Flooding in an Uncertain Future: Can Policy Keep Up with Science?

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- Over the past 10 years, rainfall depths considering climate change have been adjusted 5 times in Victoria, Australia.
- The current policy of setting flood levels based on a 1% Annual Exceedance Probability (AEP) event with adjustments for climate change that change every 2 years on average is likely to result in poor planning outcomes in the long term.
- Changes to flood management policy must consider the uncertainty of climate change.

Abstract

This study investigates the challenges of incorporating rapidly evolving climate science into flood planning policies in Victoria, Australia. Recent draft updates to the climate change chapter of Australian Rainfall and Runoff 2019, released for public consultation in December 2023, will result in significantly increased rainfall depths for short-duration storms along with revisions to predicted sea level rise for the year 2100. Frequent changes to climate science over the past 10 years has created difficulties for long-term infrastructure planning, as flood planning levels become outdated quickly due to ever changing climate science.

The current policy of setting flood levels based on a 1% Annual Exceedance Probability (AEP) event with adjustments for climate change that change every 2 years on average is is likely to result in poor planning outcomes. Alternative risk-based approaches should be considered within future planning policy for infrastructure, residential and commercial developments.

Keywords

Flooding, Planning, Climate Change, Development, Policy

Introduction

Planning flood-resilient infrastructure in Australia is becoming increasingly challenging due to rapid changes in climate science predictions in the last 10 years. Although seasonal rainfall is experiencing decline across Victoria (DELWP *et al.*, 2020), individual event 'daily and sub-daily rainfall are increasing with warming' (Wasko *et al.*, 2023). The rate of change for rainfall burst predictions makes planning for future infrastructure particularly difficult.

The role of setting flood levels for development across Victoria currently sits with Melbourne Water and the Catchment Management Authorities (CMA) for riverine flooding and local councils for stormwater flooding. This critical role ensures development is sufficiently protected from potential inundation to an appropriate level. The ability to set flood levels is provided to authorities under the *Water Act 1989*, which specifies in section 204 that 'an Authority may adopt a flood level, a flood fringe area or a building line which, in its opinion, is the best estimate, based on the available evidence, of a flood event which has a probability of occurrence of 1 per cent in any one year' (Water Act 1989). The requirement to consider climate change, however, is defined by the Victorian Floodplain Management Strategy (DELWP (Vic), 2016).

The City of Melbourne has recently proposed an update to inundation overlays for their council area via Planning Scheme Amendment C384. This amendment looked to consider climate change flood modelling for the year 2100 as the most appropriate flood level for development assessment and planning. Due to the timeframe for implementation of this amendment, which commenced in 2021 and has not yet been implemented, the data will likely be considered out of date before it is published. This is due to the Draft update of the Climate Change Considerations chapter in Australian Rainfall and Runoff (DCCEEW, 2023) superseding amendment data created in amendment C384.

Regular updates to climate science guided by IPCC updates, the latest being the AR6 Synthesis Report, have resulted in frequent and recent changes to climate change Intensity Frequency Duration (IFD) depths over the past 10 years, requiring the need for frequent updates to flood modelling. The changes, which are represented by percentage increases to IFD depths, have varied, as shown in Table 1. The guidance, provided by Melbourne Water via the Flood Mapping Technical Specifications and informed by IPCC reporting has resulted in flood extents for 2100 that have changed 5 times in the last 10 years. The constantly changing guidance for rainfall in 2100 makes planning for long term infrastructure increasingly difficult if it is used as a predefined scenario for planning and development. The most recent change to the climate change factors has also introduced variations in rainfall depth based on storm critical duration, as shown in Table 1.

Table 1 Melbourne Water Flood Mapping Technical Specification Climate Change Rainfall IFD depth increases for 1% AEP, 2100, RCP 8.5

Melbourne Water Flood Mapping Technical Specification Year	Climate Change Rainfall IFD Depth increase for sub 1-hour storm in Melbourne, Victoria (2100)	Climate Change Rainfall IFD Depth increase for greater than 12-hour storm in Melbourne, Victoria (2100)
2015	32%	
2016	16%	
2018	18.3%	
2021	18.5%	
2024#	88%	41%

#Anticipated based on draft DCCEEW Guidelines for SSP5-8.5

The 2024 value outlined in Table 1 has been calculated based on a very high emissions scenario of SSP5-8.5, which predicts warming of 4.5°C by 2100. SSP5-8.5 is consistent with Melbourne Waters guidance for the use of Representative Concentration Pathway 8.5 (RCP8.5) (Melbourne Water, 2023). Utilising Equation 1 (DCCEEW, 2023), where α is defined as 15 %/°C and, ΔT, is defined as 4.5°C for a 1 hr storm in 2100 (SSP5-8.5) we can see that the increase in rainfall of 88% for storms of 1 hour or less duration is significant in comparison to previous years.

$$I_p = I \times (1 + \frac{\alpha}{100})^{\Delta T} \quad (1)$$

where

- Ip is the projected rainfall depth or intensity
- α is the rate of change from Table 1
- I is the design rainfall depth or intensity
- ΔT is the most up-to-date estimate of global (land and ocean) temperature projection for the design period of interest and selected climate scenario relative to a baseline time period. When used in conjunction with the 2016 IFD curves, the baseline is recommended to be the 1961-1990 period.

Flood Study impacts on Development Planning

Long-term infrastructure planning in Victoria involves all levels of government. The industry has already felt the effects of evolving climate change guidelines over the past decade. This evolution will continue to produce varying flood planning levels, influenced by the timing of flood study updates and the specific technical standards applied during development of planning applications.

The Metro Tunnel Rail Project was one of the early projects in the last 10 years to consider the impacts of climate change on flood planning levels. The consideration of climate change for this project used a 32% increase to rainfall IFDs for the 1% AEP event (AJM Joint Venture, 2016). This assessment was guided by the Flood Mapping Projects, Guidelines and Technical Specifications (Melbourne Water, 2015) which was summarised in Table 1. Looking at recent changes to the guidelines, the use of 32% would have been considered conservative until the release of the draft DCCEEW update to the climate change chapter (DCCEEW, 2023) in Australian Rainfall and Runoff 2019, which has now been updated to 88% for 1 hour or less storms and 41% for longer duration storms.

In addition to major projects, development projects considering climate change also face a similar level of uncertainty when navigating the development planning system. The guidelines for development in flood prone areas (DELWP, 2019) are currently the standard for assessment of residential development in flood prone areas. These guidelines require assessments to ‘apply an increase in the design rainfall intensity, based on a consideration of climate change’, referring to Australian Rainfall and Runoff (ARR) (Book 1 Chapter 6). This linkage requires planners to be sufficiently familiar with Australian Rainfall and Runoff to understand any changes that may occur. This can become problematic when climate change standards are adjusted, and the full impact of these changes is not yet understood. Continual updates to the climate change chapter of ARR produce constantly changing flood planning levels and may result in neighbouring properties having different standards depending on their year of assessment.

Impacts of Recent Changes to Australian Rainfall and Runoff

The most recent change to the Australian Rainfall and Runoff Climate Change chapter has been shown for Melbourne, Victoria in Table 1. This is based on the recently released draft climate change guidelines, which are due to be made final in mid-2024. If implemented as outlined in the draft update, the climate change projections will have the most significant impact on local catchments prone to flash flooding.

Considering the Melbourne location (144.939, -37.818) as an example, the Climate change IFD depth for 2100 for SSP5-8.5 for a 1-hour duration storm (Figure 1) in comparison to various current day IFDs for a 1-hour duration storm. It is evident that the most recent updates to the ARR climate chapter will result in significant increases to flood levels where the critical duration is at or less than 1 hour with downward tapering increases above 1 hour.

The 2024 update to climate change guidelines will introduce yet another new flood modelling derived planning level for consideration across Victoria and Australia more broadly. Due to these frequent changes, further consideration needs to be given to how flood planning levels are set across Melbourne. As climate science is still largely uncertain, it might be an opportunistic time to consider alternative approaches.

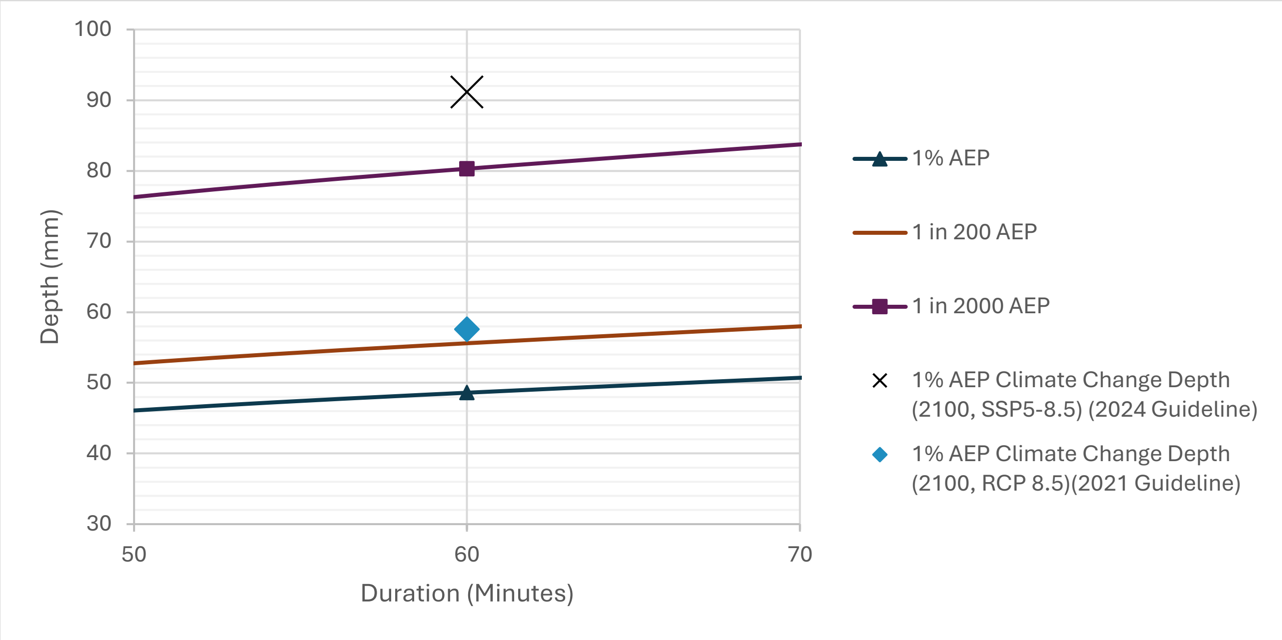

Figure 1 **IFD Design Rainfall Depth (mm) (Location: 144.939, -37.818) of various AEP events compared to adjusted Climate Change IFD depths.**

Policy Changes to keep up with science

It is evident that policy outlining the requirement for flood planning levels to be set at the 1% AEP specifically will continue to result in adjustments as climate science evolves. The future consideration of policy should make note that climate science will continue to evolve and constant changes to flood levels is an impractical outcome when considering the long-term nature of planning. Future policy should look at a risk-based approach or consideration of rarer events based on the criticality of infrastructure under consideration.

A risk-based flood management approach must consider additional assessment of catchment risk and flood mapping between the 1% AEP event and probable maximum flood (PMF) levels. As flood prone land is defined to be the land within the PMF (CSIRO, 2011) policy driven adaptation measures beyond structural mitigation should be employed for communities on land defined as flood prone. Adaptation measures could include flood warning systems with adequate redundancy; strengthened emergency response measures including evacuation plans and systems; and public education and awareness activities including mapping (Okazumi, T & Ootsuki, E, 2009) in addition to structural options.

Additionally, consideration should be given to requiring more infrastructure to be placed outside flood prone land while requiring flood resilient design for infrastructure prone to flooding. With the variability in climate science and uncertainty around the future, the types of infrastructure approved for use within flood prone land should be scrutinised closely to consider significantly different inundation increases into the future.

Conclusions

The ever-changing nature of climate science and its relationship to hydrology has a complex connection with current and future planning policies and practices. As climate science is extremely uncertain, policy should look to alternate approaches for setting flood planning levels across both Victoria and Australia, which can either adapt or will not be subject to change on a relatively frequent basis. Future policy could consider the use of rarer events between the 1% AEP and PMF to identify flood prone land and adopt additional adaptation measures to manage risk such as warning systems; public education and public awareness processes in addition to infrastructure to preserve life while climate change science is regularly updated.

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