

# Water Spray Systems for Bushfire Protection

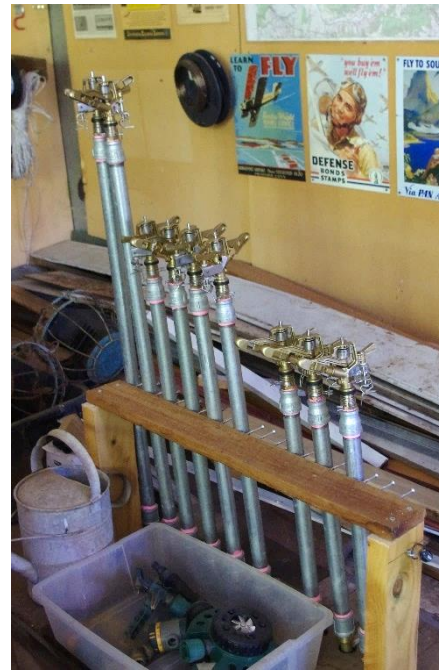
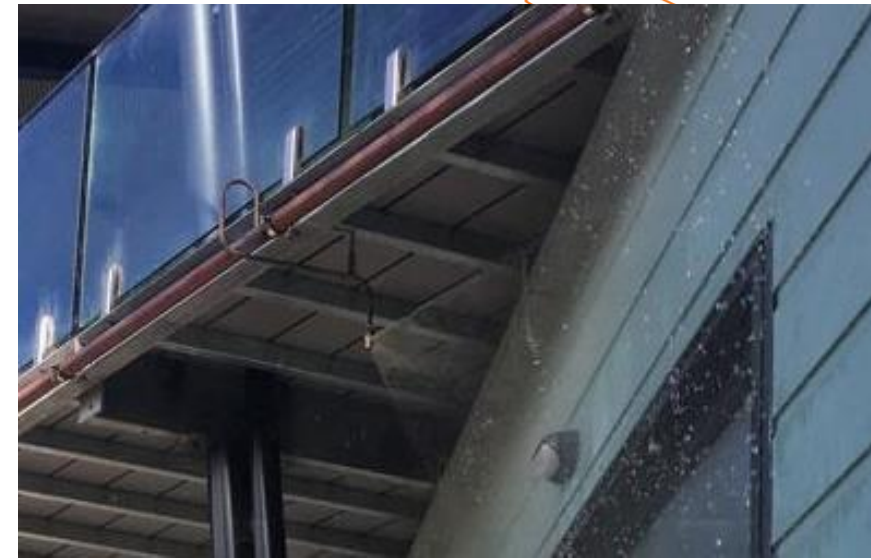
Alan Green

February 2025



# External sprinklers for bushfire protection

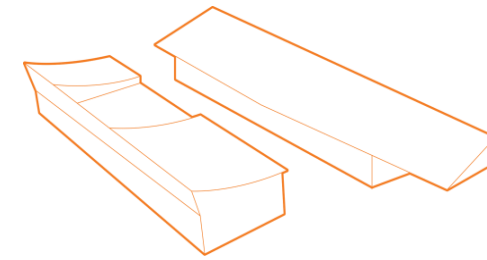
- Used by many households
- Typically retrofitted, and combined with 'passive' measures
- Sophistication of existing systems varies widely
- Design guidance is inconsistent, lacks detail



Green A, Cooper P, 2022. Bushfire Sprinkler Systems for Increasing Bushfire Resilience of New and Existing Residential Buildings – Phase 1 Final Report. A report for Forest & Wood Products Australia Ltd.

Green, A., 2019. Sprinkler Systems for the Protection of Buildings from Wildfire, Doctoral Thesis, University of Wollongong. <https://ro.uow.edu.au/theses1/617/>

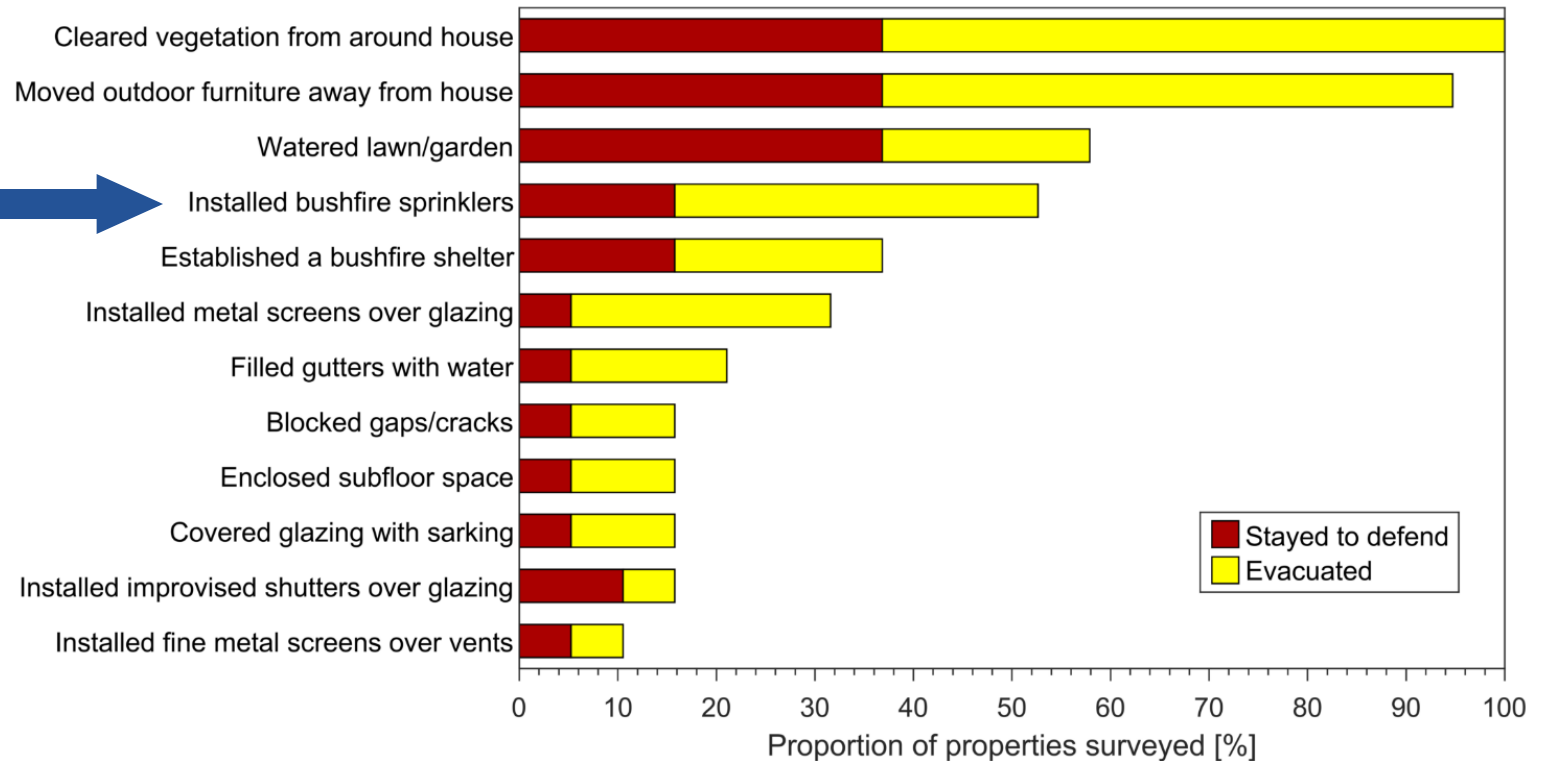
# Example data from Kangaroo Valley, NSW



~50 % of houses had sprinklers in this case (some ad-hoc systems installed as the fire approached)



Actions taken by residents prior to 2020 Currowan Fire



Green A, McKinnon S, Daly M, Boehme T, Cooper P, Eriksen C, 2024. Community-led disaster resilience initiatives: a case study. Australian Journal of Emergency Management. <https://knowledge.aidr.org.au/resources/ajem-october-2024-community-led-disaster-resilience-initiatives-a-case-study/>

McKinnon S, Green A, Daly M, Boehme T, Cooper P, Eriksen C, 2022. Building Community Resilience to Bushfires: A Case Study of Kangaroo Valley. Final Report. <https://www.uow.edu.au/global-challenges/building-resilient-communities/building-community-resilience-to-bushfires/>

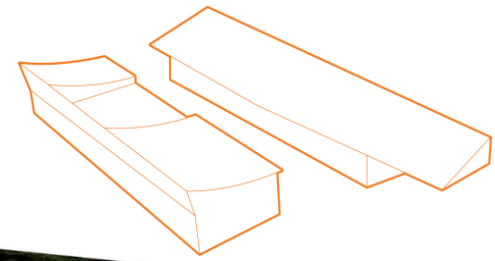
# AS 5414 Bushfire water spray systems

- The most detailed design guidance available
- However, it has limitations:
  - Requires each sprinkler arrangement to be tested
  - Addresses BAL 19 only
  - Water requirements are relatively high – leads to large, expensive systems
- Currently not used by designers

AS 5414 is currently being revised



# Design process



2. Identify building vulnerabilities

3. Identify which vulnerabilities can be protected by sprinklers

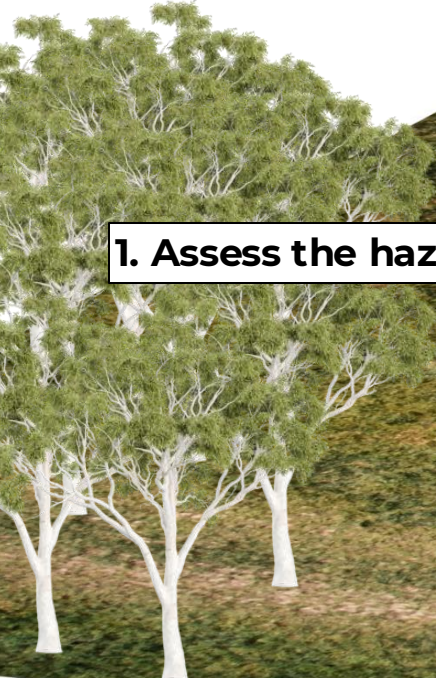
4. Calculate required water delivery rates and duration

5. Select sprinkler type, supply pressure, location, spacing

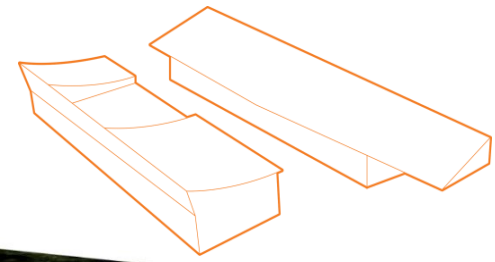
1. Assess the hazard

6. Design water supply system

7. Ongoing maintenance



# Design process



2. Identify building vulnerabilities

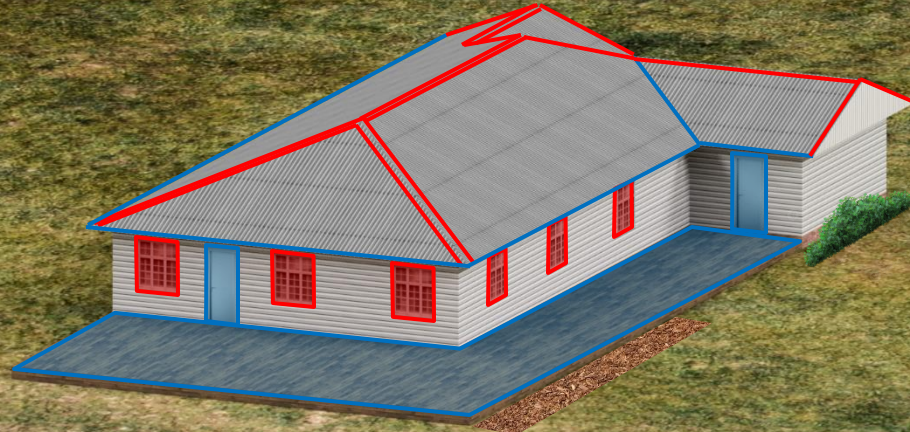
3. Identify which vulnerabilities can be protected by sprinklers

**How do sprinklers protect buildings?**

4. Calculate required water delivery rates and duration

5. Select sprinkler type, supply pressure, location, spacing

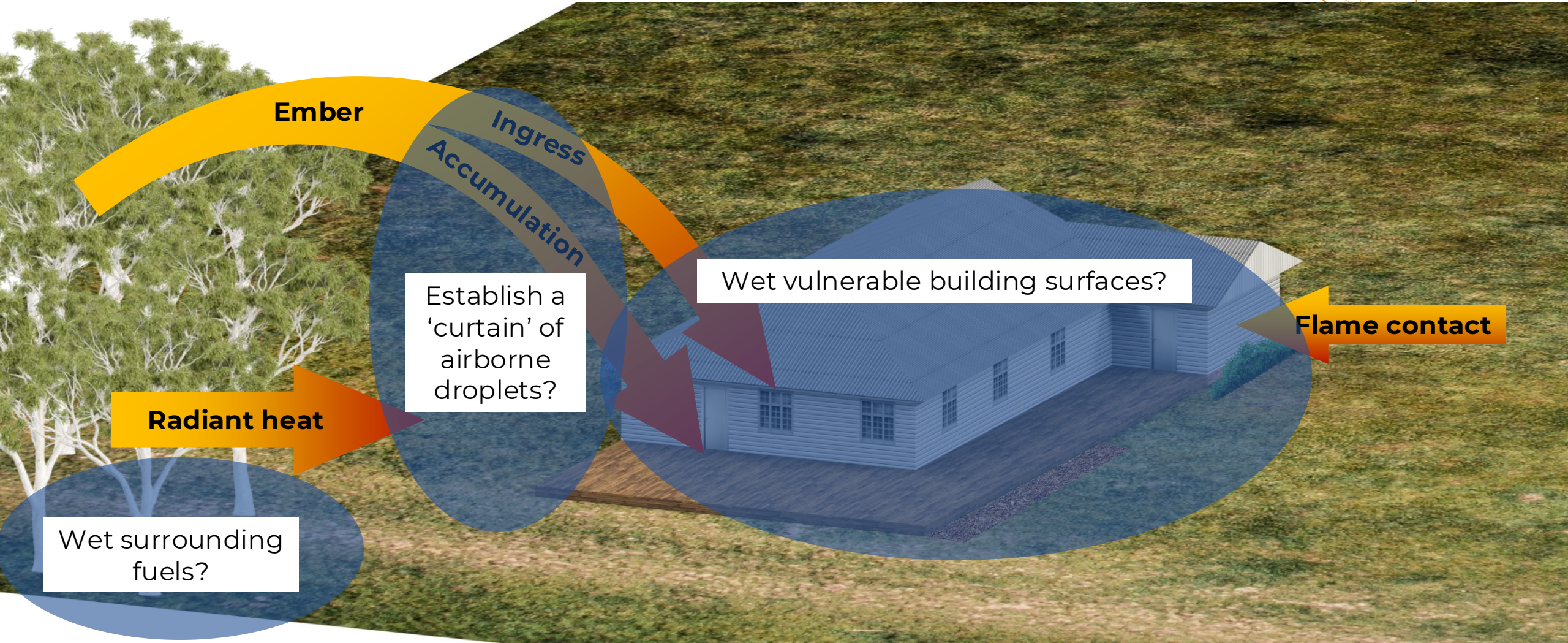
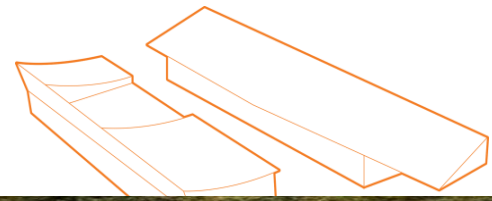
1. Assess the hazard



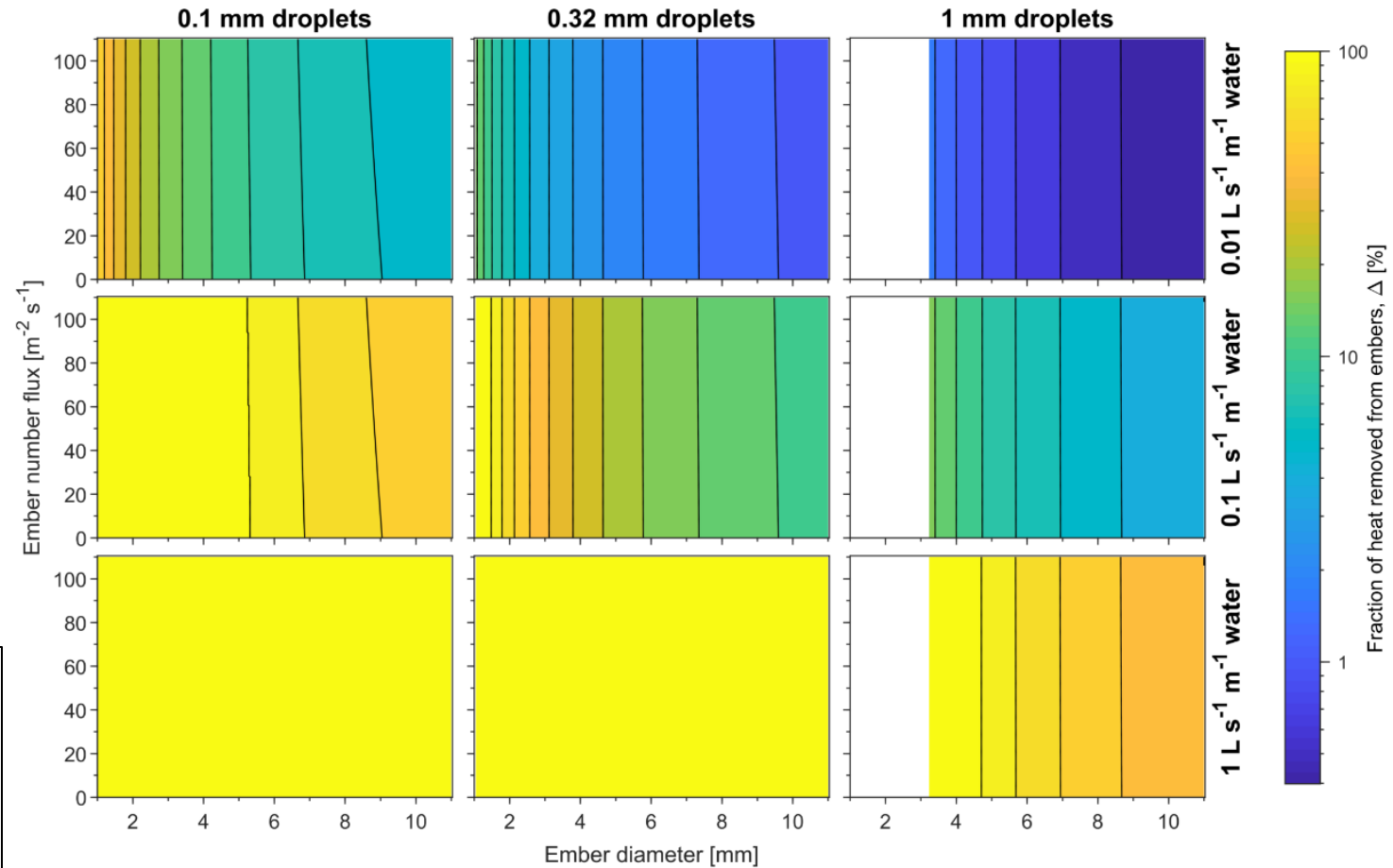
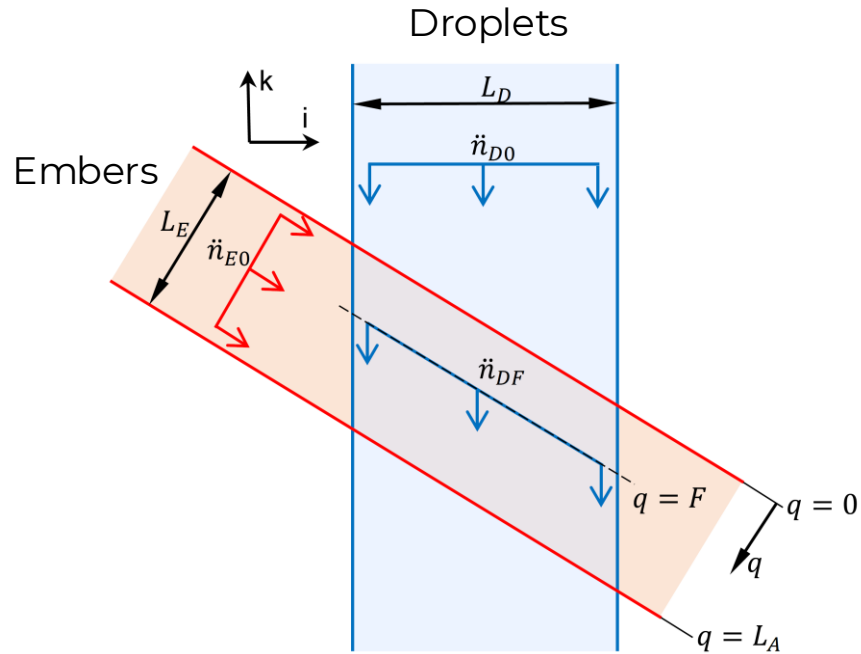
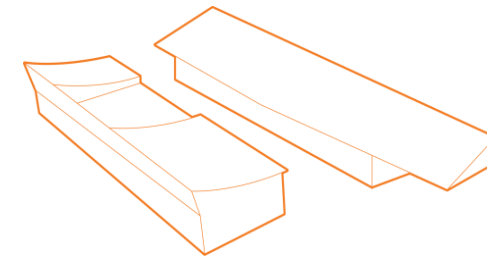
6. Design water supply system

7. Ongoing maintenance

# How do water sprays protect buildings?



# Will droplets collide with airborne embers?

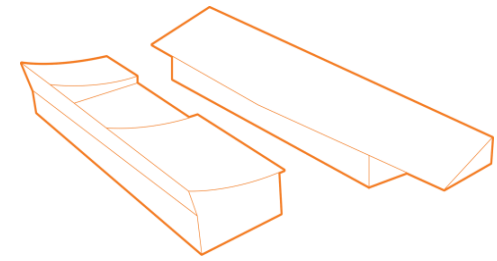


Requires either:

- Extremely high water flow rates ( $\geq 1$  L/s per m)
- Very small ( $\approx 0.1$  mm) droplets and moderate flow rates ( $\approx 0.1$  L/s per m building perimeter)

Does not appear to be an effective approach

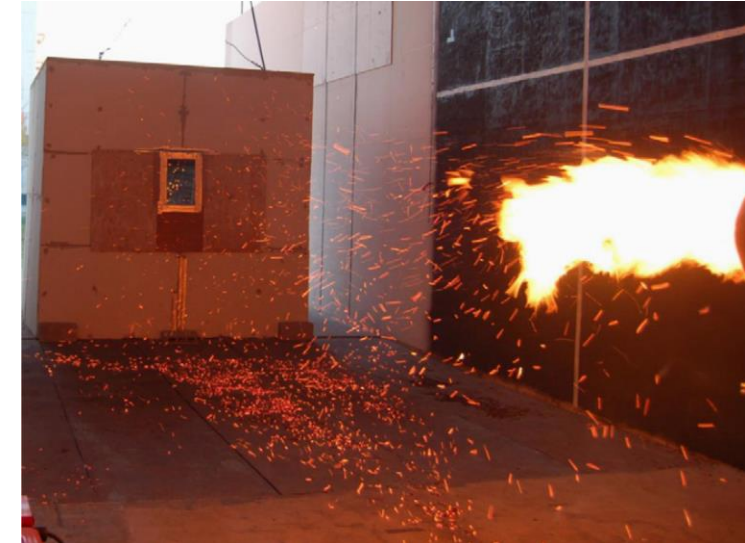
# Can sprays prevent ember ingress through gaps/cracks?



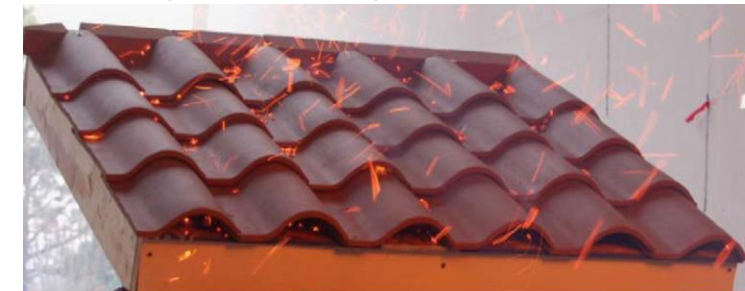
- A significant hazard, especially for older buildings – it leads to building ‘burning from the inside out’
- Ember ingress can be tested in wind tunnels
- Water sprays have not yet been tested

Has not been shown to be an effective method to protect against ember ingress

Testing ember ingress through vent



Testing ember ingress between tiles



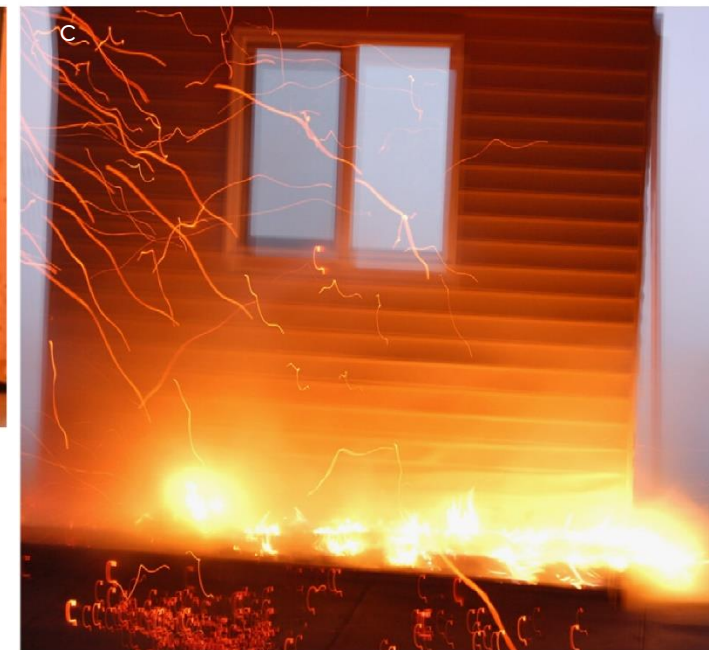
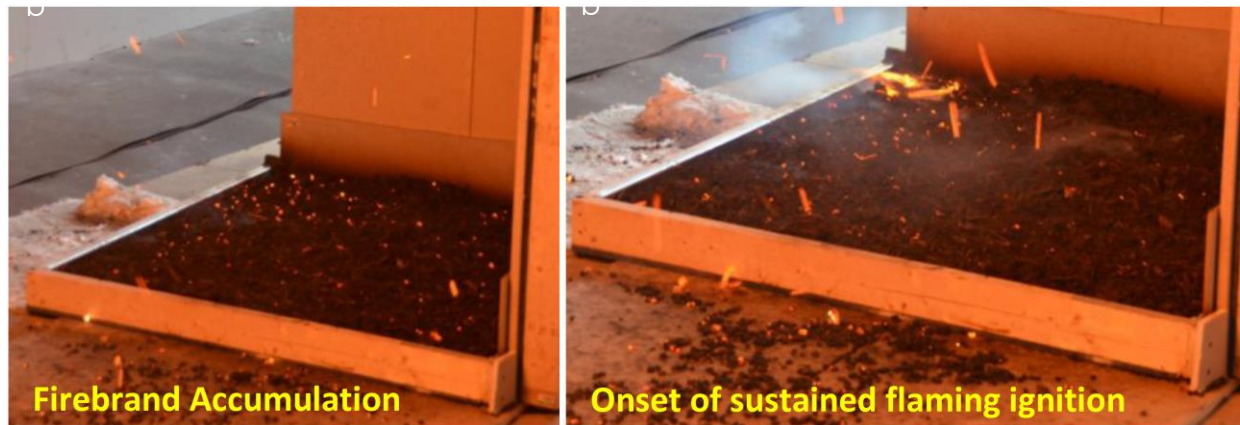
Manzello, SL, Hayashi, Y, Yoneki, T & Yamamoto, Y 2010, 'Quantifying the vulnerabilities of ceramic tile roofing assemblies to ignition during a firebrand attack', Fire Safety Journal, vol. 45, no. 1, pp. 35-43. <https://doi.org/10.1016/j.firesaf.2009.09.002>

Manzello, SL, Park, S-H, Suzuki, S, Shields, JR & Hayashi, Y 2011, 'Experimental investigation of structure vulnerabilities to firebrand showers', 9 Fire Safety Journal, vol. 46, no. 8, pp. 568-78. <https://doi.org/10.1016/j.firesaf.2011.09.003>

# Extinguishing embers after they settle outdoors

- Extinguishment of Class A fire by water sprays is relatively well understood <sup>a</sup>
- Required water application rate is related to the heat content of the burning fuel, which is not much in the case of embers and leaf litter
- No studies appear to have quantified requirements for bushfires yet

Likely to be an effective method to protect against embers accumulated outside building

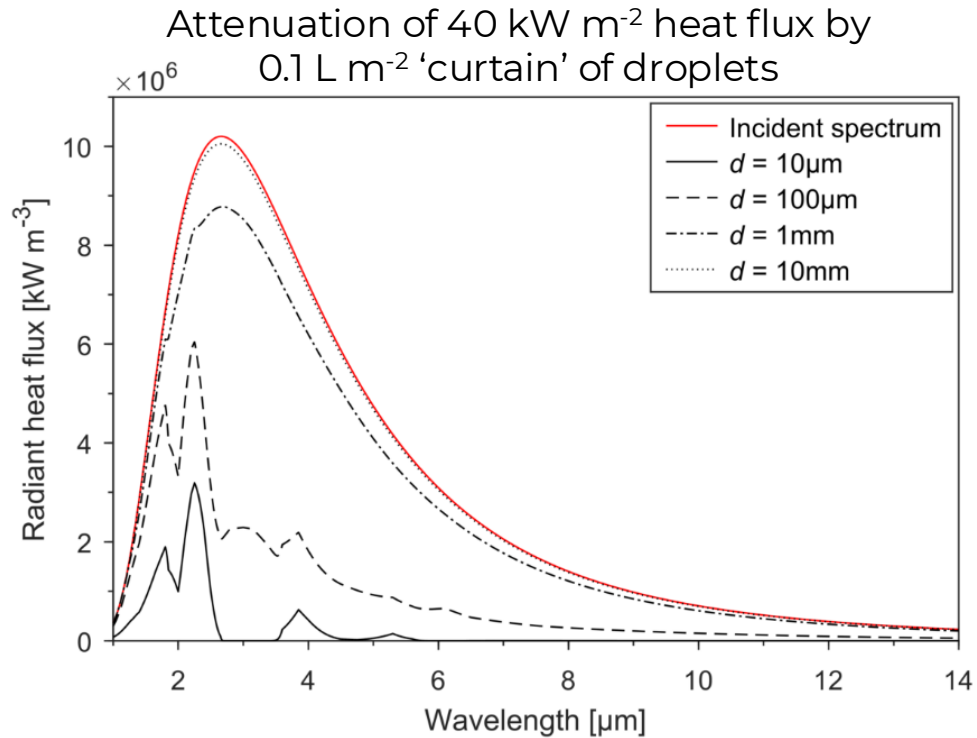
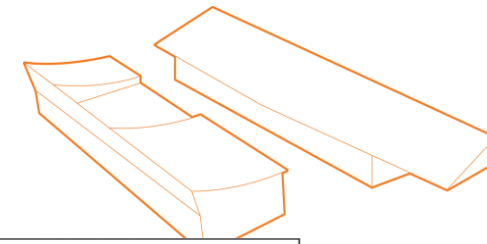


<sup>a</sup> Grant, G, Brenton, J & Drysdale, D 2000, 'Fire suppression by water sprays', Progress in Energy and Combustion Science, vol. 26, no. 2, pp. 79-130. [https://doi.org/10.1016/S0360-1285\(99\)00012-X](https://doi.org/10.1016/S0360-1285(99)00012-X)

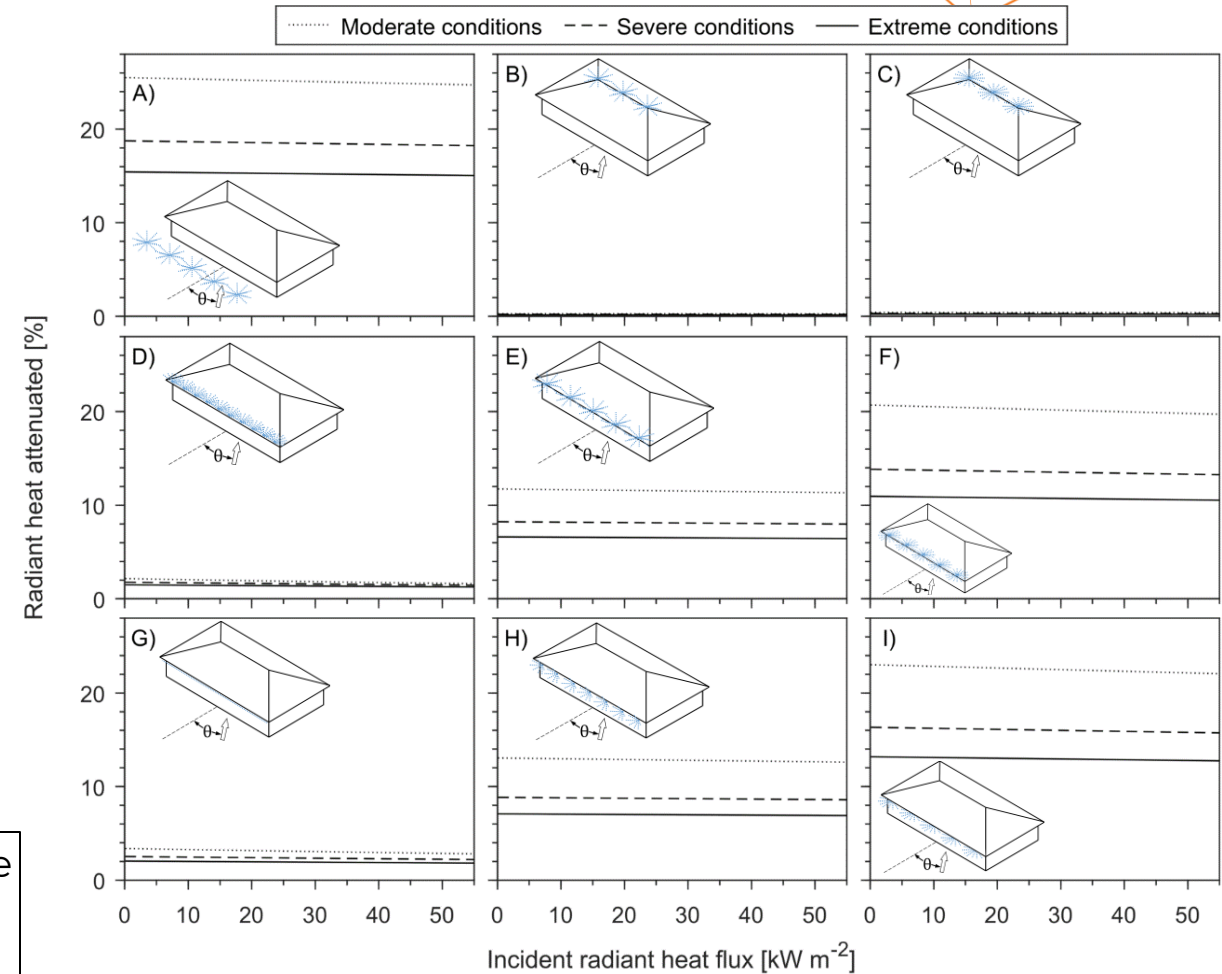
<sup>b</sup> Manzello, SL & Suzuki, S 2012, Exposing wood decking assemblies to continuous wind-driven firebrand showers, National Institute of Standards and Technology, United States Department of Commerce. <http://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1778.pdf>

<sup>c</sup> Manzello, SL 2014, 'Enabling the investigation of structure vulnerabilities to wind-driven firebrand showers in wildland-urban interface (wui) fires', Fire Safety Science, vol. 11, pp. 83-96. [https://publications.iafss.org/publications/fss/11/83/view/fss\\_11-83.pdf](https://publications.iafss.org/publications/fss/11/83/view/fss_11-83.pdf)

# Radiant heat attenuation by airborne droplets



- Very effective protection provided by fine mists, but these are not practicable for bushfire protection
- Some systems can achieve ~20 % attenuation of radiant heat, but this may not be the most effective way to use limited water resources



# Direct cooling of vulnerable building surfaces

- Each L/m<sup>2</sup> min of water evaporated can remove ~40 kW/m<sup>2</sup>
- However, non-uniform application, splashing, etc. reduces effectiveness
- Many studies have measured cooling of glazing <sup>a,b</sup>
  - Glass can break if it is already hot when sprinklers activate
  - Glass can break if water application is incomplete
  - Tempered glass is less sensitive to thermal shock
  - Protection from heat fluxes 40 kW/m<sup>2</sup> and higher is possible
- Measured cooling of opaque surfaces <sup>c</sup>
  - Film forms runnels, except at very high flow rates
  - Measured cooling effect matches predictions based on theory

This is one effective method to address radiant heat

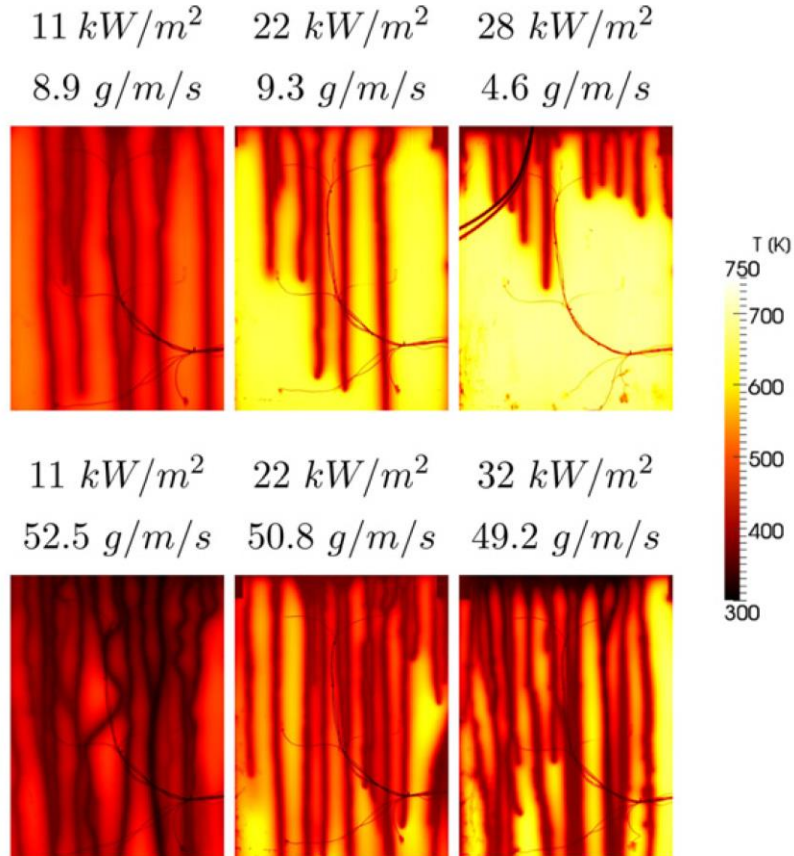
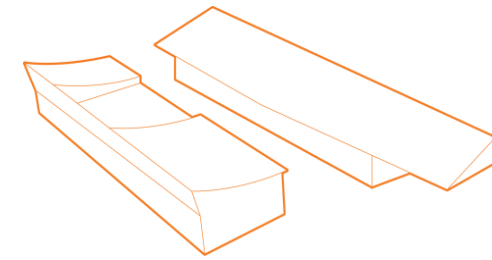


Image from Meredith 2013<sup>c</sup>

<sup>a</sup> Kim, A.K. 1988, Fire exposure of glazing, 4th Conference on Building Science and Technology, February 18, 1988, Toronto, Ontario, Canada. <https://doi.org/10.4224/40001416>

<sup>b</sup> Kim, A.K., Taber, B & Loughheed, G 1998, 'Sprinkler protection of exterior glazing', Fire Technology, vol. 34, no. 2, pp. 116-38. <https://doi.org/10.1023/A:1015325418666>

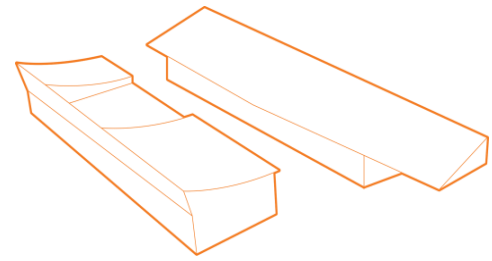
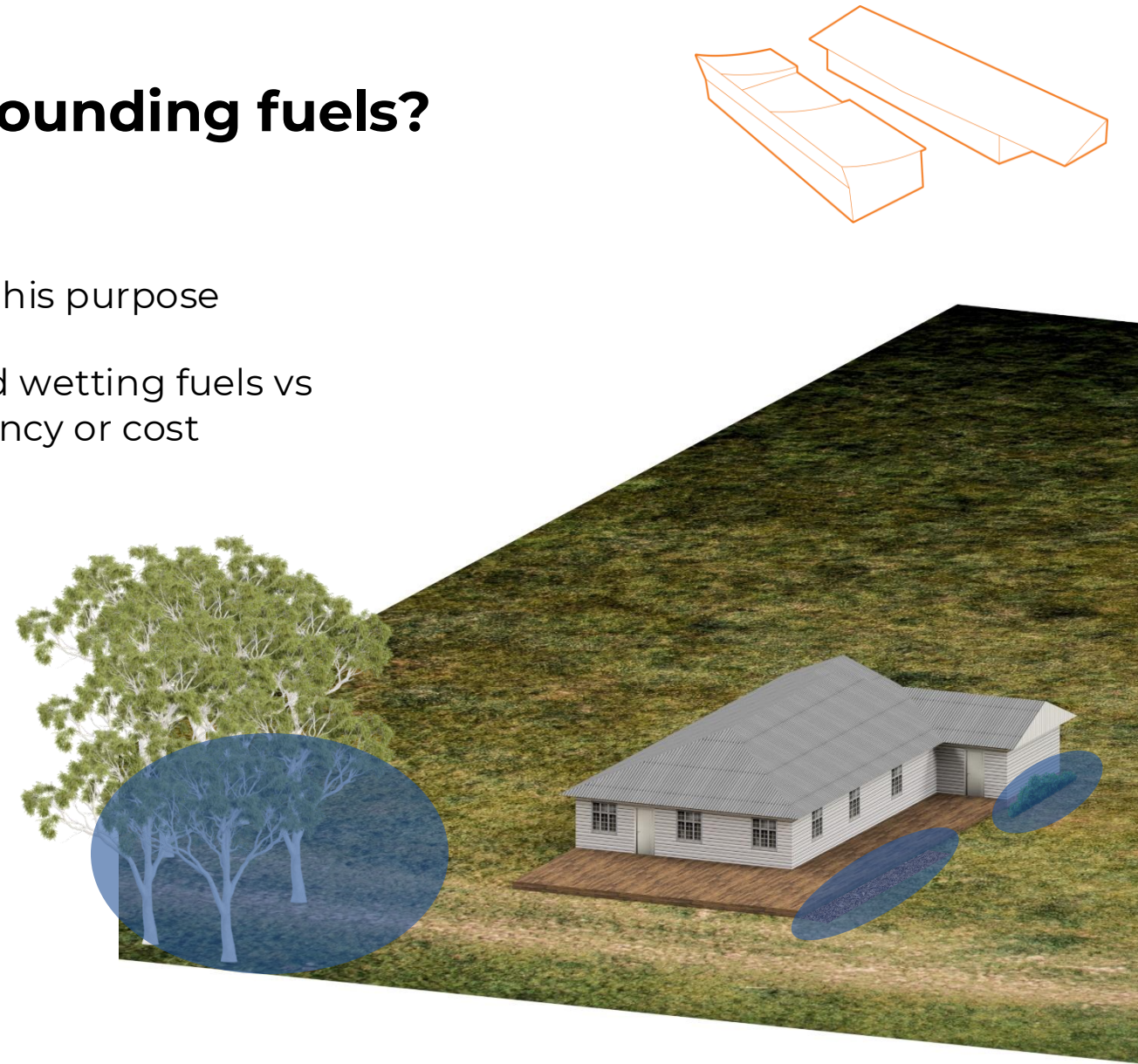
<sup>c</sup> Meredith, K., de Vries, J., Wang, Y. and Xin, Y., 2013. A comprehensive model for simulating the interaction of water with solid surfaces in fire suppression environments. *Proceedings of the Combustion Institute*, 34(2), pp.2719-2726. <https://doi.org/10.1016/j.proci.2012.06.094>

# Is it more effective to wet the surrounding fuels?

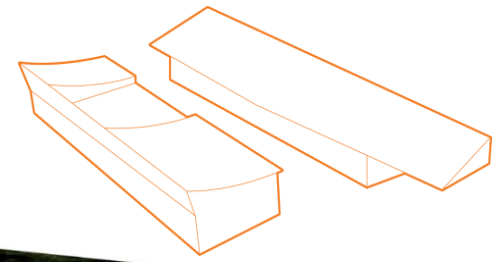
- Many existing systems include perimeter sprays for this purpose
- We are not aware of any studies that have compared wetting fuels vs wetting the building in terms of effectiveness, efficiency or cost

A reasonable approach would be:

- First focus on wetting vulnerable building features
- If enough water is available, include sprays to wet surrounding fuels as well



# Design process



2. Identify building vulnerabilities

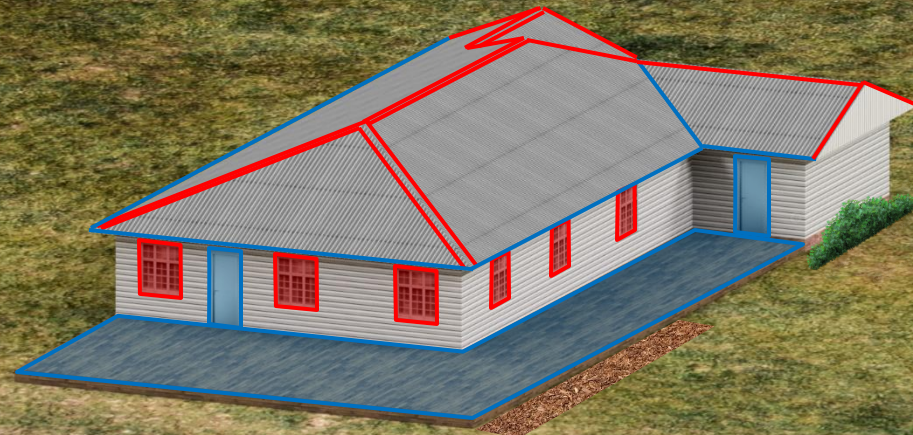
3. Identify which vulnerabilities can be protected by sprinklers

**How do sprinklers protect buildings?**

4. Calculate required water delivery rates and duration

5. Select sprinkler type, supply pressure, location, spacing

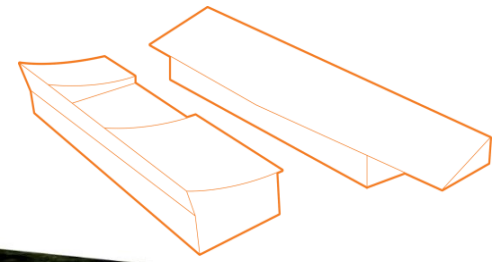
1. Assess the hazard



6. Design water supply system

7. Ongoing maintenance

# Design process



2. Identify building vulnerabilities

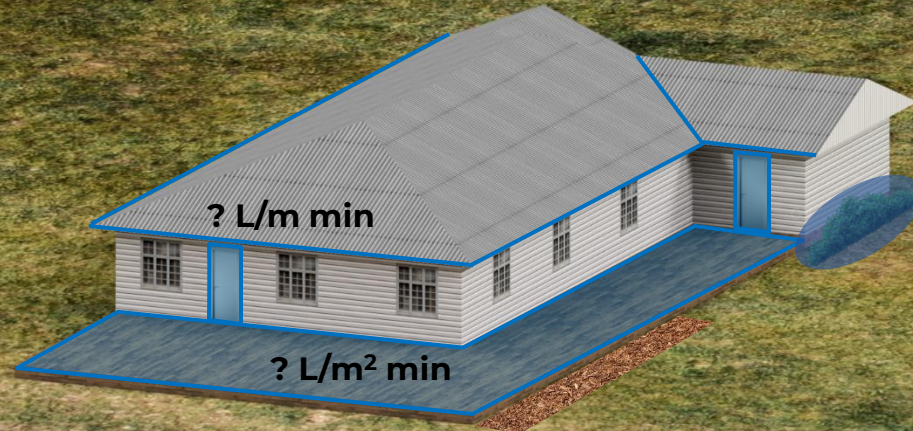
3. Identify which vulnerabilities can be protected by sprinklers

4. Calculate required water delivery rates and duration

**How much water is needed?**

5. Select sprinkler type, supply pressure, location, spacing

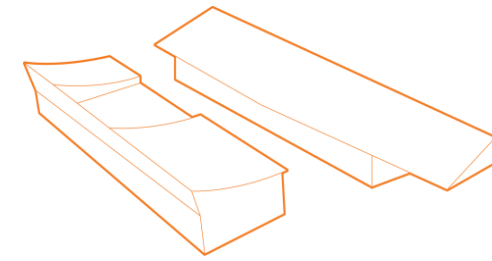
1. Assess the hazard



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# Minimum water application rates



Standard or guideline	Radiant heat; max kW m <sup>-2</sup> applicable	Water delivered to surface, or supplied to sprinklers <sup>C</sup>	Water flow rate per unit wall area (L min <sup>-1</sup> m <sup>-2</sup> )		
			Unscreened glazing	Combustible wall	Non-combustible wall
AS 5414	19	Delivered	10	5	5
AS 2118.2 <sup>A</sup>	40	Supplied	6.5	6.5	5
FM Global <sup>B</sup>	40	Supplied	NA	5.5–9.3	4.4–5.9

<sup>A</sup> Note that AS 2118.2 was not developed for bushfire protection.

<sup>B</sup> Values specified for 30–40 kW/m<sup>2</sup> radiant heat exposure over the range of vertical sprinkler spacings listed in the FM Global datasheet.

<sup>C</sup> Recent testing by the SBRC found sprinkler-to-surface delivery efficiencies of between 10% and 46% (with no wind).

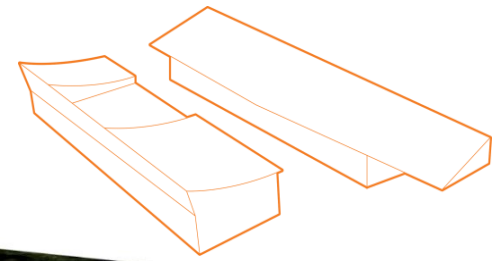
- When comparing like-for-like, AS 5414 requires 4-5 times more water
- AS 5414 is currently being revised
- Systems providing ember protection only may require significantly less water than any of these standards (e.g. 0.5 L min<sup>-1</sup> m<sup>-2</sup>)

Adapted from: Green A, Cooper P, 2022. Bushfire Sprinkler Systems for Increasing Bushfire Resilience of New and Existing Residential Buildings – Phase 1 Final Report. A report for Forest Wood & Products Australia Ltd.

Sources:

- AS 5414:2012 – Bushfire water spray systems
- AS 2118.2:2021 – Automatic fire sprinkler systems - Part 2: Wall wetting sprinkler systems
- Factory Mutual Insurance Company, FM Global Property Loss Prevention Data Sheets 9-19: Wildland Fire, 2022.  
<https://www.fm.com/resources/fm-data-sheets>

# Design process



2. Identify building vulnerabilities

3. Identify which vulnerabilities can be protected by sprinklers

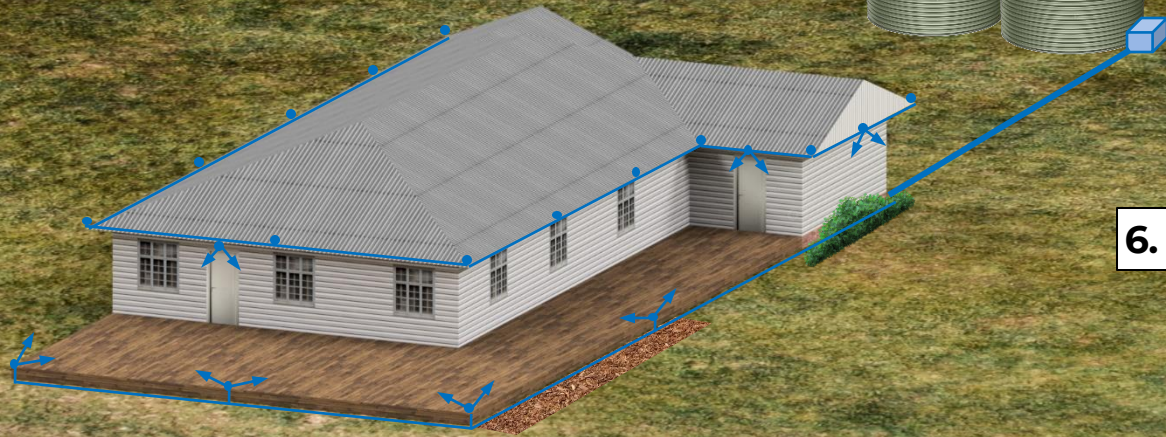
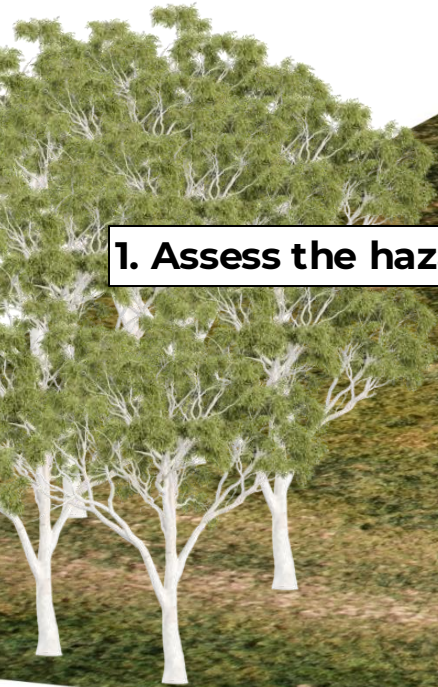
4. Calculate required water delivery rates and duration

5. Select sprinkler type, supply pressure, location, spacing  
**How to minimise wind effects?**

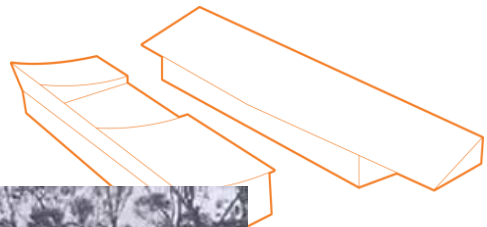
1. Assess the hazard

6. Design water supply system

7. Ongoing maintenance



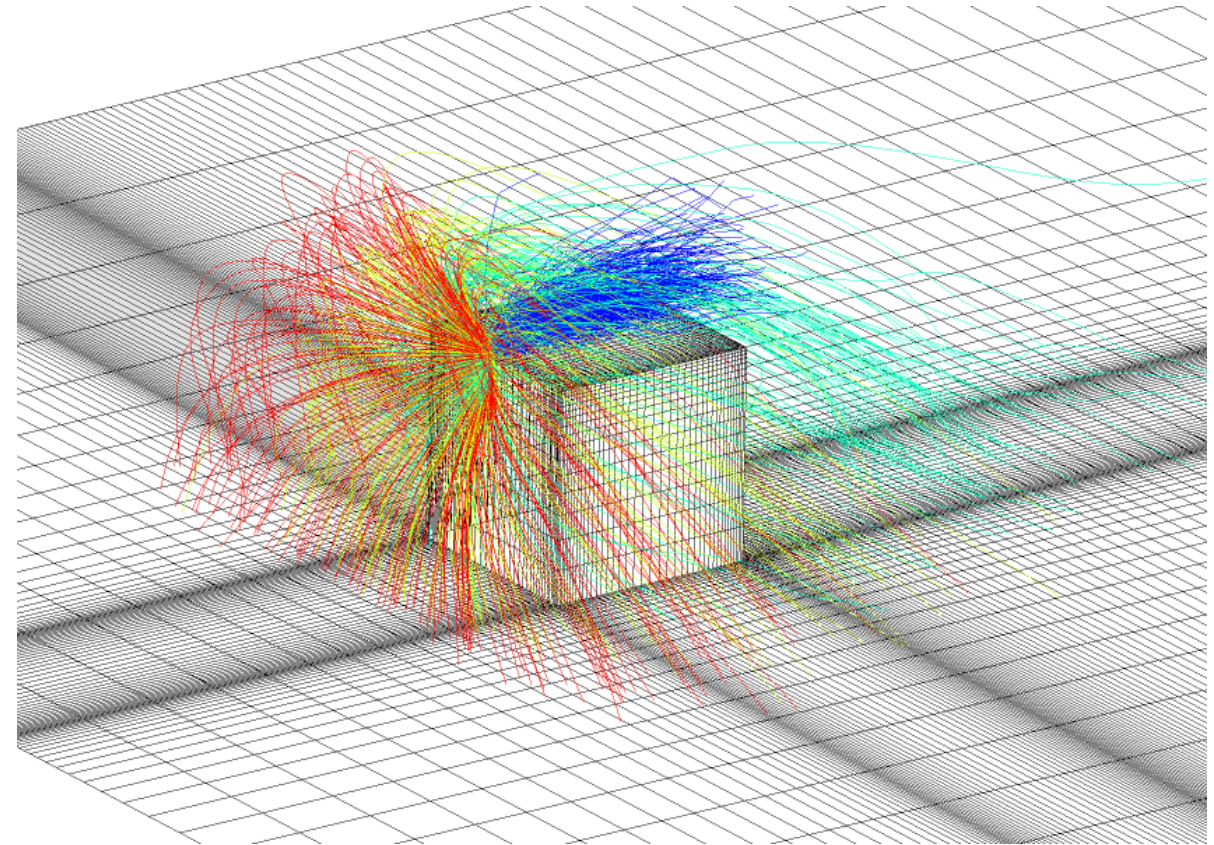
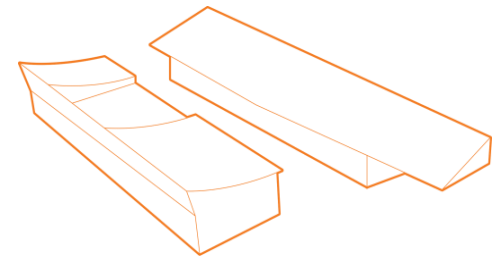
# Wind effects



Wind

Impact sprinkler

# Wind effects: Computational fluid dynamics

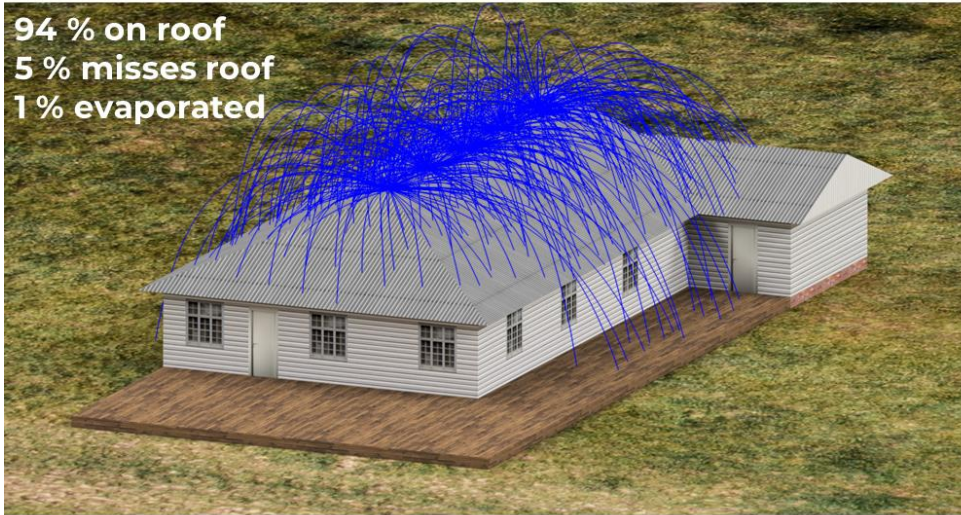


Green, A., 2019. Sprinkler Systems for the Protection of Buildings from Wildfire, Doctoral Thesis, University of Wollongong. <https://ro.uow.edu.au/theses1/617/>

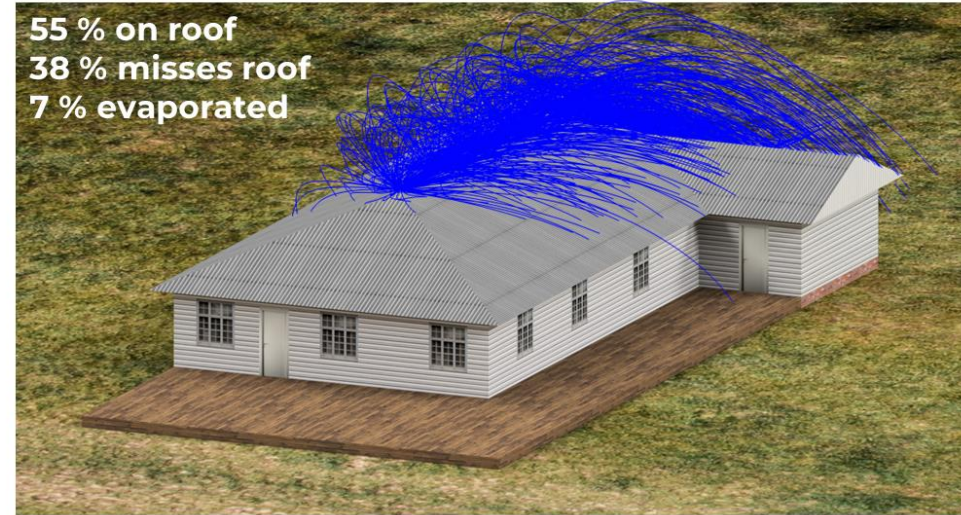
Green, A., Cooper, P., Montazeri, H., 2021. Experimental Study of Water Spray Dispersion Around a Surface-Mounted Cube in Atmospheric Boundary Layer Flow. International Journal of Multiphase Flow. <https://doi.org/10.1016/j.ijmultiphaseflow.2021.103721>

# Wind effects: Butterfly sprinklers on roof

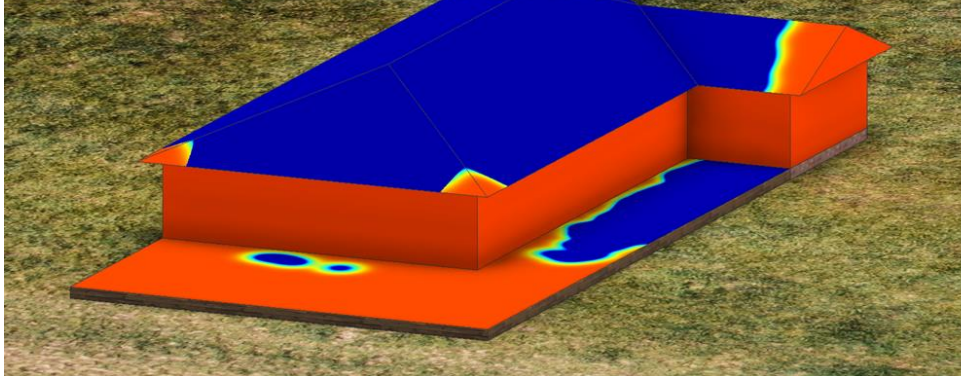
### Calm conditions



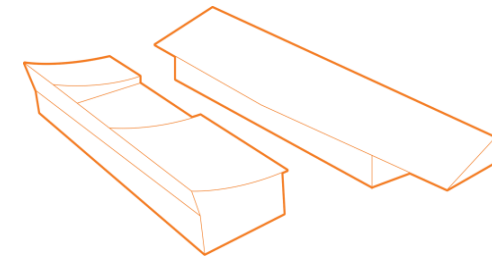
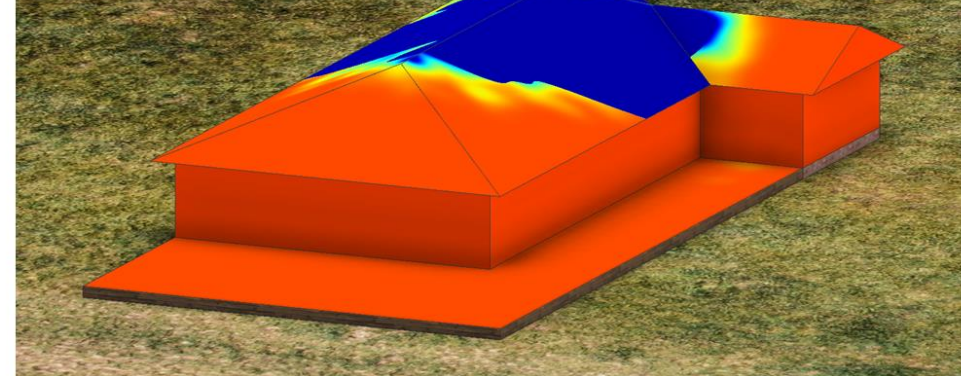
### During a bushfire



### In calm conditions coverage of roof appears good

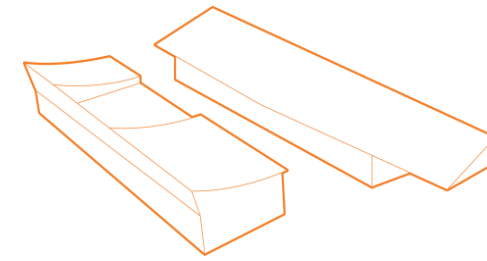


### During bushfire water cools roof with 26 % efficiency



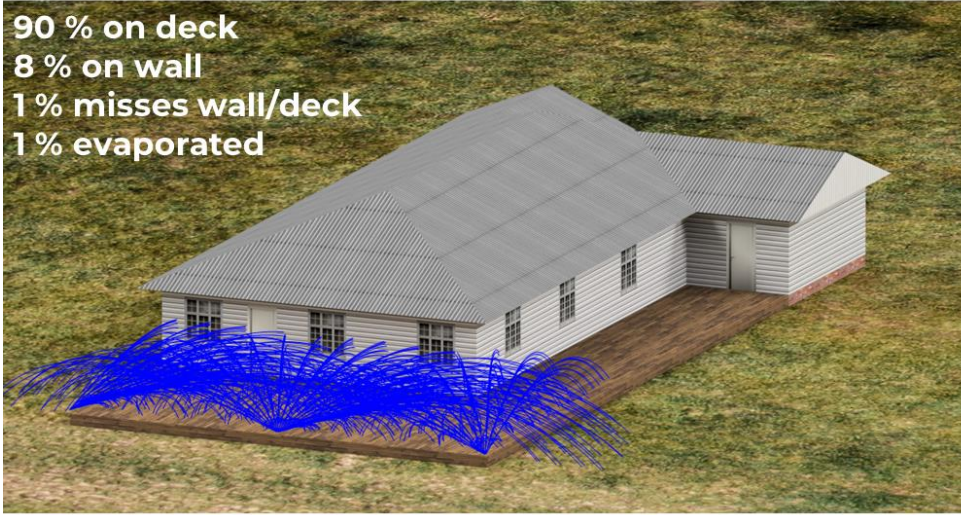
34 L/min per sprinkler  
× 5 sprinklers  
= 170 L/min

# Wind effects: Impact sprinklers mounted at edge of deck



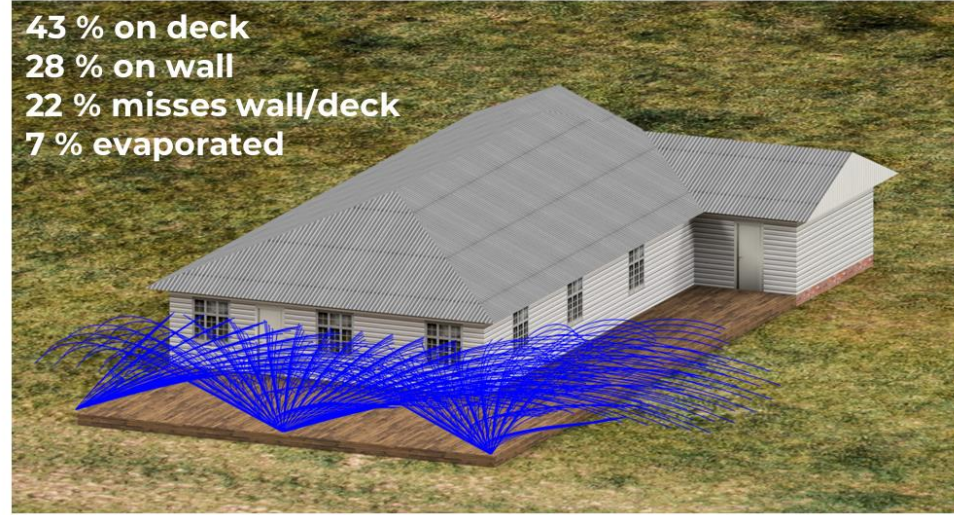
### Calm conditions

90 % on deck  
8 % on wall  
1 % misses wall/deck  
1 % evaporated

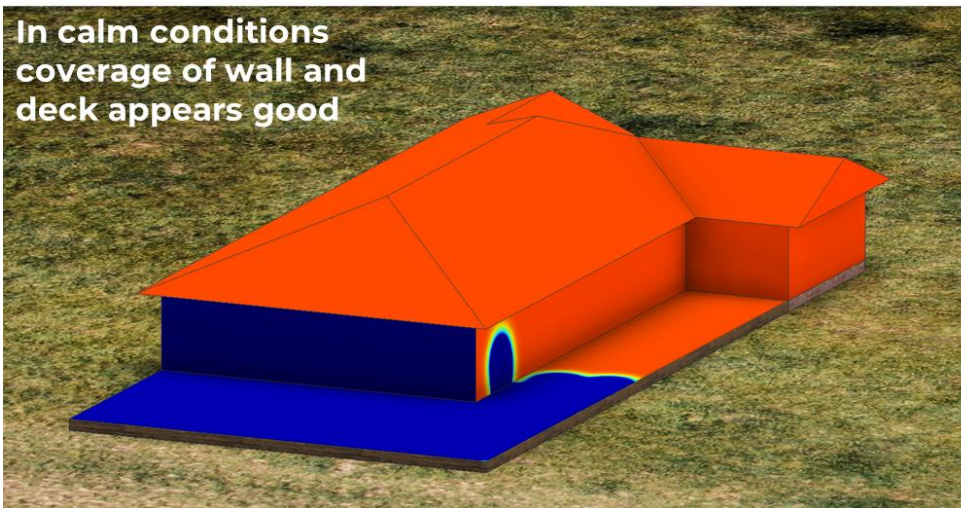


### During a bushfire

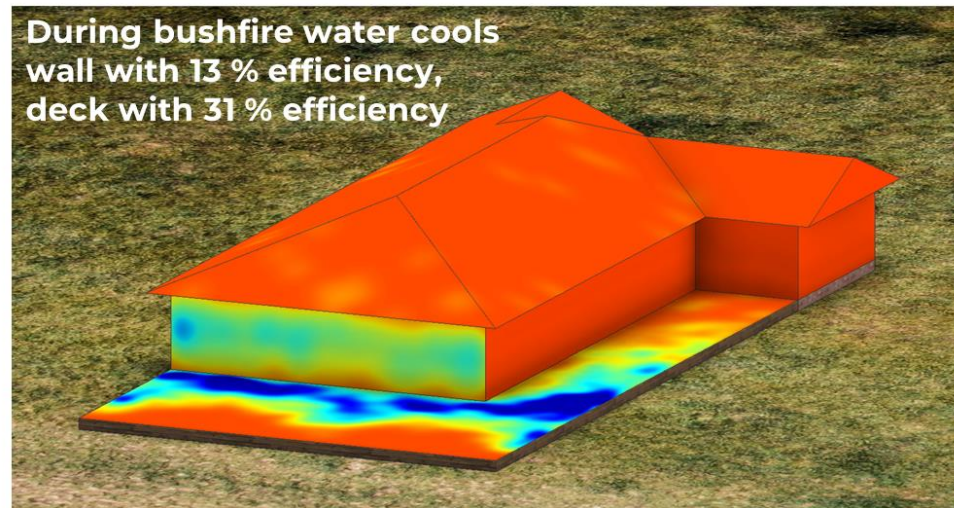
43 % on deck  
28 % on wall  
22 % misses wall/deck  
7 % evaporated



In calm conditions  
coverage of wall and  
deck appears good

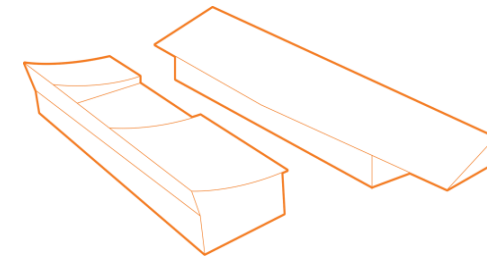


During bushfire water cools  
wall with 13 % efficiency,  
deck with 31 % efficiency



17 L/min per sprinkler  
× 3 sprinklers  
= 51 L/min

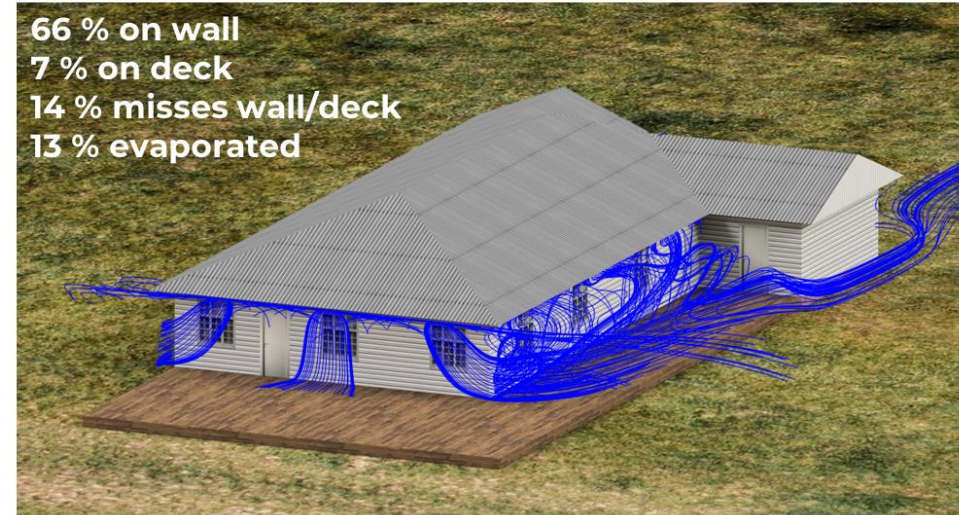
# Wind effects: Flat fan sprinklers mounted under eaves



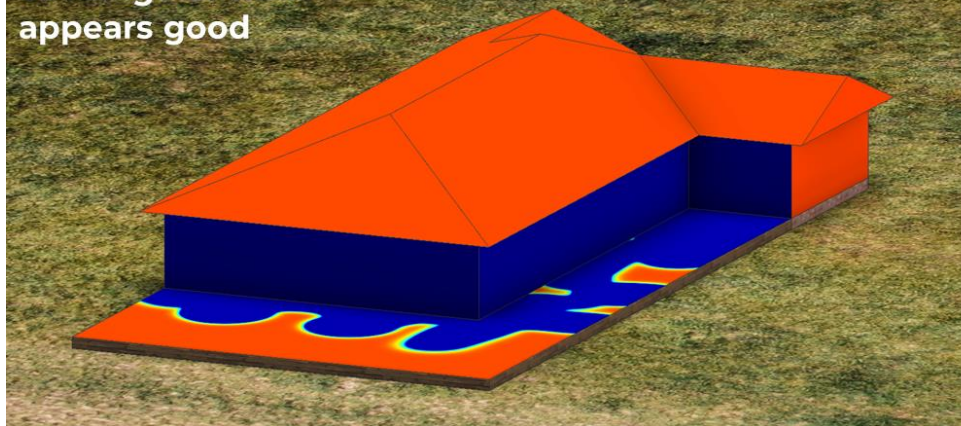
**Calm conditions**



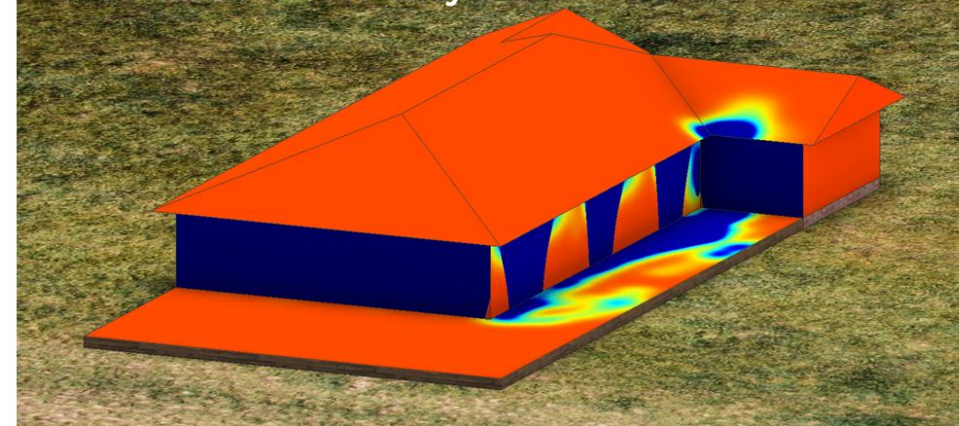
**During a bushfire**



**In calm conditions coverage of walls appears good**

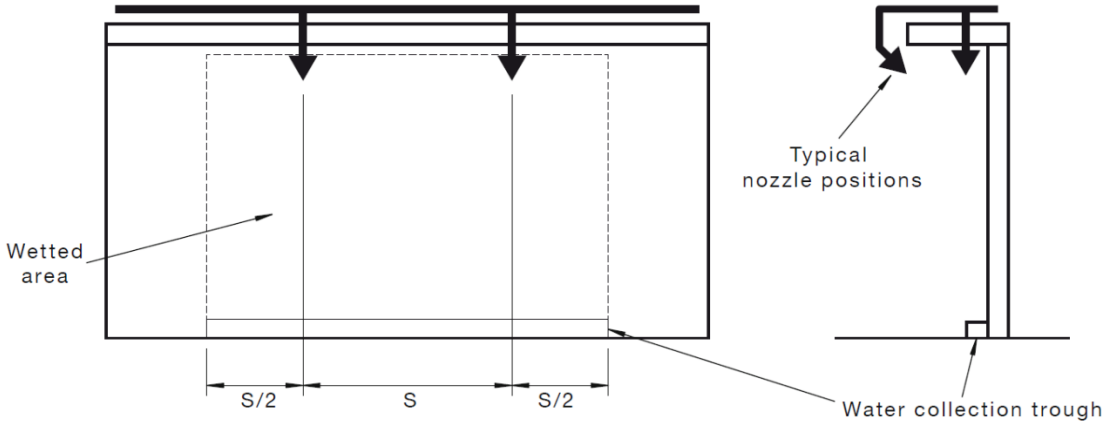
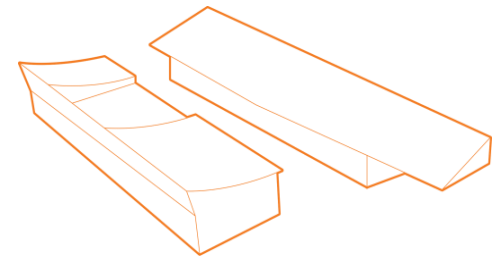


**During bushfire water cools walls with 36 % efficiency**

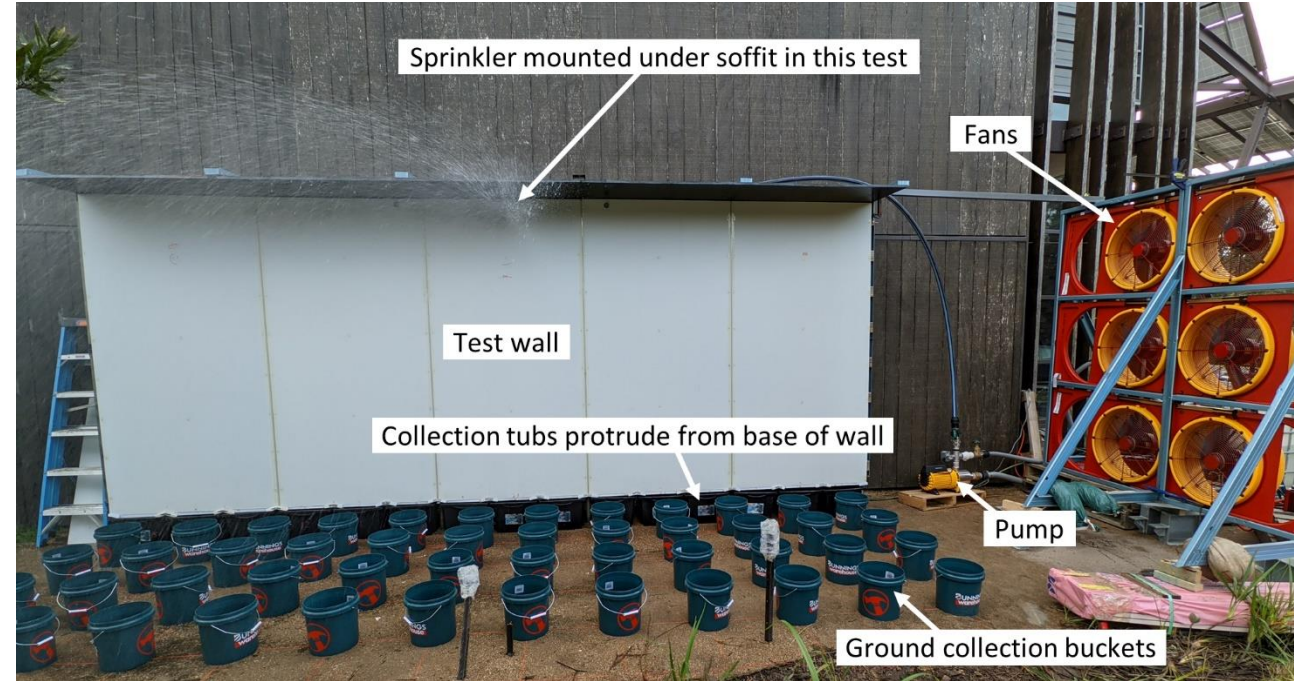
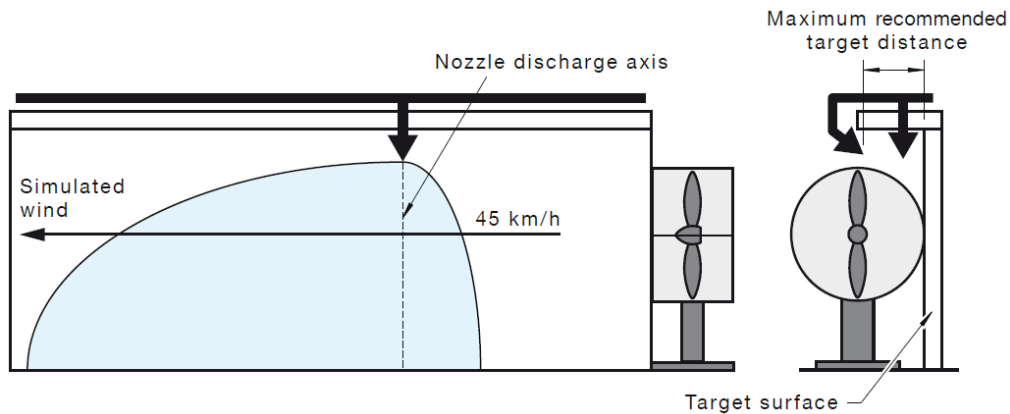


40 L/min per sprinkler  
× 6 sprinklers  
= 240 L/min

# AS 5414 water delivery tests



S = Manufacturer's maximum nozzle spacing

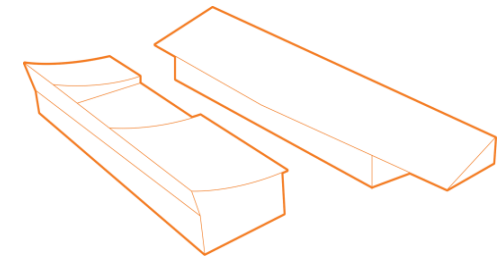


AS 5414—2012 Bushfire water spray systems

Green A, Cooper P, Tibbs M, Beltrame S, 2023. Development of a Facility to Test the Water Delivery Effectiveness of Bushfire Sprinkler Systems. A report for Forest Wood & Products Australia Ltd.

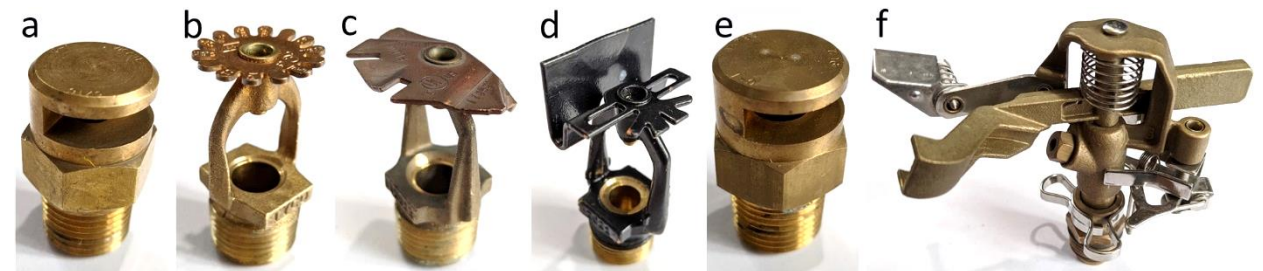
Green A, Cooper P, Tibbs M, Liu J, Beltrame S, 2024. Bushfire Sprinkler Spray Deposition and Wind Drift Tests – Final Report. A report for Forest Wood & Products Australia Ltd.

# AS 5414 water delivery tests

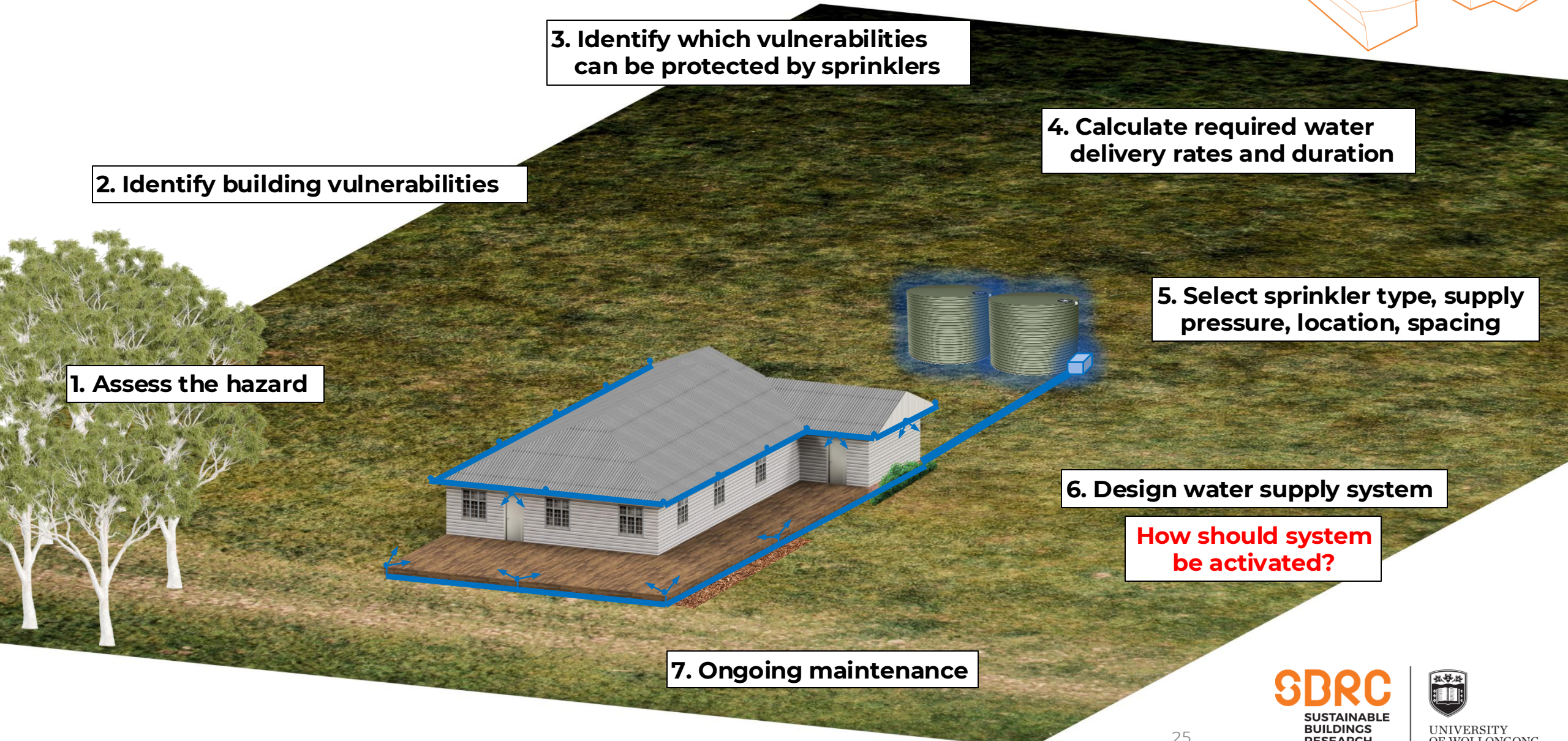
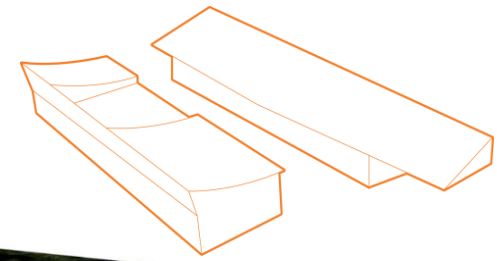


## General findings:

- Water delivery efficiency of only 9–46 %
- Spraying water over a short distance minimises wind effects
- Different sprinkler types can perform different roles
- Specification of the test method in AS 5414 can be improved



# Design process



2. Identify building vulnerabilities

3. Identify which vulnerabilities can be protected by sprinklers

4. Calculate required water delivery rates and duration

5. Select sprinkler type, supply pressure, location, spacing

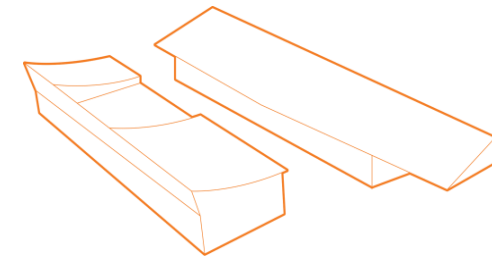
1. Assess the hazard

6. Design water supply system

How should system be activated?

7. Ongoing maintenance

# System activation



## Manual activation on site

- Simple, reliable hardware but residents aren't always home to activate system
- Signage to guide fire agencies on operation of system

## Remote manual activation

- Radio, SMS, and/or satellite internet communication with system
- Ideally with information from the site (e.g. security camera feeds)

## Automatic activation

- Conventional heat-activated fire sprinklers are not suitable
- Modified heat-activated sprinkler heads have been tested
- Heat or smoke sensors, camera-based systems also exist

Needs to fit into residents' Bushfire Survival Plan, including contingencies

The technologies exist, but their relative performance, reliability, etc. have not yet been compared in a systematic way

# Summary

- Not a 'silver bullet', but useful in some situations as part of a holistic approach
- A methodical design process is advisable
- AS 5414 update will improve the quality of design guidance
- New research will continue to improve design guidance over the next 5-10 years

