions.

A peer review of the Report prepared by Associate Professor Jason Sharples has been undertaken. The review found that although the report contains some important information and insights, these matters were in most cases known to those involved in the development of and review of AS3959-2009. The report makes a fundamental error in considering AS3959-2009 to be the basis for a risk assessment of bushfire matters as part of the development assessment process. This is not the role or purpose of AS3959.

The report concluded that AS3959-2009 has perceived failings based on the four factors of:

- is based entirely on the assumption that fires propagate in quasi-steady manner;
- is predicated on the notion that the main cause of house loss is radiant heat exposure;
- factors in the effect of embers in an over-simplistic way via an assumed relationship with radiant heat exposure;
- offers no consideration of the potential effects of pyrogenic winds.

On the surface, this report presents as an attractive approach but fails in the fundamental understanding of the provision of the NCC, and building practice requirements in Australia. The purposes of the bushfire performance requirement only require a reduction of risk which may equate to 10% loss at a 1:50 design bushfire event. Near Ginninderry, this design bushfire (of 1:50) would equate to approximately an FFDI of 100 for forest environments, however, a better way forward would be to consider a Project Vesta assessment.

AS3959 is based on quasi-steady state equations and can be improved on, however consideration of ‘eruptive pyrogenic events’ needs to be subject to a quantifiable site assessment methodology. It will also need to be subject to cost-benefit assessment. The NCC is not directly concerned with fire fighter considerations for bushfire fighting. This is a planning matter.

Radiant heat exposure is used as the basis of site assessment and is linked to the engineering principles associated with materials science. In many ways this maybe conservative and in other ways less so. It is not appropriate to consider the overwhelming losses sustained in major events, including those of Canberra in 2003, and Victoria in February 2009 where few houses were subject to bushfire protection measures, and compare that with houses built in accordance with the regulatory environment. Studies of Wye River and Winmalee suggest that significant houses were protected using the current regulatory environment (Douglas and He, 2017).

Ember protection is predicated on the fact that embers are a bushfire attack mechanism and that although grasslands have little to offer in the way of embers, this is not true of forest fires. Ember protection is intended to be an inherent characteristic of construction practice.

AS 3959 does not offer any consideration of pyrogenic wind effects. This is a challenge for building regulators and fire agencies, which have been unable to be persuaded within their jurisdictional boundaries or to persuade the national body, the ABCB that this is worth pursuing. This may not necessarily be a problem for AS3959 but may sit within the wind loadings code(s). Either way, some protection can be afforded, but at this point in time would be qualitative rather than quantitative in nature.

The Standard, AS 3959-2009 can be improved, and is currently subject to a major review. This will include some improvements to the site assessment methodology, as well as construction aspects of the Standard. *Planning for Bush Fire Protection* is also currently being reviewed.

The revised Standard will not address any of the concerns raised in the Sharples report. There is no appetite by the ACT or NSW Government to push beyond the current legislative arrangements for construction. In NSW, the provisions which enhance ember protection may be adopted as NSW variations to the NCC as part of the *Planning for Bush Fire Protection* review, or it may well fall to the planning provisions to address.

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