NSW GOVERNMENT

Hawkesbury-Nepean Valley Flood Risk Management Strategy

Interim Evaluation to June 2021

The Flood Strategy

The Hawkesbury-Nepean Valley Flood Risk Management Strategy (the Flood Strategy) aims to reduce flood risk to life, property and social amenity from regional floods in the Hawkesbury-Nepean Valley, now and in the future. It is working to improve community resilience and prepare for the impacts of climate change on flood risk.

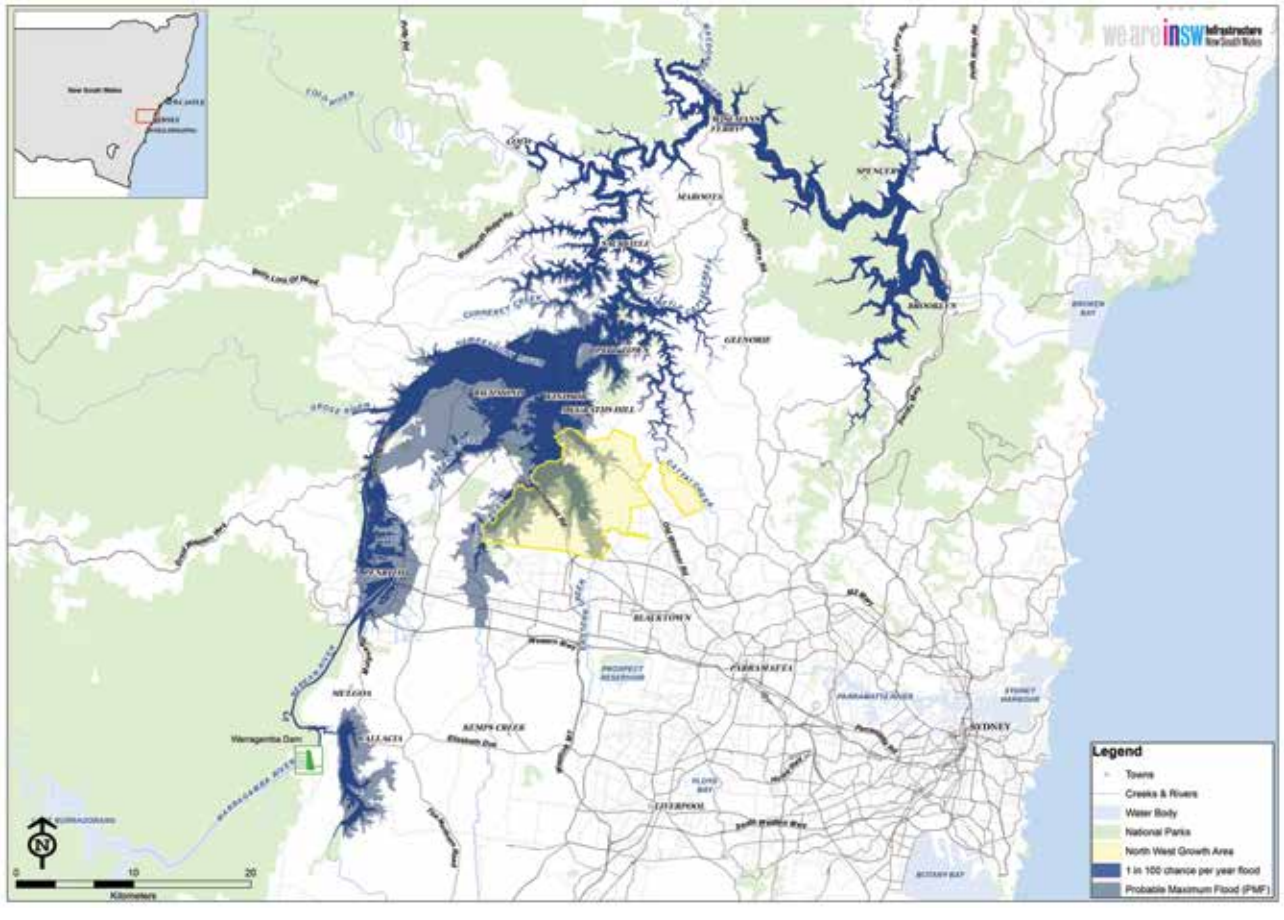
Due to its large existing population and unique geography, the Hawkesbury-Nepean floodplain has the most significant and unmitigated community flood exposure in Australia.

In 2018, there were over 140,000 people living or working in the floodplain. The population is projected to increase with committed and permissible development in the current planning envelope, while projected climate change will affect rainfall patterns and increase the likelihood of severe flooding. Further, a major flood has the potential to impact the entire NSW economy by affecting transportation routes and utilities outside the valley.

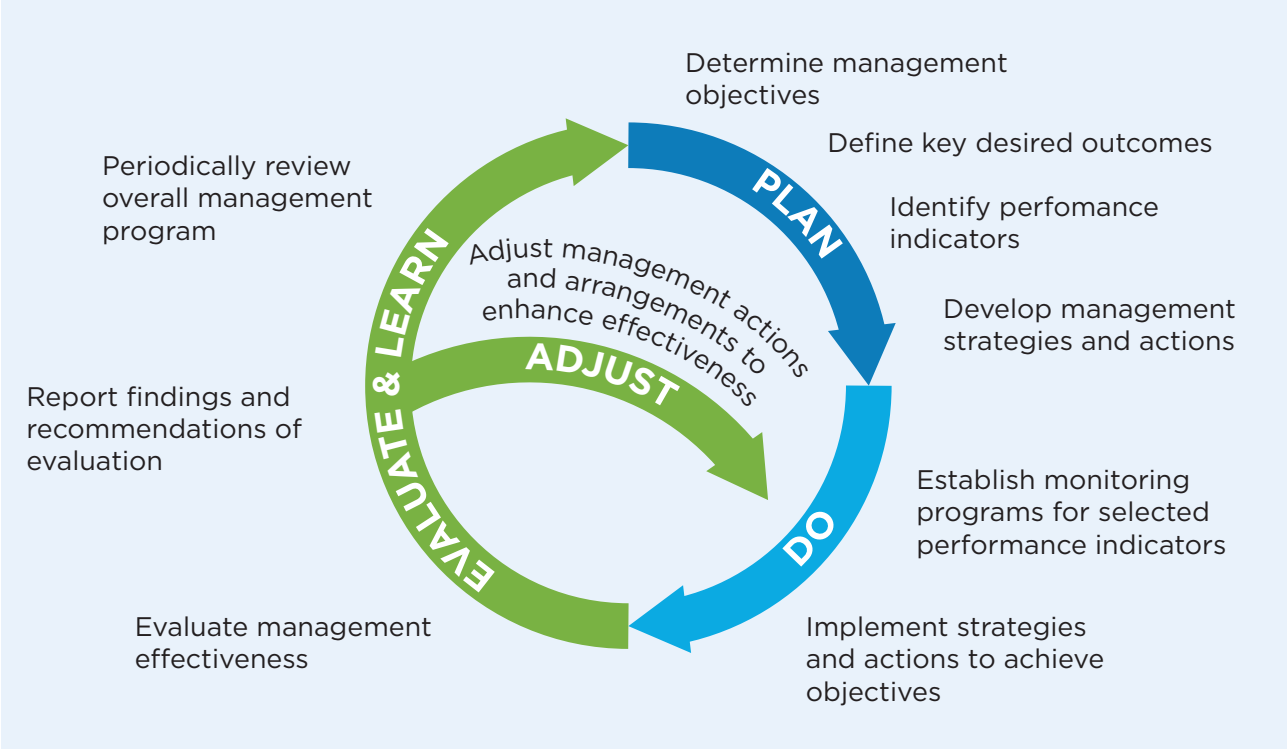
The Flood Strategy comprises a suite of integrated measures to mitigate flood risk. The Climate Change Fund provided $58.46 million for Phase One of the Flood Strategy, which started in 2016 and is nearing completion as at June 2021.

The Flood Strategy is a long-term strategy of the NSW Government and will continue with infrastructure projects and complementary measures beyond 2021 as part of normal disaster resilience practice.

A best-practice evaluation framework was applied to assess performance and guide adaptive management of the Flood Strategy. This report outlines the interim findings from the evaluation at June 2021, pending completion of Phase One in 2021-22.



The Hawkesbury-Nepean floodplain



Adaptive management cycle, Source: DPIPWE 2014 after Jones 2005, 2009

Flood Emergency Planning for Schools: Flood Risk Briefings.
Source: INSW Image: Adam Hollingworth

Evaluation framework

The evaluation framework focuses on 4 key evaluation questions (KEQ), asking if delivery of the Flood Strategy was efficient, effective and appropriate, and what has been learnt from recent flood events. The framework was endorsed by the Climate Change Fund and evaluations were conducted externally from Infrastructure NSW.

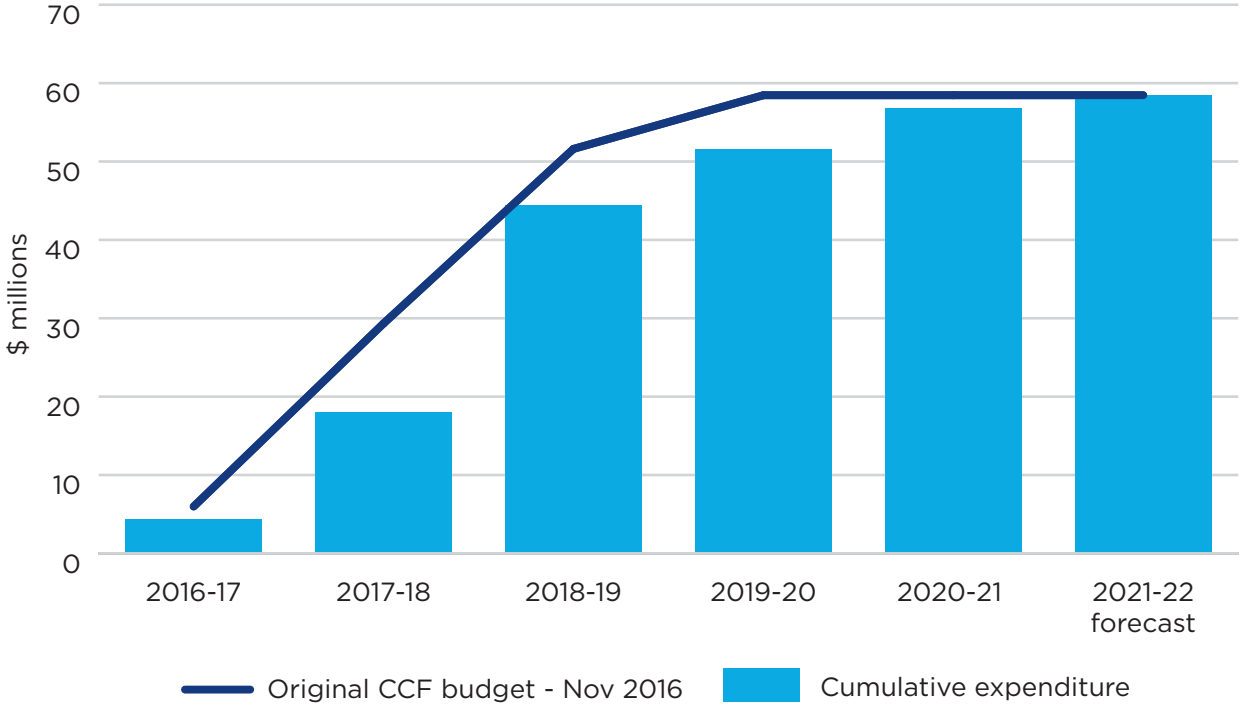
KEQ 1 EFFICIENCY	**How efficiently have the actions in the Flood Strategy been delivered?**
KEQ 2 EFFECTIVENESS	**How effective has the Flood Strategy been in achieving its end-of-program outcomes?**
KEQ 3 APPROPRIATENESS	**To what extent does the Flood Strategy remain appropriate, or should it be adapted or revised?**
KEQ 4 ACTUAL FLOOD EVENT	**To what extent has the Flood Strategy achieved the expected outcomes in an actual flood event?**

Efficiency

The 9 outcomes for Phase One of the Flood Strategy have been delivered efficiently and to a high standard, with most actions completed by June 2021 or well advanced and due for completion in 2021-22 (see summary below, case study 1).

Expenditure is within the program budget approved by the NSW Government, including $58.46 million from the Climate Change Fund.

Flood Strategy – Phase One CCF cumulative expenditure



Effectiveness

The Flood Strategy is making real progress toward its vision of increasing flood resilience in the Hawkesbury-Nepean Valley. The program has been effective in coordinating a holistic approach to managing regional flood risk, and has been a driving force for change with the necessary resources, leadership, coordination, governance and accountability to make a real difference.

Appropriateness

The interim evaluation found that the Flood Strategy is still appropriate, although obtaining planning and funding approvals for raising Warragamba Dam wall to create a flood mitigation zone remain critical to delivering the strategy.

The Flood Strategy's adaptive management approach across the disaster management spectrum of prevention, preparedness, response and recovery has ensured its continued relevance.

Actual flood events

A moderate flood occurred in February 2020, and a major flood in March 2021. Modelling of these flood events demonstrated the significant benefits in reducing flood levels downstream if the proposed raising of Warragamba Dam wall to create a flood mitigation zone is approved.

The following case studies illustrate key findings from the interim evaluation of the Flood Strategy to June 2021.

Case study 1:

Efficient outcomes delivered in Phase One

1. Coordinated flood risk management

- The Flood Strategy Directorate was established in Infrastructure NSW to coordinate regional flood risk management in the Hawkesbury-Nepean Valley.
- Infrastructure NSW partnered with state agencies, local councils, businesses and the community to reduce and manage existing and future flood risk across the valley.

2. Reduce flood risk by raising Warragamba Dam wall

- A comprehensive Environmental Impact Statement (EIS) and detailed concept design have been prepared for the proposal to raise Warragamba Dam wall to create a flood mitigation zone to reduce flood risk to the lives and homes of thousands of people downstream.
- Public exhibition of the EIS is planned for later in 2021, along with further community and stakeholder consultation.

3. Strategic and integrated land use and road planning

- A leading-edge flood evacuation model supports integrated land use, road and evacuation planning.
- Government agencies are working with floodplain councils to develop a new Regional Land Use Planning Framework for the valley.
- Transport for NSW is continuing to develop flood resilience design guidelines for road transport planning in the floodplain.

4. Accessible contemporary flood risk information

- A new region-wide flood study was completed in 2019, using up-to-date science and data to provide the latest mapping of flood risk for decision-makers.
- The regional flood model is now being extended to provide a two-dimensional model with higher resolution. This will also incorporate the latest information from the March 2021 flood event.
- Web-based interactive flood maps can be accessed from the NSW SES website to help the community to understand flood risk for their location in the floodplain.

5. Aware, prepared and responsive community

- The Community Resilience Program has raised awareness of flood risk and readiness to respond to a flood, through multi-faceted programs targeting broad public awareness, outreach to communities of concern, and education programs for young people.
- A new evacuation road signage system was designed, tested, and 150 new signs installed.

6. Improved weather and flood predictions

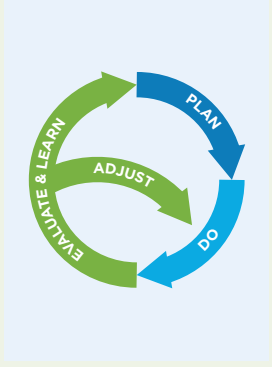
- A pilot tool for the Hawkesbury-Nepean Valley was developed by the Bureau of Meteorology to enable extended lead time forecasts to provide more certainty of warning for emergency response and managing evacuation.
- The next step is to operationalise the pilot tool.

7. Best practice emergency response and recovery

- The Hawkesbury-Nepean Valley Flood Emergency Plan (a sub-plan of the State Emergency Management Plan) and the Hawkesbury-Nepean Valley Flood Recovery Strategy were revised and updated.
- Emergency management agencies conducted a range of emergency response and recovery exercises, including Exercise Deerubbin for a catastrophic flood in the valley.

8. Adequate local roads for evacuation

- Detailed investigations were undertaken for road infrastructure upgrades to improve access to the existing evacuation road network by addressing legacy issues of local flooding at low points and other constraints.
- A Strategic Business Case was prepared for the 110 priority road resilience upgrades identified through the detailed investigation process.



9. Ongoing monitoring, evaluation, reporting and improvement

- Best-practice monitoring and evaluation were integrated into delivery of Phase One of the Flood Strategy.
- Evaluation findings contributed to adaptive management and informed decisions for the ongoing Flood Strategy beyond 2021.

Case study 2:

Effective communications and engagement

Community Resilience Program

The Community Resilience Program has contributed to raising community awareness and understanding of flood risk, and to increasing preparedness in the Hawkesbury-Nepean Valley. The program includes 3 key focus areas - broad public awareness, outreach to communities of concern, and engaging young people.

The outreach program to communities of concern aims to increase resilience in communities most at risk from floods, focusing on vulnerable groups and the service providers who support them. It included outreach to childcare, disability, aged care and family support services, culturally and linguistically diverse communities, the social housing sector, and people with animals. This important work will continue as part of the Flood Strategy beyond 2021, along with programs targeting business resilience.

The Community Resilience Program was recognised for implementing best practice engagement, receiving the Floodplain Management Australia – NRMA Insurance 'Flood Risk Management Project of the Year' award for 2021.

COMMUNITY RESILIENCE PROGRAM

19 PROJECTS	37 PARTNERS	300 ORGANISATIONS

Broad public awareness and preparedness

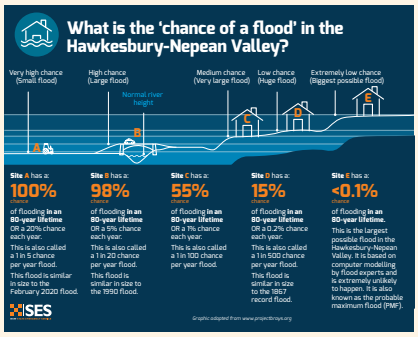
Public safety campaign, resources, mapping tool, events and warnings research

Outreach program for communities of concern

Projects focussed on 9 groups of people who are most at risk from flooding

Education and engagement program for young people

Primary and secondary school resources and emergency planning for local schools

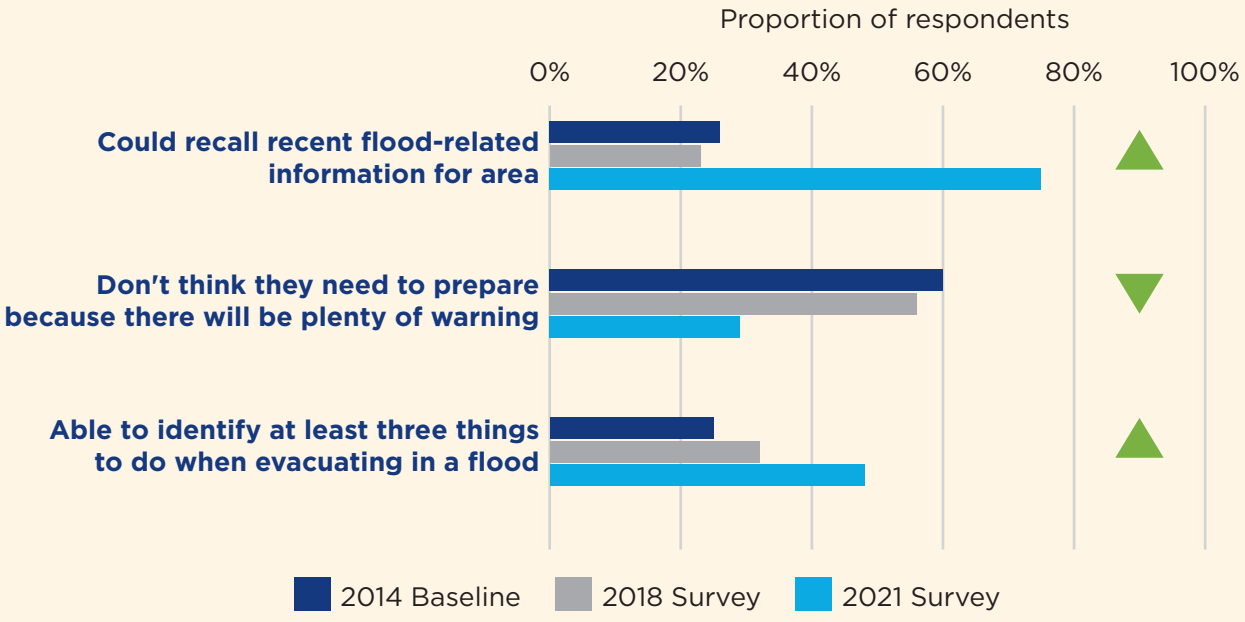


Social research

In 2014, a baseline for community awareness and readiness was established through quantitative and qualitative social research conducted by Newgate Research. Repeat surveys in 2018 and 2021 provide a time series to assist in evaluating the effectiveness of the Flood Strategy's communications and engagement program.

A snapshot of key findings from the social research from 2014 through to 2021 includes:

- the number of respondents who recalled seeing or hearing flood information increased from 26% to 75% – this significant increase would be influenced by recent flooding and related media stories and weather reports, in addition to the flood awareness campaigns
- there is a greater awareness of the need to prepare for a flood, with the number of people who don't think they need to prepare because there will be plenty of warning reduced from 60% to 29%
- the proportion of people able to identify at least 3 things to do in an evacuation nearly doubled from 25% to 48%.



However, from 2014 to 2021 there has been little change in the way people say they would respond in a flood evacuation, with 70% saying they would follow directions, while 27% said they would use their own judgement and a further 2% saying they would ignore instructions because they think they know the best thing to do. Following directions in a flood evacuation is an important topic for ongoing public awareness and preparedness programs.

Public awareness campaign "Floods. The Risk is Real." delivered in 2019 and 2020

Case study 3:

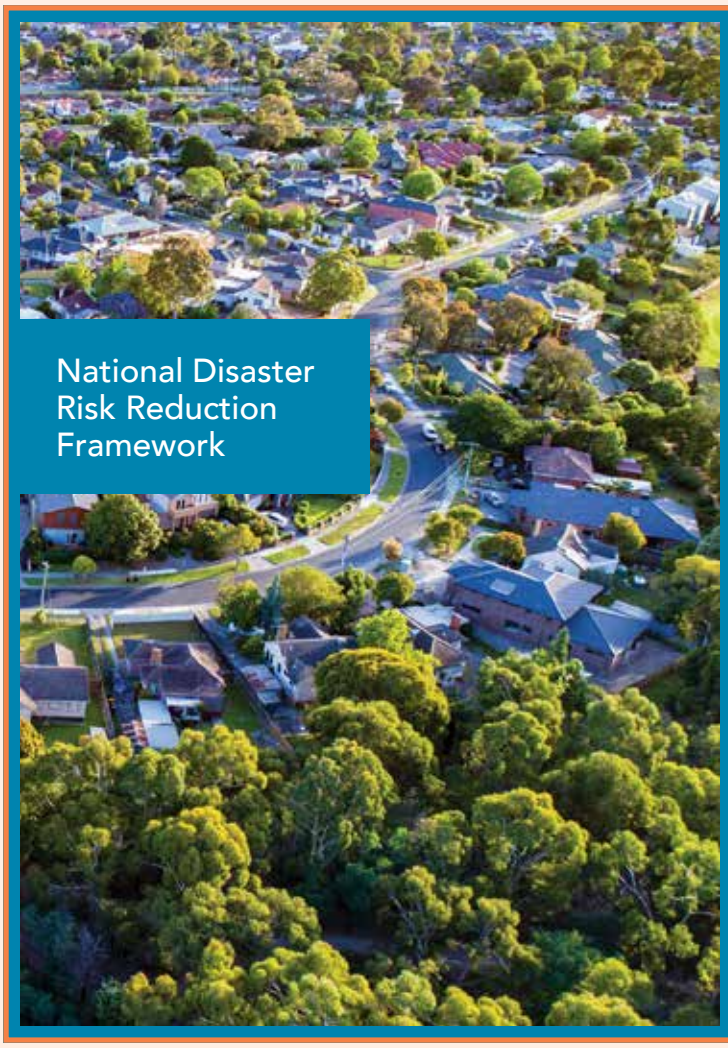
Best available information for decision-making

National framework

The National Disaster Risk Reduction Framework (NDRRF, 2018) identifies 4 national priorities to reduce risk and increase resilience to natural disasters in Australia:

- understand disaster risk
- accountable decisions
- enhanced investment
- governance, ownership and responsibility.

The NDRRF highlights the need to collate the best available information to contribute to a more comprehensive understanding of disaster risk, and to equip decision-makers in all sectors with the information and capabilities they need to make decisions that reduce disaster risk – considering existing risk, future risk scenarios, and residual risk.



National Disaster Risk Reduction Framework

"To be reduced, all components of disaster risk and impacts must be understood by all sectors: vulnerability, capacity, exposure of persons and assets, hazard characteristics, and the environment.

Across all sectors, there is an urgent and growing demand for trusted and authoritative disaster risk information and services to inform operational and strategic decisions."

National Disaster Risk Reduction Framework, 2018

Applying this to the Flood Strategy

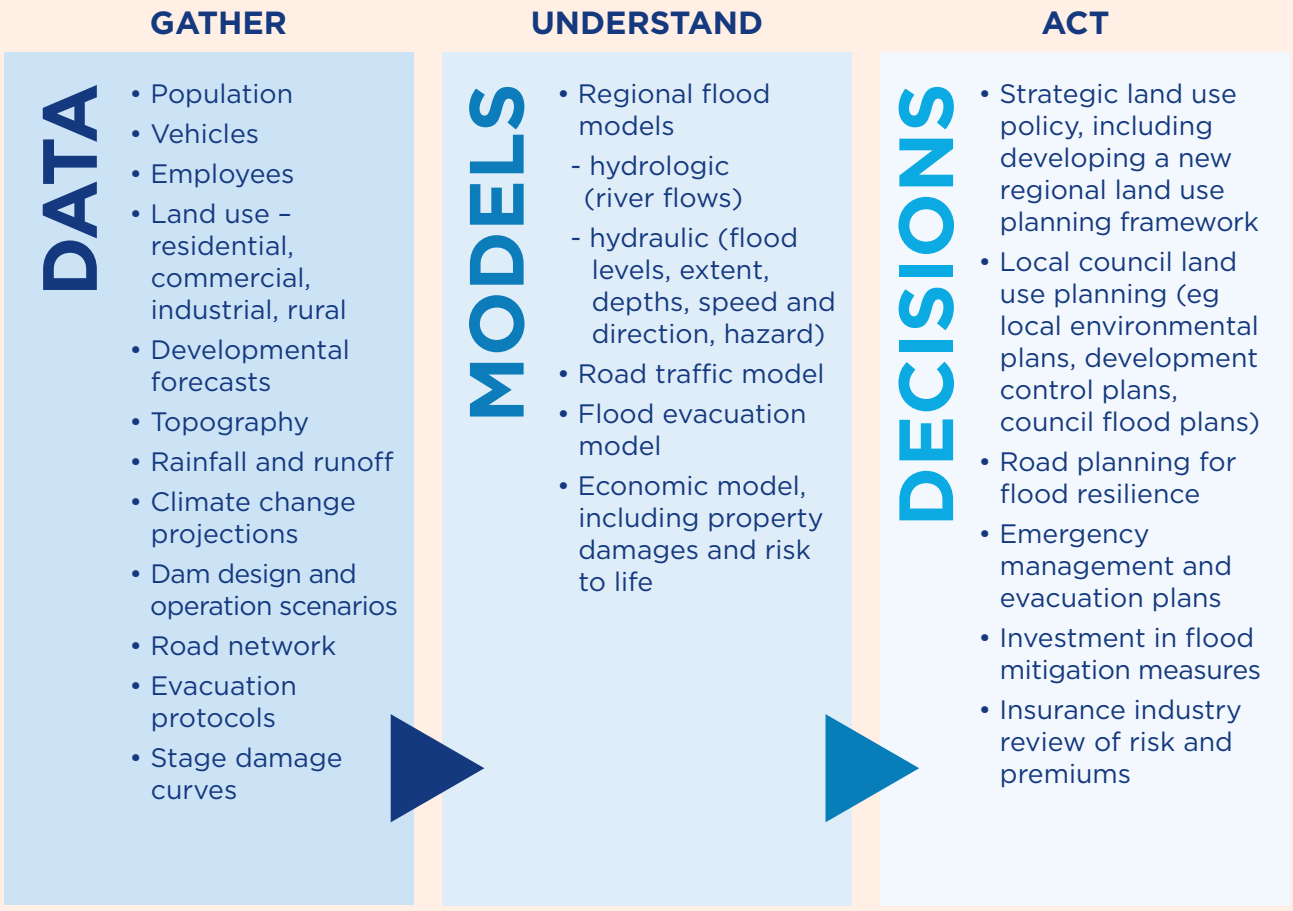
The Flood Strategy has applied best practice to understanding flood risk in the Hawkesbury-Nepean Valley and developing leading-edge decision support tools. Some key achievements include:

- the comprehensive Flood Strategy database that underpins the modelling tools has been updated and expanded
- the Hawkesbury-Nepean Valley Regional Flood Study provides the best available information and modelling of flood behavior, including impacts of climate change, to guide land use and emergency management planning
- the new Flood Evacuation Model provides government with a sophisticated decision support tool to more effectively consider flood risk in strategic land use and road planning decisions and optimise evacuation planning.

Examples of how best available information has guided recent decisions to reduce flood risk and increase resilience include:

- a better understanding of the cumulative impact of growth in the Hawkesbury-Nepean Valley has resulted in some proposed development within the floodplain being refused due to inadequate evacuation capacity, including at Penrith Lakes, Windsor and Emu Plains
- recent land releases have required flood provisions to manage the location and density of development to ensure new residents can evacuate safely.

At a statewide level, the NSW Government's Floodplain Development Manual requires all councils to consider the full range of flooding up to the probable maximum flood. The updated Flood Prone Land Package also requires the impact of a planning proposal on evacuation and emergency response measures to be considered.



Using best available information to guide decision-making

Case study 4:

Appropriate investment to mitigate risk

When the Flood Strategy was developed in 2016, it was clear there was no single or simple means of reducing existing and future flood risk in the valley, which is increasing due to population growth and the effects of climate change. Hence the Flood Strategy is a multi-faceted program of initiatives across the disaster risk management spectrum of prevention/mitigation, preparedness, response, and recovery.

The large Warragamba catchment contributes the most floodwaters to the most dangerous and damaging floods in the Hawkesbury-Nepean Valley, historically contributing up to 70% of flows. To mitigate risk to the many thousands for people who live and work in the floodplain, raising Warragamba Dam spillways by up to 14m to create airspace for the infrequent, temporary capture of flood inflows was found to have the most benefit in meeting the Flood Strategy's objective of reducing risk to life, property and social amenity in the valley, now and in the future.

The short-listed options considered in developing the 2016 Flood Strategy were thoroughly reassessed in determining the package of ongoing actions for the Flood Strategy beyond 2021 and to inform the Environmental Impact Statement (EIS) for the Warragamba Dam Raising Proposal. The assessment used the latest available information, investigations, design, costings and decision support tools to compare the infrastructure and land use planning measures against targets for cost-effectiveness, risk to life and property damages.

The short-listed options included:

- creating air space in Warragamba Dam to temporarily hold floodwaters and reduce the depth and extent of downstream flooding by:
  - raising the wall to create a 14m flood mitigation zone, or
  - lowering the full supply level (FSL) by either 12m or 5m (with consequent loss of water supply security, requiring alternative water sources to be developed at significant cost)
- new or upgraded regional roads incorporating flood resilience in the road design
- development controls such as buying back dwellings below the 1 in 100 chance per year flood level, or not allowing any future residential development below the current 1 in 500 chance per year flood level.

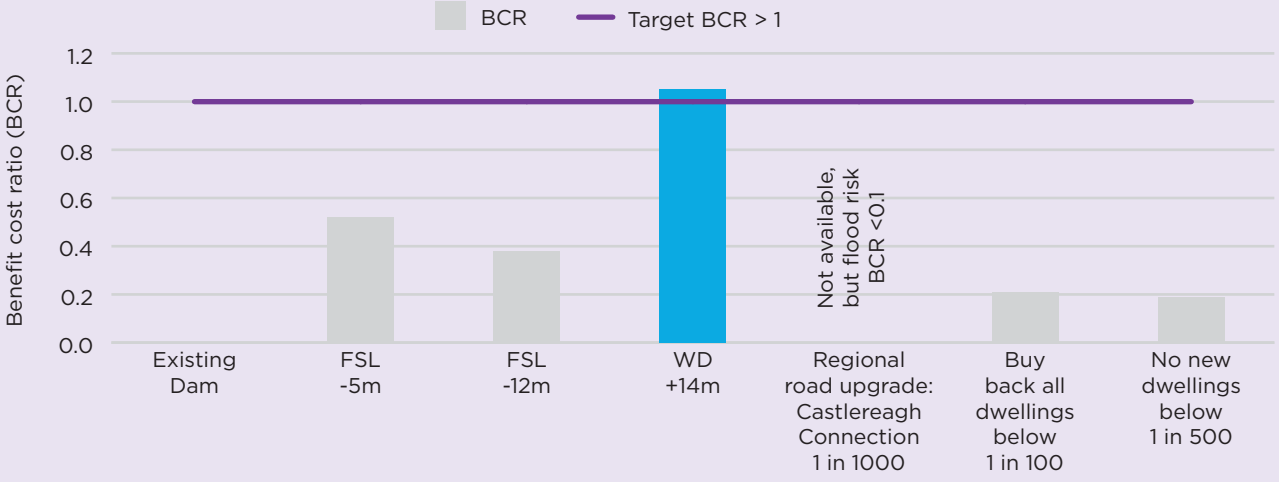
The reassessment confirmed that raising Warragamba Dam spillways to create a flood mitigation zone is still the most cost-effective option by a long margin, and delivers the greatest reduction in risk to life and property. This is illustrated by the blue columns in the graphs adjacent – the Warragamba Dam proposal is the only option with a benefit-cost ratio above 1.0 (meaning that the benefits exceed the costs), and the only option to achieve the target of around 75% reduction in exposure to risk to life and property damages.

The Warragamba Dam proposal is subject to environmental and planning approval.

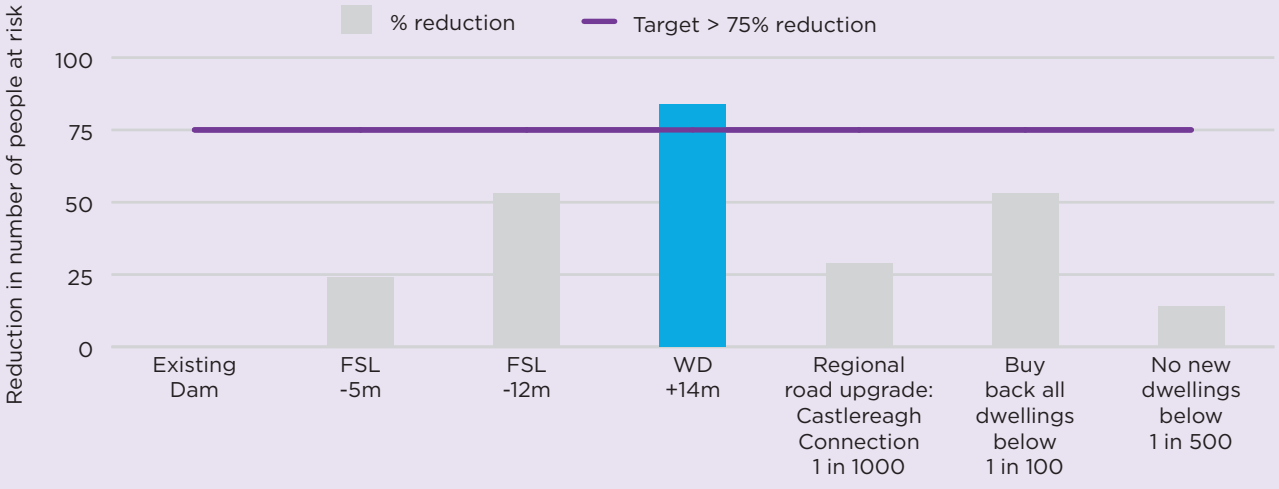
The ongoing complementary measures for the Flood Strategy beyond 2021 include:

- integrated land use, road and emergency management planning for the Hawkesbury-Nepean Valley
- community resilience programs to raise public awareness and increase the resilience of vulnerable communities
- coordinating regional flood risk management and governance
- understanding flood risk and supporting informed decisions through a knowledge hub for regional flood risk information
- continuing to build capacity and capability for best practice emergency response and recovery.

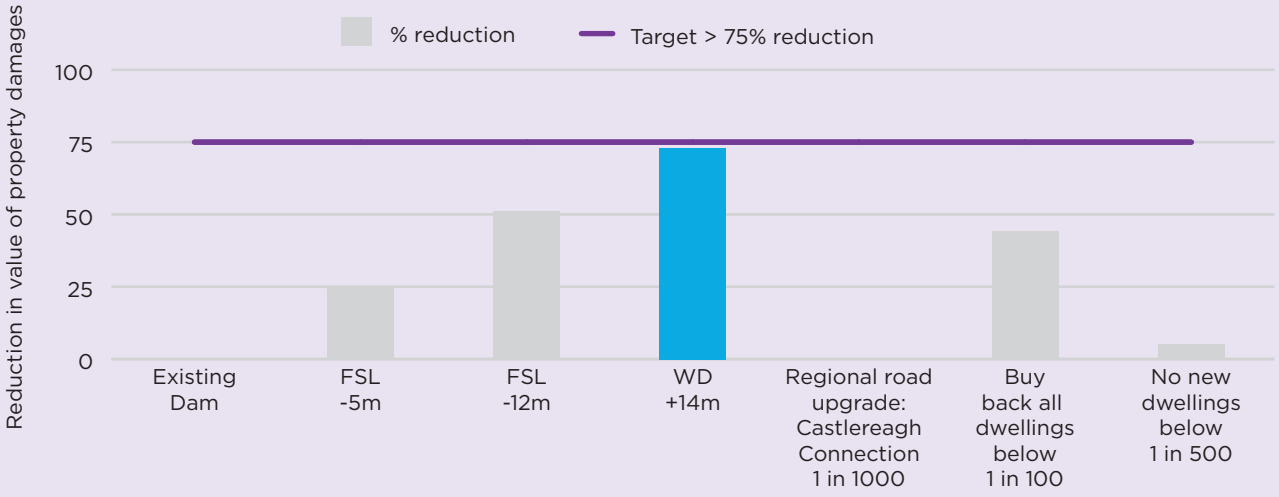
Cost effectiveness
Discounted 7% over 30 years



Risk to life
2041, no climate change



Property damages
2041, no climate change



Case study 5:

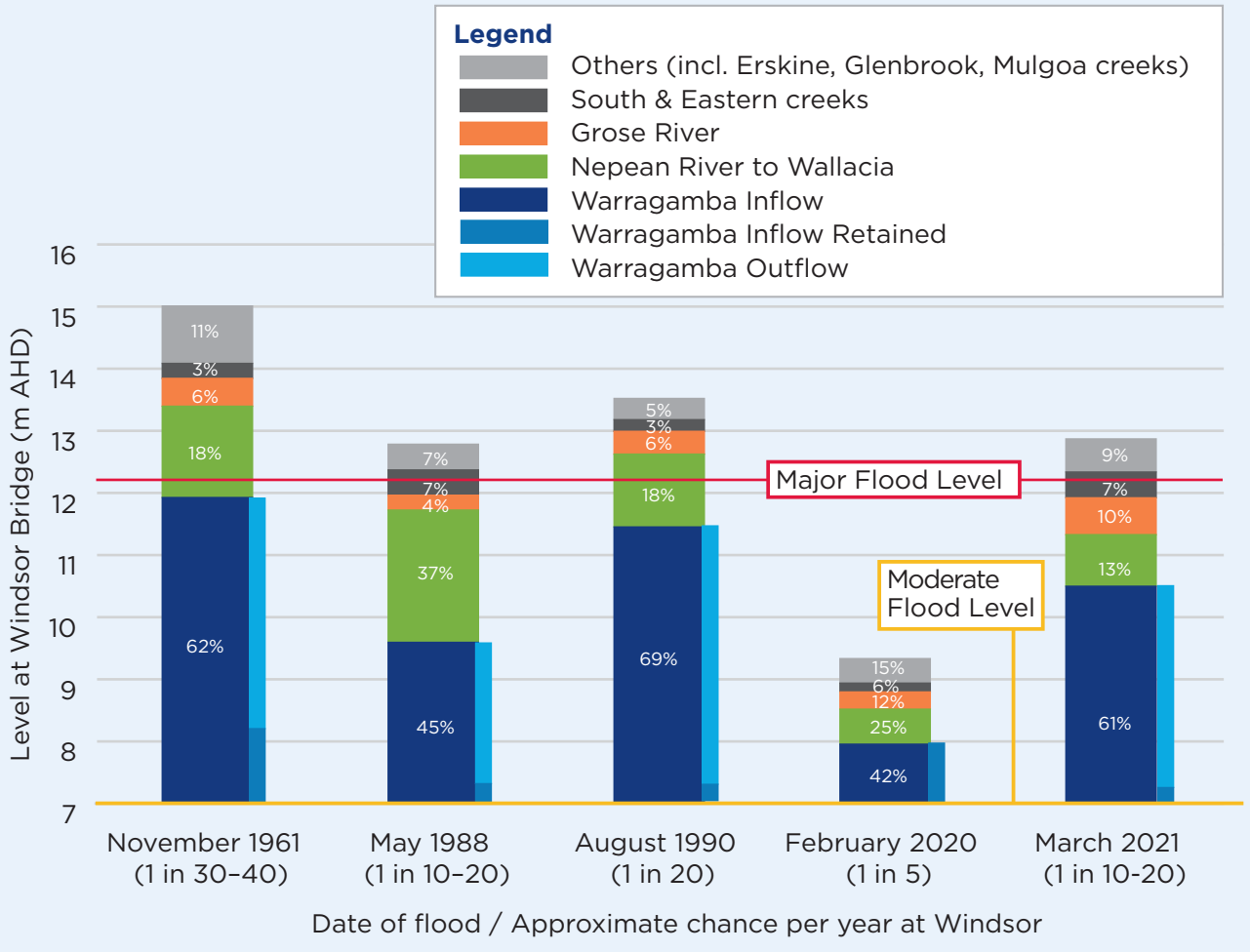
Learning from recent flood events

Catchment contributions

The Hawkesbury-Nepean catchment is made up of several subcatchments. The largest of these is the Warragamba subcatchment, making up around 71% of the total catchment to Windsor. The graph below shows the significant contribution to flooding at Windsor from the Warragamba subcatchment for selected historic floods. It also shows the proportion of inflow retained in the dam for each of these events.

Flows from the Warragamba Dam catchment make a higher contribution to the larger floods that pose a significant risk to life, homes and businesses. Floods resulting from flows only generated by the Nepean and Grose rivers and all other tributaries do not pose as significant a risk as floods that involve the large Warragamba Catchment.

Hence measures that retain and delay floodwaters coming from the Warragamba catchment have the greatest benefit in reducing flood risk downstream.



Contributions to flooding at Windsor from the Warragamba and other catchments

February 2020 flood

The February 2020 flood was the first 'moderate' flood in the Hawkesbury Nepean Valley since 1992, with a likelihood of approximately 1 in 5 (or 20%) chance per year. At the start of the February 2020 event, Warragamba Dam was at less than 43% capacity, or 18.8m below full supply level. The dam captured all inflows from its catchment, so the dam did not spill during this event, and did not contribute flows to the downstream flooding.

Most of the flooding in this event was in low-lying areas, driven by the inflows from catchments other than Warragamba. Bridges were closed at Wallacia, Yarramundi, North Richmond and Windsor, ferries were closed, and around 100 residential dwellings and 280 manufactured homes were affected.

Modelling indicates that if Warragamba Dam had been full at the start of the February 2020 flood, the flood levels would have been around 3m deeper for the Penrith/Emu Plains and Richmond/Windsor floodplains. This demonstrates the benefit of airspace in Warragamba Dam. The proposal to raise the dam wall, if approved, will create a flood mitigation zone above the current full supply level, which will be reserved as temporary storage to mitigate flood events.

March 2021 flood

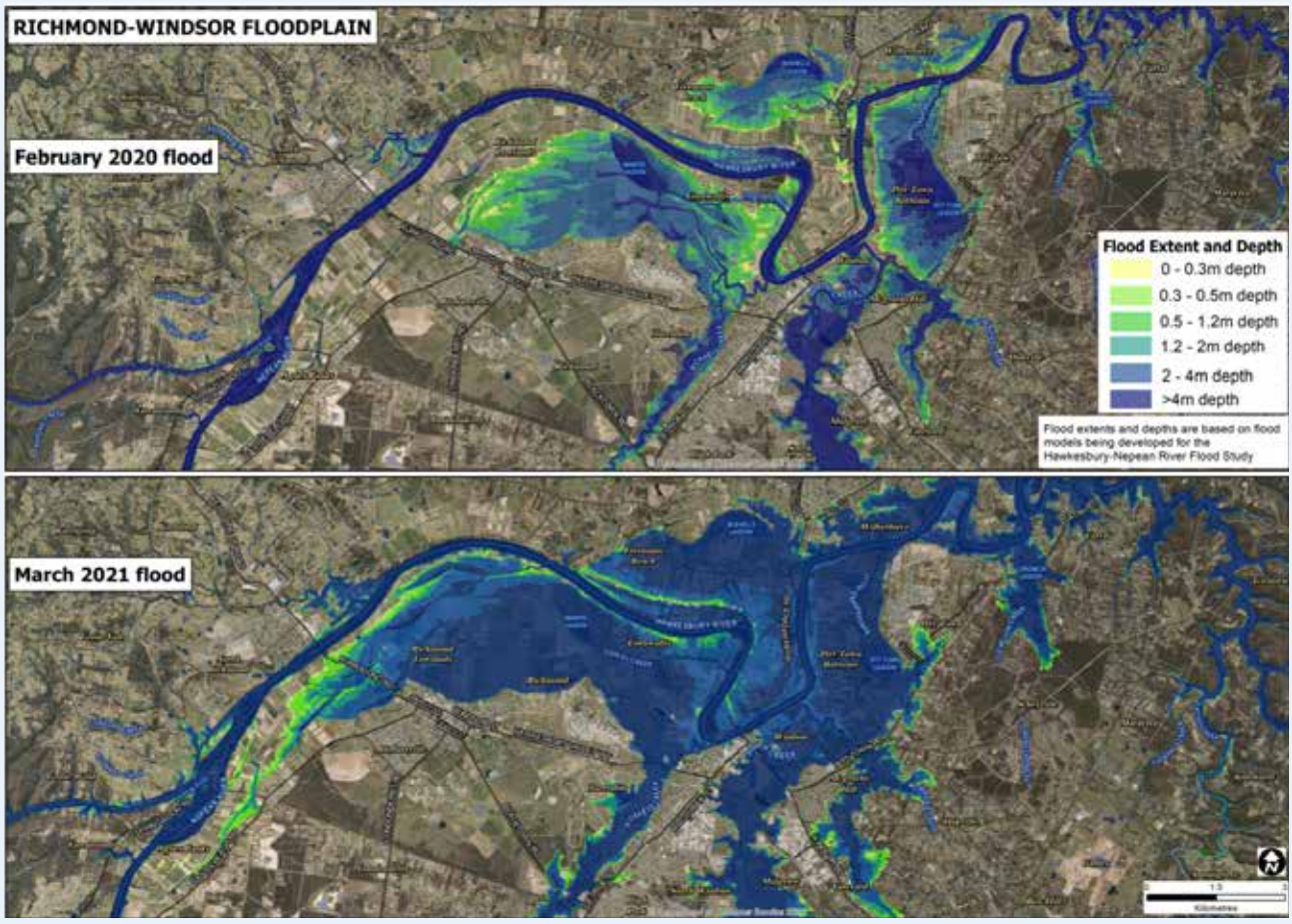
The March 2021 flood was the first 'major' flood experienced by Hawkesbury River communities since 1990 with a likelihood of around 1 in 10-20 chance per year at Windsor. When the March 2021 rainfall event began, the dam was at 96.3% capacity, with the water level at 1.0m below full supply level.

Around 600 residential dwellings and over 1400 manufactured homes were impacted by the flooding. New residents were generally not prepared for flood impacts, and bridge and road closures caused significant disruption and concerns. A landslide on Bells Line of Road caused issues for flood response including re-supply for populations west of the Hawkesbury River.

Downstream impacts were most significant in low lying and riparian areas of the Hawkesbury and Lower Hawkesbury – including severe riverbank erosion, damage to local roads, severe damage to turf and vegetable farms, and impacts on caravan parks and recreational areas.

Modelling indicates that if Warragamba Dam had already been raised, the March 2021 flood levels would have been reduced by around 5.3m at Penrith and 3.4m at Windsor, and the dam spill would have been delayed by 3 to 4 days.

Looking north along the Nepean River at Penrith, March 2021
Source: INSW Image: Adam Hollingworth



Comparing the extent of the February 2020 and March 2021 floods

Some community members have suggested that the water level in Warragamba Dam should have been drawn down before the March 2021 flood. This suggestion is not feasible, for the following reasons:

- Warragamba Dam is a water supply dam holding around 80% of Greater Sydney's supply
- the existing dam was not designed, built or operated to provide flood mitigation
- WaterNSW is currently authorised to make controlled releases when the dam reaches full supply level, but only to draw the storage down by up to one metre for operational and maintenance purposes
- pre-releasing water rapidly ahead of a forecast flood could cause significant downstream flooding and damage in low lying areas, while also reducing evacuation time and increasing the risk to life as roads could be cut by the released floodwaters
- calls for pre-releases ahead of potential floods assume levels of precision in rainfall and weather forecasting that are not currently possible
- analysis of the March 2021 flood event indicates that to avoid the dam spilling would have required lowering the water level to around 35% of full storage, which would be similar to the level experienced in the millennium drought – equivalent to losing around 2.5 years of water supply for Greater Sydney – and could not have been achieved within the forecast time available in this flood event (nor could it have been calculated in advance).

A wide range of flood mitigation options were assessed in detail for the Flood Strategy and reassessed for the Warragamba Dam Raising Environmental Impact Statement. Infrastructure NSW has also undertaken a comprehensive evaluation of the March 2021 flood event, which was in progress at the time of this interim evaluation of the Flood Strategy implementation. Further information is available at www.infrastructure.nsw.gov.au.

Warragamba Dam spilling, March 2021
Source: INSW Image: Adam Hollingworth

Flooding of the Hawkesbury River and South Creek, 25 March 2021
Source: INSW. Image: Top Notch Video

More information

Visit
www.infrastructure.nsw.gov.au
for more information about the Flood Strategy

Visit
www.ses.nsw.gov.au/hawkesbury-nepean-floods
for more information about flood risk and preparing for a flood

Contact
your local council for flood risk information specific to your property

This report was developed by an external consultant using an evaluation framework endorsed by the Climate Change Fund. The evaluation framework focuses on four key evaluation questions, asking if delivery of the Flood Strategy was efficient, effective and appropriate, and what has been learnt from recent flood events.

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