How Science, Diligence and Luck saved our Home.

Mick Harewood, February 2020.

We always knew we had chosen to live in a fire-prone forested area[i]. Our cottage, built in the 1890's, had survived the major fire in 1952, partly due to its location, low- down towards the toe of a ridge and above the river flats and swamp.

The loss of life associated with the 2009 "Black Saturday" fires in Victoria caused a shift in advice from "stay and defend" to "leave early" if catastrophic fire conditions were anticipated. Sue suggested we should build a bushfire bunker because, surrounded by a sea of wood-chipping regrowth, we might have difficulty evacuating by road to a safe place.

Bunker Design.

The CSIRO had investigated the use of bunkers or "dugouts" and had concluded that they are extremely dangerous due to the likelihood of carbon monoxide poisoning. This meant that the bunker had to be gas-tight. We are indebted to Chris Pullen who collated information and posted it on a website after the 2009 fires.

In brief, our bunker is half underground and half above. On narrow concrete footings, we constructed of a double cavity wall of standard house bricks, sealed for water-proofing on the outside, and added 250mm thick puddled mudbricks to make up the full height on a sloping site. The roof is of reinforced concrete about 125mm thick. The supporting reinforcing steel on which the concrete slab was poured extended just half-way across the walls, so there was a gas-tight seal between walls and roof. The slab extends 100 mm beyond the wall, providing weather protection for the mud-brick walls. The internal space is about 3 metres by 3 metres by 2.6 metres, and the fire door opens into an external passage with a metal screen door for vermin exclusion and ventilation when the bunker is not in use.

To determine when it is safe to exit, we have a thermometer with a probe through the wall (obtained from "Instrument Choice". The thermocouple thermometer I chose was YC-8XX series K type, dual chanel.), a metal pipe with a gate valve for sampling air quality and a small window of 3 layers of ceramic glass in an insulated steel frame (made by "Nilfire").

The fire door was a solid-core standard hardware-store door fitted in a metal architrave, backfilled with cement mortar. On the outer face of the door, I attached a sheet of fibre cement and covered this with old corrugated iron. The gas-tight seals were of two types (supplied by Lorient Seals). Bat-wing seals were fitted in the entire perimeter. At the foot of the door, the architrave had to be completed with a 13mm step in the concrete, faced with a metal angle piece. Rebated in the perimeter of the door were "intumescent" seals. These expand when heated, so attention needed to be given to opening the door if the intumescent seals got hot enough to expand. Initially, I reinforced the door handle with metal strapping and attached a 50 mm block of wood to the wall nearby. This facilitated leverage with a heavy crowbar. Subsequently, I fitted a metal cable to the opposite wall and attached a turnbuckle and hook so as to be able to pull the handle with little effort.

In hindsight, I possibly should have purchased and approved fire-door assembly, which has a 25mm overlap with the architrave.

Tight closure of the door was achieved with a sliding bolt.

We were concerned that if the bunker had to be occupied for more than an hour by two people, the air might start to run out. I purchased a second-hand compressed air cylinder from a local dive shop. When I bought it, the vendor asked what I was going to do about CO2? He said that CO2 and humidity would build up rapidly once the door was closed. I resolved to purchase a CO2 meter (search "Instrument Choice", I chose the EXTECH CO2 meter model CO250, which also gives temperature and relative humidity) and to lower the position of the metal pipe with gate valve (CO2 is heavier than oxygen and nitrogen).

We experienced a heat-wave one summer of 3 to4 days. We found the bunker got quite hot even in the absence of fire. We added a perimeter of bricks to the concrete slab roof, filled the space with humus-rich soil and planted *mesenbyranthemums*, which the possums ate! Local grasses and a *Myoporum bayteii* subsequently germinated. We also attached new Zilcalume corrugated iron to the north and east walls with 25mm spacers (copper pipe) behind the sheets. A gap at the bottom and top allows air circulation so the tin heats up in the sun but the bricks stay cool. It is typically 5 to10 degrees cooler in the bunker on a hot day, even with the fire-door open and only the screen door closed.

<u>House Design for Bushfire Resilience.</u>

After Ash Wednesday 1983, the CSIRO had advised that houses burnt down for two main reasons. Leaves and sticks igniting in guttering cause a fire to enter the roof-space, always a tinder-dry place. Secondly, embers building up over time at the junction of a vertical and horizontal surface can eventually cause a flammable building material to ignite.

Having surrounded the house with verandas, we knew we needed a sprinkler system to wet- down the unpainted weatherboard walls and tongue-and- groove hardwood verandas. We also took care to seal the gap between the top of the walls and the underside of the veranda roof with flexible "bird scallop" tin. Below floor level, the house was boxed in with mudbricks and metal mesh (on the southwest), mudbricks and corrugated iron doors (northwest) and corrugated iron doors (northeast).

The bottom two weatherboards were replaced with mudbricks, fitted between the studs and rendered to cover the studs and plates then sealed with "Bondcrete" for water-proofing.

We attached the guttering to the ends of the veranda rafters using external metal brackets attached to metal rafter extensions ("facia-savers"). These enabled adjustment of the height of the guttering to achieve a maximal slope. (A good slope avoids ponding of water and rotting leaves in the guttering, ensuring good water- quality in rainwater tanks.) To be able to fill the sloping guttering, we made blockers using trouser legs or shirt sleeves tied up with string and loosely filled with fine river sand. These can be placed at intervals and manipulated to form small dams of ~50mm depth, with a groove in the centre to allow excess water to flow to the next blocker. Thus the entire perimeter guttering can be filled using just two hoses.

Just prior to the New Year's Eve fire which devastated Mallacoota, our large dam ran out. It had been supplying water to bird baths on each side of the house and we had intended to fill the guttering by connecting hoses to dam-water taps. We installed an additional copper pipe from the house water supply to the south-western side of the house to fill the guttering on that side.

The sprayer system consists of 19mm plastic tubing attached near the top of the house walls and fitted with ½ round micro-jet sprayers at ~1.5 meter intervals. On first testing, unsightly water stains appeared on the weatherboards. We resolved to support the tubing with clips right next to the sprayers so that these were the highest points. We also installed 3 vertical copper pipes fitted with end-flushing valves to rapidly drain the system. End flushing valves open when the pressure falls below ~16 psi. (Reliable gravity-type end-flushing-valves can be obtained from specialist garden irrigation outlets such as the one in Fyshwick, ACT).

We also replaced the insect screen material on 3 standard metal (aluminium?) mesh screens with "Invisiguard" security grade steel mesh. Although this was fitted to the same wooden frames, these were thoroughly wetted by the sprayer system.

December 17th Visit.

As the drought worsened and the fires in northern NSW and Southern Queensland progressed down the NSW coast and tablelands, we became increasingly concerned. We contacted a friend, Rob Pearson, who was a member of the Merimbula RFS brigade and a former member of the Brogo and Cobargo brigades.

Rob reviewed our bushfire plan[ii] and made several suggestions, many of which we acted on. I wish we had acted on them all. There is great value in getting someone outside your household to audit your fire preparation.

New Year's Eve Trial.

On NYE 2019/20, fires burning rapidly under hot NW winds ravaged Mallacoota, Cobargo and suburbs south of Bateman's Bay. This event gave us the opportunity to implement our fire plan for real. We tested the sprinkler system and found that one of the end-flushing valves had failed to close properly. We also found that the tongue-and-groove decks were well-wetted but not-so the walls. I rotated the pipes about 10 to 15 degrees and clamped them more-securely in place. I also refined the shaping and placement of the guttering blockers.

January 4, 2020.

On the Saturday morning, my partner Sue evacuated to Eden to stay with my brother in his rented unit at "the lookout" in Eden, arguably one of the safest locations in the Shire. I heard a farmer from Buckenboura say on ABC local radio that he and his father had sheltered under their brick house during the NYE fire. When they came out to put out spot fires, they found all the hoses they had pre-positioned had burnt or melted! I resolved to bring 3 hoses with fittings inside.

From about 4 pm, the smoke from the Border fire made the day completely dark. I used external lighting to move about 30 walnut drying trays, which had been stored in the shade behind our power block, into the dryer itself.

At around 8:30 on Saturday evening, Sue and David evacuated from Eden to Merimbula. After about 10 pm, Sue phoned to say the Border Fire had reached Wonboyn. I turned on the sprinkler system which was fed by gravity from a 13,500 litre plastic tank. I donned my overalls, respirator, face-shield mesh, woollen skull cap, leather gloves and boots. I entered the roof space and gave it a fine spray for a minute or so; not enough to damage the plaster-board ceilings but enough to increase the humidity a little. I followed the lime-line (laid earlier) to the bunker. I dithered at the entrance taking hopeless photos in the dark and foolishly allowed a lot of smoke to enter the bunker! I closed and bolted the fire-door and put fresh batteries in the CO2 meter. I recorded these numbers from my thermocouple thermometer (with a probe through the wall), CO2 and relative humidity meter and a barometer. I had left a light on over the kitchen sink so that I might view the house through a tiny, expensive, window.

Time pm	Temp in	Temp out	CO2 ppm	Relative humidity	Barometric Pressure	Observations
1022	20.9	40.3	1760	94.9		Fire progressing slowly downhill
1026		45.1			1021	House obscured
1029	21.0	40.9	2104	87		Small bird landed on window grill, then flew off
1040	20.9	40.2	2388	87		Turned on compressed air a little
1048	21	38.8	2684	86	1021	Firewood store has caught alight
1053						House obscured, firewood blazing
1058						Some radiant heat through bunker window.
1106	20.8	40.4	3138	90	1021	
1122	21.2	37.7	4141	92	1022	Opened exit valve a little, opened compressed air valve more (cold).
1132	21.4	35.5	4493[iii]	93.4	1021	

I geared up and exited the bunker. At the house, I found the power off, water off and smoke-alarm screaming. I turned off the power to the studio, which was burning from the inside. I reset the inverter (which had indicated AC overload) and the 240 volt power to the house came back on.

I donned a hard hat and made my way uphill past the burning studio to the concrete tank. I turned off the gate valve to a 13,500 litre plastic tank which had supplied the house sprinkler system for a time before melting and disintegrating. I turned on the concrete tank gate valve and made my way back through the burning landscape to the house. The water pressure was pathetic. I made my way back uphill and found that there were several leaks in the network, even though we had taken care to be able to isolate each plastic tank with a gate valve connected to a galvanised metal elbow connected to pipework underground. Small plastic fittings had melted (a nipple and an end-connector) and in one case a pipe had burnt underground, perhaps inadequately buried in rocky soil. I turned off the concrete tank and turned on the metal studio tank which I knew still had about 300 litres of water.

I used one hose to fill a plastic watering can which I used to put out various fires burning garden fence posts etc.

What was lost and what was saved.

Our main loss was Sue's mudbrick studio. I believe sustained ember attack ignited a wooden door on the southwest side from the base. Viewing the galvanised iron roof from above, it is clear that the tin over the eves is intact but the tin over the internal space has lost its galvanised surface. The fire inside the studio was so hot that it melted glass which flowed down an internal mud-brick wall. Apart from the structural timbers, the studio fire burnt half-a-lifetimes worth of paintings and drawings, as well as numerous documents, files, books etcetera.

We also lost a timber and tin carport, two mowers, several hoses and fittings, anything plastic such as grated drains in the roads, the 3 tanks, PVC pipe ends where they were exposed as part of "smart" culverts, PVC first flush diversion devices and PVC tank overflow fittings.

Conclusions.

A cheap and simple sprinkler system fitted under a veranda or under eves saved an old weatherboard house in an intense fire. (The January 4th 2020 fire destroyed about 40 homes in the Kiah locality, as well as the community hall and church). However, having a finite amount of water, it was imperative to turn on the sprinkler system at the optimum time. Even though the water eventually ran out, the flammable surfaces were saturated enough to prevent the house from burning in spite of sustained ember attack.

Having a solid, gas-tight bunker enabled me to stay safely to turn on the sprinkler system and then put out a few spot fires after the main danger had passed.

Bunkers are not for everyone but a sprinkler system might be operated remotely (via a modem and solenoid valve?) or automatically (once the temperature reaches, say, 50 degrees C at an appropriate point outside the building.)

To lose one's home must be one of the most devastating experiences that one can endure. While only a few lives were lost in this shire this season, hundreds of homes have been destroyed. Neither "stay and defend" nor "leave early" is ideal. Leaving early from a home designed to survive sustained ember attack un-attended might be a feasible option for many.[iv]

Position in the landscape is also an important factor in determining the chance a building will survive.

The extent of fuels management by prescribed burning is an area of great controversy. The Macarthur fire danger meter can be used in reverse to determine the fuel load required to ensure that direct- attack on a head- fire by ground crews is possible. The Bushfire fighter's manual says that ground crews can only get near enough to a fire front to attack it if the flame height is less than about 1.5 meters. If you plug in the temperature, wind speed, relative humidity and drought index etc. into the Macarthur model, there is no fuel level at which a fire can be attacked by ground crews under extreme or catastrophic fire-weather conditions.

In the Eden forests, fuels accumulate rapidly following a fire to an equilibrium level of about 10 tons per hectare[v]. They reach 8.8 tons per hectare in about 3 years. As the climate warms, the window of opportunity for safe burning is diminishing. The idea that all forest areas can be burnt every 2

years or less is delusional. Moreover, many of our serious fires have actually been escapes from approved burns which have re-ignited on days of bad fire weather (e.g. Yankey's Gap Road).

Prescribed burning can have uses other than just fine fuel reduction such as reducing the amount of loose bark on the butts of trees and providing experience with active fires for training crews. However, it is difficult and unpopular in the peri-urban fringe due to smoke, the risk to fences and sheds and the sheer amount of effort involved. In these areas, pile burning of gathered sticks followed by brush-cutting of near-surface fuels may be a better option. This tends to encourage grazing by macropods.

My view is that, while prescribed burning may have a role in some circumstances, it is folly to expect it to do what it cannot achieve in a warming climate with more frequent days of extreme or catastrophic fire danger.

We have seen the devastation, all down the east coast, to which just 1 degree of warming has contributed through the enhanced drying of fuels and depletion of water resources.

We need to stop burning fossil fuels.

---

[i] The 1952 fire came from the north-west and burnt trees on the ridge, well-above the house and to the south. Another factor may have been the absence of guttering-the house certainly had none by the time I bought it in 1976.
In 1972, fires at Nadgee and Yambulla had burnt vast areas of forest to the south and west.
The November 1980 Timbillica fire burnt 46,000 hectares of mainly woodchip regrowth forest in 6 hours.
We moved to "Heartwood" in 1982 and were very lucky that the wind dropped before the 1983 Combienbar fire got very far over the Victorian border. By March 1983, the extreme winds which fanned the "Ash Wednesday" fires in Victoria did not pose a threat to us because the Combienbar fire and a smaller blaze at Rockton had been blacked-out.
We gradually restored the cottage and surrounded it with verandas. We built a mud-brick studio, in which we lived while we replaced the roof of the cottage in around 1991.

[ii] Fire plan for Heartwood

- Put treasured items in bunker (lap tops and hard drives) or car – guitar, paintings, clothes and drive car to the flat under nut trees.
- Turn off gas and disconnect bottles, remove them away from the house and bunker.
- Move fuel to the loco (nut-dryer) fire box shed.
- Put water in the guttering using the blockers from back of the house and hoses with hooks (under house).
- Fit studio metal doors and water gutters too.
- Fill bath and recycling bins (put around house with mops) and place wet towels under doorways.
- Fill knapsack sprayer and fit with jet fitting.
- Shut windows. Remove curtains.
- Open ceiling and put ladder in place.
- Turn on spray system to check.
- Switch house water supply to concrete (and top plastic) tanks.

- Bring some hoses and fittings inside house

[iii] At 2000 to 5000 ppm, CO2 can cause drowsiness, headaches, poor concentration. At >5000ppm, serious health effects can be experienced, including oxygen deprivation leading to coma and even death. The level of CO2 achieved after about 1.5 hours in the bunker has led me to question whether the compressed air cylinder was fully charged at the time of entry.

[iv] Paul Whitington has described the construction of their home near Wonboyn, which survived the 4/1/2020 fire unattended. See Info@atlasforlife.org.au Feb 2020 newsletter, Forest Recovery Read more on life in a southern forest (Jan 27, 2020).

[v] Newman L (1977) Cited in R.J.Raison, P.V. Woods and P.K Khanna. Dynamics of fine fuels in recurrently burnt eucalypt forests. Aust. For. 1983 46 (4) 294-302.