Flood Resilient Infrastructure – A Design Framework

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A Guide to Best Practice in Flood Risk Management in Australia' (Australian Institute for Disaster Resilience 2017, page 86) states:

"Infrastructure providers need to consider design standards that enable continuity of use or ready re-establishment of services after a flood, as appropriate. These standards may involve reducing the likelihood of infrastructure flooding or the vulnerability of the infrastructure to the impacts of flooding when it occurs, and using readily available components to re-establish services easily after a flood. "

However, there is no clear guidance as to what are appropriate flood design standards for various types of infrastructure.

Through the use of case studies in Australia and overseas, this paper:

- gives examples of actual and potential catastrophic failure of infrastructure which is avoidable
- explains how the direct, indirect and intangible costs of infrastructure damage can be estimated and taken into account in floodplain risk management and infrastructure design
- shows why the interdependencies between infrastructure types must not be overlooked
- proposes a framework for developing flood design standards for critical infrastructure based on type, function, scale and redundancy.

He went on to explain the concept of risk-based design saying that like any design method it is important that it results in plant that is fit for purpose. He also pointed out that Sydney Water is always under the community's microscope and the way it operates its assets before, during and after a flood will need to meet community expectations. In particular it will be important that Sydney Water understands what the community may expect in terms of level of service because the starting point for risk based design is determining what is an acceptable level of service and then working out what can be done to achieve that in light of the risks to the assets.

Undertaking a risk assessment involves identifying hazards and their consequences then understanding the probabilities of those hazards occurring. This applies to floods as well as other natural and human induced hazards. He reinforced that the workshop would only be looking at flood hazards.

He then explained that the identified risks could be managed by:

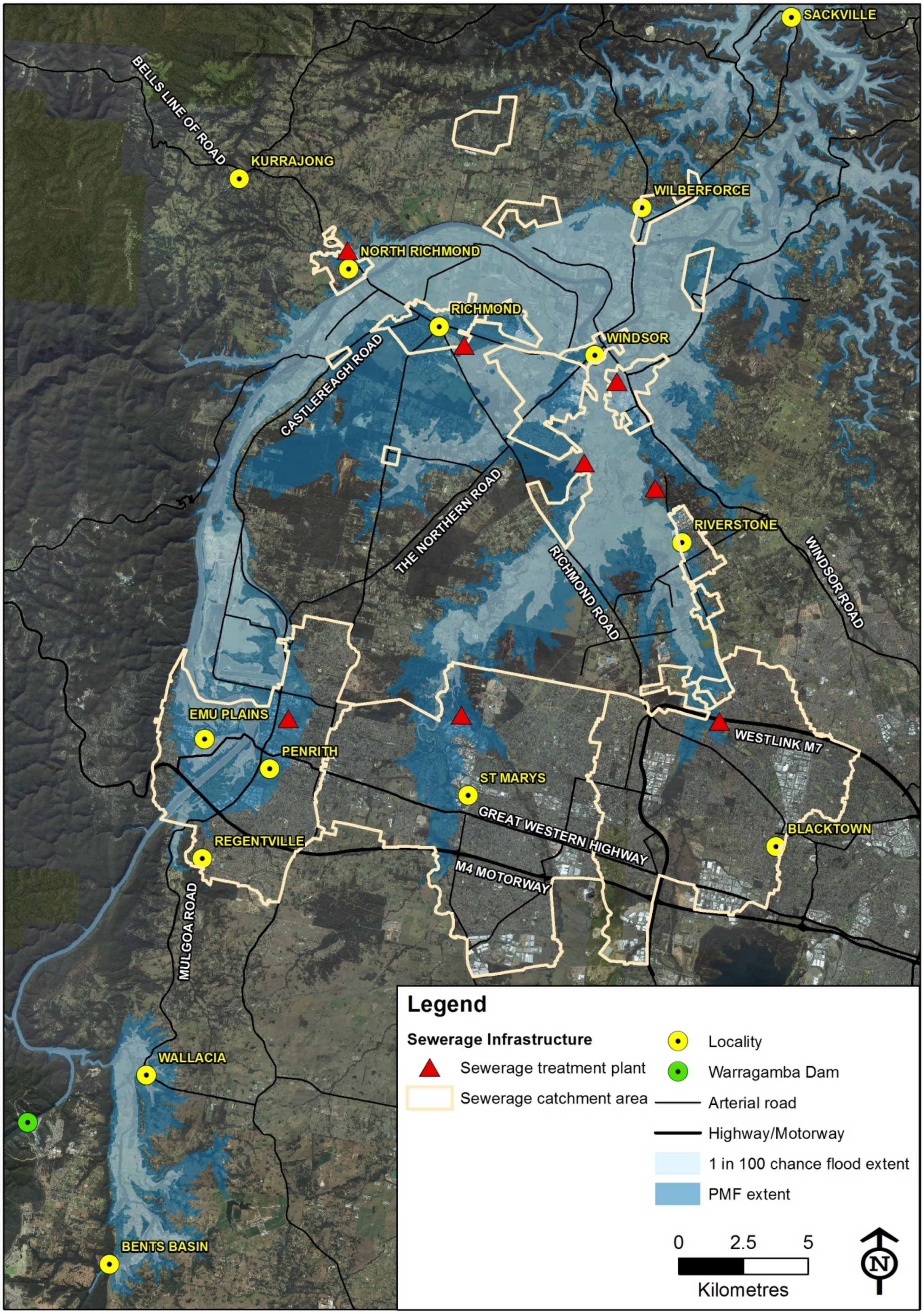
- A design which reduces the risk, such as placing assets in a location of lower hazard or designing them to withstand effects of the hazard; and/or

- A strategy that deals with the residual risk by having appropriate means of response and recovery during and after a flood.

The cost of risk management must be compared with the costs of not managing the risks and the latter must be considered both in terms of:

- Average annual damages – how much will flood damage cost on average over the life of the plant; and

- Realised costs – how much would the flood damage from the worst single event cost



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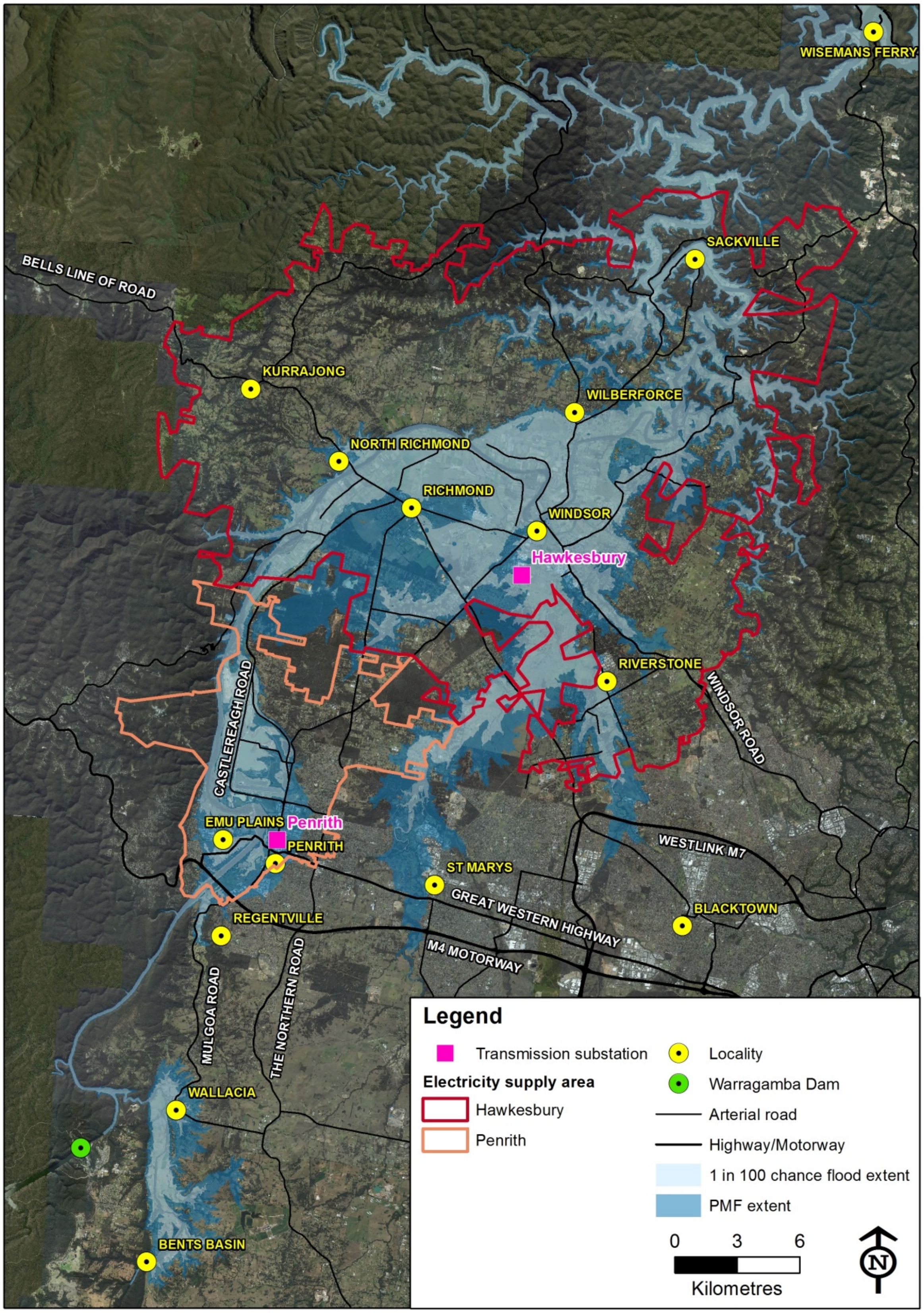
WILBERFORCE
NORTH RICHMOND
RICHMOND
WINDSOR
CASTLEREAGH ROAD
THE NORTHERN ROAD
RIVERSTONE
RICHMOND ROAD
WINDSOR ROAD
EMU PLAINS
PENRITH
WESTLINK M7
ST MARYS
GREAT WESTERN HIGHWAY
BLACKTOWN
REGENTVILLE
M4 MOTORWAY
MULGOA ROAD
WALLACIA
BENTS BASIN
Legend
Sewerage Infrastructure
Sewerage treatment plant
Sewerage catchment area
Locality
Warragamba Dam
Arterial road
Highway/Motorway
1 in 100 chance flood extent
PMF extent
0 2.5 5
Kilometres
N



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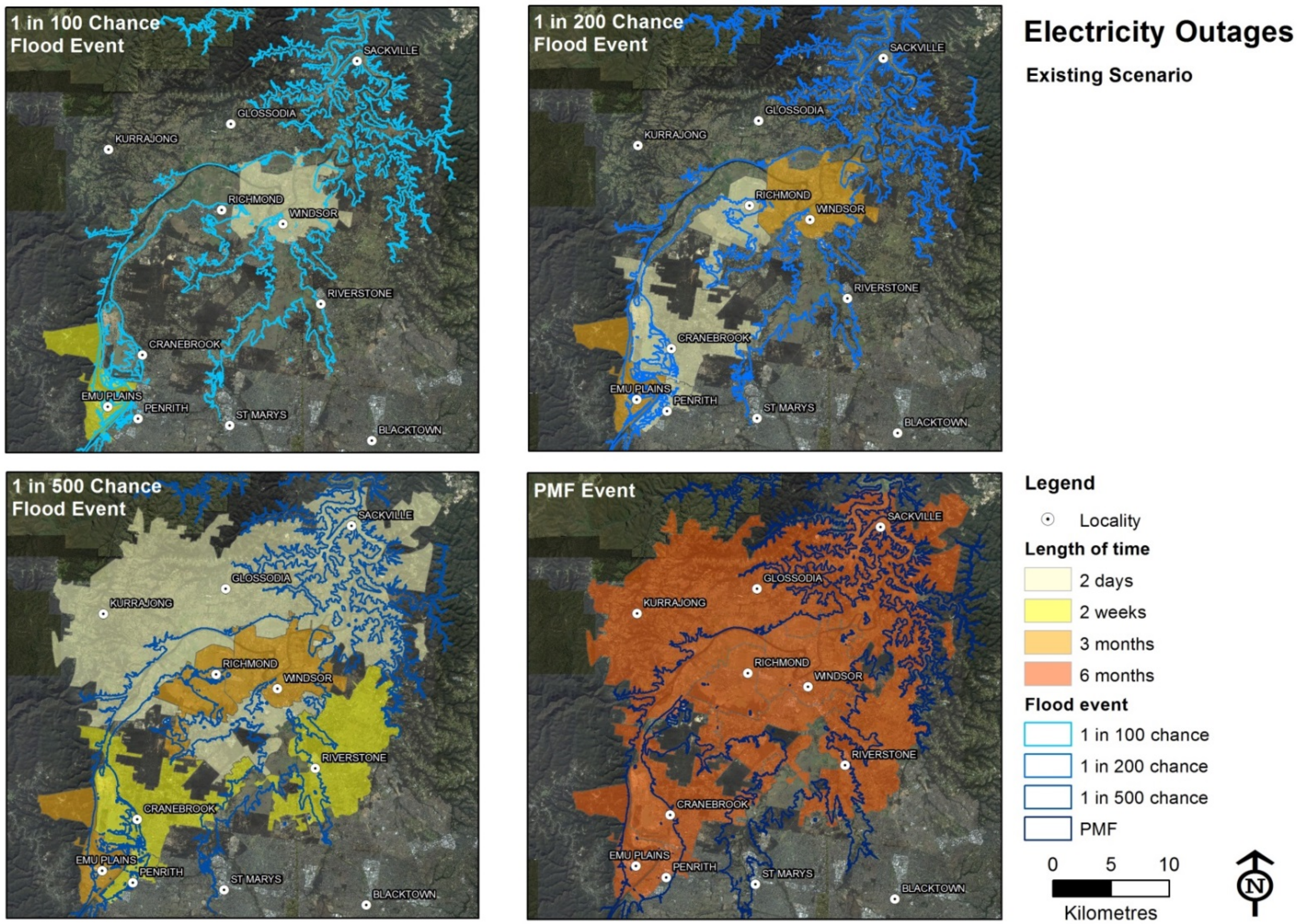
RIVERSTONE
WINDSOR ROAD
CASTLEREAGH ROAD
EMU PLAINS
Penrith
PENRITH
WESTLINK M7
ST MARYS
GREAT WESTERN HIGHWAY
BLACKTOWN
REGENTVILLE
M4 MOTORWAY
MULGOA ROAD
THE NORTHERN ROAD
WALLACIA
BENTS BASIN
Legend
Transmission substation
Locality
Warragamba Dam
Electricity supply area
Hawkesbury
Penrith
Arterial road
Highway/Motorway
1 in 100 chance flood extent
PMF extent
0 3 6
Kilometres
N

https://www.statedevelopment.qld.gov.au/resources/guideline/qra/planning-resilient-electrical-infrastructure.pdf


Electricity Outages
Existing Scenario
1 in 100 Chance Flood Event
1 in 200 Chance Flood Event
1 in 500 Chance Flood Event
PMF Event
SACKVILLE
GLOSSODIA
KURRAJONG
RICHMOND
WINDSOR
RIVERSTONE
CRANEBROOK
EMU PLAINS
PENRITH
ST MARYS
BLACKTOWN
Legend
Locality
Length of time
2 days
2 weeks
3 months
6 months
Flood event
1 in 100 chance
1 in 200 chance
1 in 500 chance
PMF
0
5
10
Kilometres
N

A Flood Risk Assessment Approach

The basic approach was to develop a set of risk tables which show what combinations of hazard and probability are acceptable, tolerable and unacceptable. The following is a generalised table in which “acceptable risk”, “tolerable risk” and “unacceptable risk”, have the following definitions:

Acceptable risk – individuals and society can live with this risk without feeling the necessity to reduce the risks any further. This is coloured green in the table

Tolerable risk - –society can live with this risk but believe that as much as is reasonably practical should be done to reduce the risks further. Note that individuals may find this risk unacceptable and choose to take their own steps, within reason, to make this risk tolerable. This is coloured yellow.

Unacceptable risk – individuals and society will not accept this risk and measures must be put in place to bring them down to at least a tolerable level. This is coloured red.

	Low Hazard	Medium Hazard	High Hazard
Low Probability			
Medium Probability			
High Probability			

Direct

Indirect

- Detours – road and rail or undelivered
- Un supplied electricity – value per KwH – must be worth more than what people pay for it.
- Untreated sewage

RULE of Thumb v BCA

he cost of outages to utility customers is not always adequately included in utility planning, according to experts at calculating those costs.

But Pacific Gas and Electric (PG&E) and Southern Company, two very different types of investor owned utilities, are among the most advanced at including the cost into their planning. That raises a very interesting question about the way utilities spend money.

“Utilities usually plan to certain minimum requirements or only consider their own costs and benefits,” according to Nexant Utility Services Managing Consultant Josh Schellenberg, co-author of the just-released report, "Updated Value of Service Reliability Estimates for Electric Utility Customers" from Lawrence Berkeley National Laboratory (LBNL).

"By providing a meta-analysis to understand the customer benefits associated with various types of reliability interruptions," Schellenberg said, "this report helps address one of the barriers to utilities incorporating the customer perspective."

Incorporating customer interruption costs into planning, which is known as "value-based reliability planning," leads to a much better assessment of the societal costs and benefits, Schellenberg said.

Often the utility is comparing multiple investments, he added. If it looks only at utility costs and benefits and doesn't incorporate the customer perspective, it could make the wrong decision because "the customer may benefit greatly from one investment and not much from another investment."

Credit: LBNL's "Updated Value of Service Reliability Estimates"

Who gets the costs and benefits?

Utility benefits from reliability investments include operations and maintenance savings and lower restoration of service costs. Though the utility incurs costs for reliability investments, those costs are generally recovered from ratepayers in time.

“Power interruptions can be incredibly costly to customers, especially to commercial-industrial customers,” Schellenberg said. “Ignoring the potential benefits to customers in the cost-benefit assessment of reliability investments can undervalue them.”

The LBNL survey provides three key metrics for planners:

- the cost for an individual interruption for a typical customer
- the cost per average kilowatt (kW)
- the cost per unserved kilowatt-hour (kWh), which is the expected amount of unserved kWhs for each interruption and is relatively high for a momentary interruption because the unserved kWhs in a 5-minute period is relatively low.

The national average price of residential electricity for 2014 was $0.1246 per kWh, according to the U.S. Energy Information Administration. The average commercial electricity price was $0.1071 per kWh and the average industrial price was $0.0703 per kWh.

The values derived from the survey, soon to be publicly acessible through the Department of Energy ICE Calculator, show customers value their electricity at “orders of magnitude larger than what they pay for the electricity,” Schellenberg said. "That shows interruptions can be highly costly to customers and utilities should incorporate those costs into planning.”

The electricity not provided that a medium to large commercial and industrial (C&I) customer otherwise would have consumed, the survey shows, is valued at $21.80 per kWh. For the small C&I customer, the value for a one hour outage is $295 per kWh. For the residential customer, it is $3.30 per kWh.

https://www.utilitydive.com/news/what-electric-reliability-is-actually-worth-and-what-it-means-for-utilities/367506/

Infrastructure Type	Within infrastructure categorisation						
Water Supply	Local water supply network	Trunk mains	Reservoirs/Towers	Water Treatment Plant processing infrastructure	Water Treatment Plant throughput pumps and pipes and mains leading out of WTP		Source (e.g. Dam) and main trunk
Electricity	11 kV distribution system	33 kV power cables	33/11 kV substation	110 kV power cables	110/33 kV substation		275/110 kV substation & 275kV and higher voltage power cables
Telecommunications	Cables connecting mini exchanges	Mini exchanges	Other mobile phone towers cables connecting terminal exchanges and mobile phone towers to switching centres and each other	Terminal Exchanges And critical mobile phone (cellular) transmission towers	intercity cables and cables between switching centres		Radio transmission infrastructure used by emergency services. Telephone switching centres
Emergency Services				Minor Evacuation Centre	Station (Police/Fire brigade/Ambulance/SES)		Major Evacuation Centre or Control Centre (Police/Fire brigade/Ambulance/SES)
Sewage and waste			Gravity Pipes	Sewage pumps and waste tips or landfill	Sewage Water Treatment Plant		
Health services			Medical Centres	Private Hospitals and aged care facilities	Local Public Hospitals		Regional Public Hospitals
Duration / Event Range					<24hrs	>24hrs	
1,000 - PMF							
100-1,000							
50 to <100							
>10 to <50							
10							

References

Australian Institute for Disaster Resilience (2017) *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*, Australian Disaster Resilience Handbook 7, Australian Government Attorney-General's Department.