HAZARD NOTE

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HOW DO ROAD CHARACTERISTICS INFLUENCE FLOOD FATALITIES?

ABOUT THIS PROJECT

This research was conducted by the Bushfire and Natural Hazards CRC, Risk Frontiers and Macquarie University as part of the *An analysis of building losses and human fatalities from natural disasters* project.

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SUMMARY

Vehicle-related flood fatalities and rescues are a significant emergency management and road safety problem. This study investigated the influence of road characteristics on a motorist's decision to enter floodwaters, as well as the chance of the vehicle being washed from the road and the chance of survival of occupants in a vehicle that has entered the flooded area. The research proposes a new risk-based procedure for assessing flood-prone roads according to the road's characteristics, which can also be used to improve the future design of roads in flood-prone areas.

▲ **Above:** THIS RESEARCH INVESTIGATED THE INFLUENCE OF ROAD CHARACTERISTICS ON A MOTORIST'S DECISION TO ENTER FLOODWATER, AND THE EFFECT THIS HAS ON FATALITIES. PHOTO: NSW STATE EMERGENCY SERVICE.

CONTEXT

An analysis of flood-related deaths in Australia between 1960 and 2015 revealed that 49 per cent were related to vehicles (Haynes et al 2016). This rate highlights the significance of the need to better understand vehicle-related flood deaths. Most research to date has focused on the circumstances of flood fatalities, the type of flood hazard and the reasoning for why motorists enter floodwater. This study assesses the influence of road characteristics on flood fatalities.

BACKGROUND

The risk to motorists in respect to floodwaters depends not only on drivers' decisions and flood hazard, but also upon the characteristics of the location, which has been the focus of this study. In 2015, Austroads, a peak body for road management in Australia, stated that the vast majority of the approximate 20,000 floodways in Australia and New Zealand were not constructed in accordance with required design and hydraulic standards, lack appropriate signage and that depth gauges where present were liable to misinterpretation by motorists (Austroads 2015).

This research, conducted in 2017, was able to identify road characteristics that are clearly more dangerous than others.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The characteristics of 21 sites across New South Wales, Queensland, Western Australia, Victoria and the Australian Capital Territory were analysed based on the quality of

information available and ease of access to the site. These sites accounted for 28 deaths, representing approximately 50 per cent of total vehicle-related flood fatalities between 2010 and 2017. Specific details regarding the number of fatalities and associated circumstances were obtained from media outlets, emergency service media releases and publicly available coronial records.

For each site, observational assessments were made about the road characteristics. Descriptions of each of these elements is provided in Table 1 (page 3).

RESEARCH FINDINGS

Characteristics most frequently identified at these dangerous sites were:

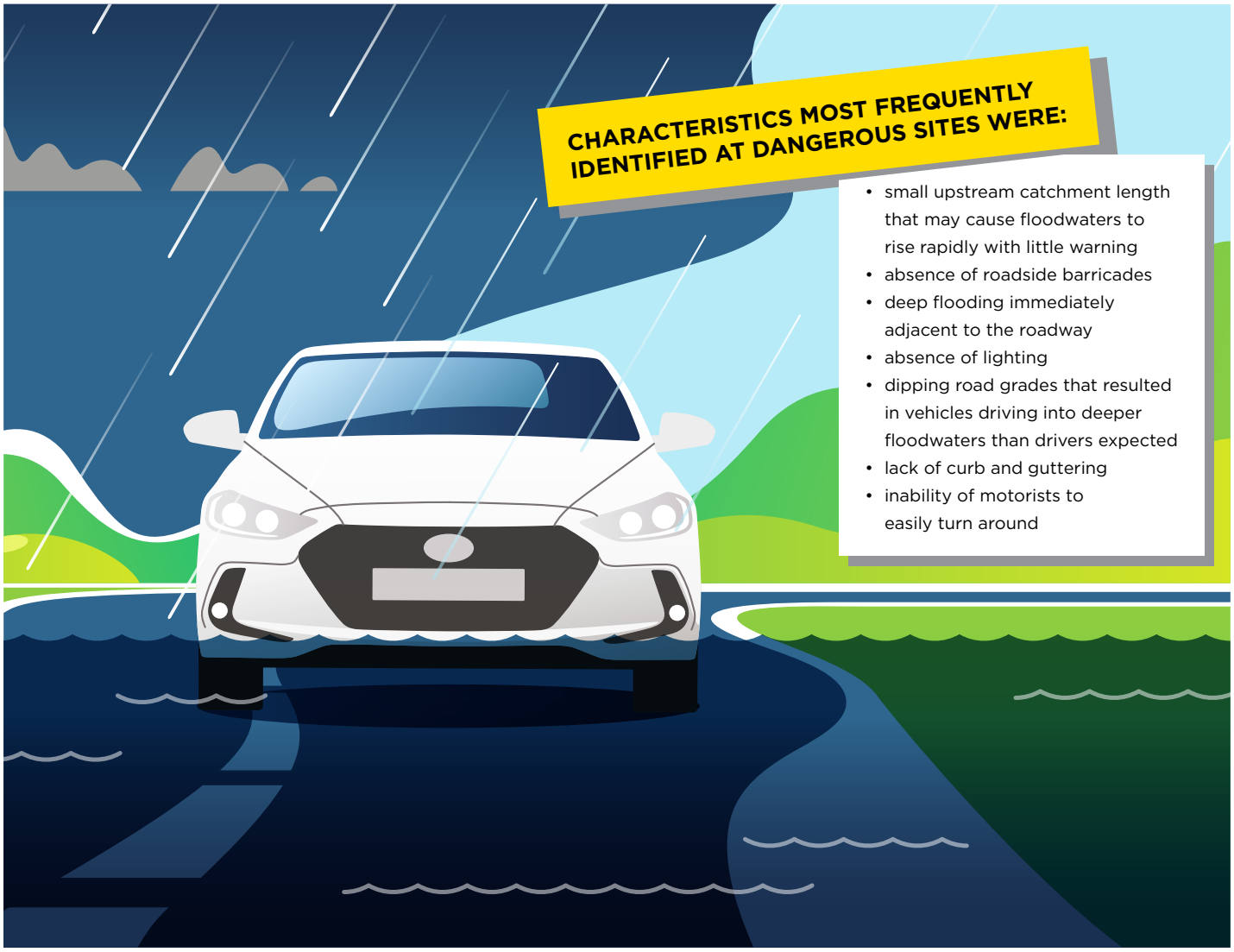
- small upstream catchment length that may cause floodwaters to rise rapidly with little warning
- the absence of roadside barricades
- deep flooding immediately adjacent to the roadway
- the absence of lighting
- dipping road grades that resulted in vehicles driving into deeper floodwaters than drivers expected
- the lack of curb and guttering
- the inability of motorists to easily turn around.

Each of these factors were observed in at least 50 per cent of the cases studied. These results demonstrate that some roadways are clearly more dangerous than others. However, emergency planning or floodplain risk management approaches tend to focus on urban flood risk and do not assess risks related to motorists entering floodwater. The large number of flood-prone roads in various areas means that it will be necessary to prioritise those locations that most require safety improvements. This should be done on a risk-informed basis.

Road flood risk factors can be categorised into those that influence a motorist's decision to enter floodwaters; factors that influence whether a vehicle might be washed or driven from the road; and those that influence survivability of occupants once a vehicle is in floodwaters. These factors are listed and described in Table 2 (page four).

HOW COULD THIS RESEARCH BE USED?

There is currently no standard practice for assessing risk of flood-prone roads. Given the large number of road sections that may not have been constructed to safe design and hydraulic standards, it is important that road operators assess and prioritise potentially vulnerable locations based on their relative risk. This study provides the basis for a risk-based assessment procedure. The results can also be utilised to improve the future design of roads in flood-prone areas. Ultimately, policy that considers road characteristics in flood-prone areas, in addition to other interventions such as education, law enforcement and emergency response, has the potential to reduce the number of vehicle-related flood deaths.



FUTURE DIRECTIONS

Through the Bushfire and Natural Hazards CRC, this research work has been extended to look at road characteristics present at sites where flood rescues have occurred. This research should be repeated further over time to contribute further to the evidence base.

FURTHER READING

Austroads (2015) Safety provisions for floodways over roads, available from https://austroads.com.au/publications/road-design/ap-r481-15.

Haynes K, Coates L, Dimer de Oliveira F, Gissing A, Bird D, van den Honert R, Radford D, D'Arcy R, Smith C (2016) An analysis of human fatalities from floods in Australia 1900-2015, Bushfire and Natural Hazards CRC, www.bnhcrc.com.au/publications/biblio/bnh-2735

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Gissing A, Opper S, Tofa M, Coates L & McAneney J (2019) Influence of road characteristics on flood fatalities in Australia, *Environmental Hazards*, 18, pp.1–12, open access, doi: 10.1080/17477891.2019.1609407.

END-USER STATEMENT

"In 2018, the NSW SES conducted an applied research project called Project U-Turn, which aimed to develop strategies in collaboration with local communities to improve motorist safety during floods. Outcomes of this research [in this *Hazard Note*] were beneficial in identifying high risk sites in NSW related to motorists entering floodwater. The research highlighted a range of location-based issues associated with motorist behaviour, allowing the NSW SES leverage in identifying local engagement opportunities that targeted behaviour from a collaborative solutions process, specific to that community context."

David Webber, Coordinator Community Capability, Metro Operations, NSW State Emergency Service

TABLE 1: CHARACTERISTICS OF ROADS THAT MAY INFLUENCE BEHAVIOUR IN FLOODWATERS

CHARACTERISTIC	DESCRIPTION
Road structure type	Road structure present at point of entry, for example bridge, floodway or roadway
Location	Whether the road was in an urban, rural or peri-urban environment
Roadside barriers	Presence of roadside barriers, for example w-beams and wire rope
Downstream depths adjacent to roadway	Height of road pavement above adjacent floodplain or river channel, indicative of the depth of floodwater at the flooded road section
Signage	Presence of flood-related signage, for example road subject to flooding, floodway, causeway and depth markers
Warning systems	Dynamic systems to alert motorists to a flooded road section for example fixed flashing light
Street lighting	Presence of fixed street lighting to illuminate flooded road section
Road pavement type	Road pavement type sealed or unsealed
Road grade	A measure of the incline of the roadway leading into the flooded road section
Speed	Speed restriction in force at flooded road section
Traffic volume	Qualitative estimation of traffic volume at time of assessment
Presence of downstream vegetation or obstacle	Presence of vegetation or obstacle on a floodplain or in a channel downstream of flooded road section that may block the passage of a floating vehicle
Ability for vehicle to turn around	Qualitative judgement of the ability for a driver to easily turn around in a sedan
Road alignment	Presence of a road bend directly before flooded section
Roadside markers	Presence of roadside marker to identify the edge of a flooded road section
Curb and guttering	Presence of roadside curb and guttering

TABLE 2: DESCRIPTIONS OF ROAD FLOOD RISK FACTORS ACCORDING TO THEIR INFLUENCE

FACTOR	DESCRIPTION
Factors that may influence a motorist to enter floodwater	
Absence of signage	Signage is aimed at informing motorists of the likely presence of water over a roadway
Road alignment	A tight bend in a roadway directly before a floodway may limit chances for a motorist to act in order to avoid entering floodwater
Road grade	The falling grade of a road may mean a motorist entering shallow water quickly progresses into much deeper water or that floodwater may be difficult to observe on approach. Such conditions may give a driver a false impression of the degree of flood risk
Road pavement	Gravel road surfaces are easier for a car to slide off the road
Lighting	Lighting of a roadway allows motorists to observe floodwater during evening hours
Traffic volume	Traffic volume controls the number of motorists at risk to entering floodwater whist travelling a specific road section. Large volumes of traffic may also hinder the ability of a motorist to turn a vehicle around
Speed limit	Speed limit may influence the speed a motorist was travelling whilst observing signage and the time for reflection prior to entering floodwaters. It will also influence the ability of a vehicle to safely stop before reaching floodwater
Ease of turning around	The width and lane structure of a road (i.e. one way or two way) influences the ability of a motorist to turn a vehicle around
Factors that influenced whether a vehicle was washed or driven from road	
Depth and velocity of floodwaters	Greater depth and flow velocities of floodwaters increase the likelihood of a vehicle being washed from a road
Rate of rise (catchment size)	Fast rates of rise are associated with smaller catchment sizes, dynamic flood conditions and short warning times
Presence of roadside barriers	Roadside barricades provide protection against a motorist leaving a roadway
Curb and guttering	Curb and guttering provide some degree of protection against a motorist leaving a roadway
Distance water was over the road	Water covering a long distance of a roadway may result in motorists becoming disorientated
Type of vehicle	Smaller vehicles are at greater risk of being washed from roadways
Factors that may influence survivability of motorists once washed or driven from the road	
Rate of rise (catchment size)	Fast rising floodwaters may limit the ability of a vehicle occupants to escape
Flood depths downstream	Vehicles will sink in deep floodwaters
Downstream flood velocities	Fast flowing floodwaters may rapidly sweep a vehicle downstream

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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