Glenelg Planning Scheme Amendment C108gelg

Expert Witness Report

Revision 2
November 2022

Catchment Simulation Solutions

Glenelg Planning Scheme Amendment C108gelg

Expert Witness Report

Client	Client Representative
Glenelg Shire Council	Jacob Clements

REVISION / REVIEW HISTORY

Revision #	Description	Prepared by	Reviewed by
1	Draft report for review	D. Tetley	C. Ryan
2	Final report	D. Tetley	C. Ryan

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1 Expert Witness Details

1.1 Report Author

This expert witness report has been prepared by:

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Qualifications:

Bachelor of Civil Engineering (Honours), University of Wollongong, 2001

Experience:

I am a civil engineer and Director of Catchment Simulation Solutions who graduated from the University of Wollongong with first class honours and the University Medal in 2001. I have 21 years of experience in preparing flood studies and floodplain risk management investigations in Australia for local government and Catchment Management Authorities. This includes flooding investigations in urban and rural catchments using a variety of computer flood modelling software.

I have been involved in the preparation of over 40 Government-funded flood and floodplain risk management studies and have also prepared several papers on floodplain risk management (this includes highly commended presentation awards at the 2014 and 2022 Floodplain Management Australia Conference). I am also a member of the consultants advisory group involved in the revision of the NSW Government's Floodplain Development Manual.

1.1.1 Statement of Expertise

With my qualifications and experience, I believe that I am well qualified to provide an expert opinion regarding the suitability of the Glenelg Planning Scheme Amendment C108gelg.

David Tetley (14/11/2022)

1.1.2 Declaration

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

I confirm I:

- will be alone in the room from which I am giving evidence and will not make or receive any communication with another person while giving my evidence except with the express leave of the Panel
- I will inform the Panel immediately should another person enter the room from which I am giving evidence
- during breaks in evidence, when under cross-examination, I will not discuss my evidence with any other person, except with the leave of the Panel
- I will not have before me any document, other than my expert witness statement and documents referred to therein, or any other document which the Panel expressly permits me to view.

1.2 Report Scope

CSS was engaged by Glenelg Shire Council (Council) to prepare the expert witness report. The scope of the report was detailed in writing by Council as follows:

- Review the Fitzroy River, Darlot Creek and Heywood Regional Floodplain Mapping Study to confirm it was prepared in accordance with modern best practice
- Review the submissions that were received following the public exhibition of the planning amendment
- Prepare this expert opinion report
- Attend the planning panel meeting

1.3 Report Structure

This expert witness report has been subdivided into the following sections:

- Chapter 2: Introduction – presents the context for the Planning Amendment including the information that formed the basis for the Expert Witness Report
- Chapter 3: Review of Floodplain Mapping – summarises the outcomes of a review of the 'Fitzroy River, Darlot Creek and Heywood Regional Floodplain Mapping Study' and the flood models that form the basis for the flood mapping. It also provides commentary on the flood overlays that were derived from the flood mapping.
- Chapter 4: Review of Community Submissions – summarises each public submission that was received during the public submission of the planning submission and provides commentary regarding whether the information provided as part of the submission is considered to warrant modification to the flood overlays.
- Chapter 5: Review Findings - Summarises the outcomes of the review process including the suitability of the planning amendment.

2 INTRODUCTION

2.1 Background

Flooding is one of the costliest natural disasters in Australia with average annual damage costs totalling $2.9 billion (NRMA Insurance, 2022). However, unlike other natural disasters such as earthquakes or bushfires, areas where flooding is likely are much more predictable. As a result, flooding is one of the more manageable natural disasters.

In this regard, the Department of Environment, Land, Water and Planning in conjunction with the Glenelg-Hopkins Catchment Management Authority and Glenelg Shire Council engaged flood consultants, Water Technology, to prepare the *'Fitzroy River, Darlot Creek and Heywood Regional Floodplain Mapping Study'* (2017). The goal of the Study was to define the extent and characteristics of flooding in the Fitzroy River and Darlot Creek catchments. The outputs from the study assist in understanding where there is a notable flood risk and where flood risk management measures can be potentially implemented in the future to best manage the flood risk.

One of the most effective flood risk management measures is appropriate land use planning. This ensures new development does not occur in high-risk areas and appropriate development controls are applied when development is proposed in lower flood risk areas. This process helps to ensure that:

- High hazard floodways are preserved for the conveyance of floodwaters
- The flooding problem is not increased because of new development
- New buildings are not exposed to frequent inundation and/or damage

As part of this process, Glenelg Shire Council is seeking to translate the results documented in the 'Fitzroy River, Darlot Creek and Heywood Regional Floodplain Mapping Study' (2017) into planning controls for future development and re-development, through the addition of flood overlays. This proposed amendment is referred to as the *Glenelg Planning Scheme Amendment C108gelg*.

The proposed amendment was placed on public exhibition and Council received six (6) submissions. This included four (4) submissions from the community, one (1) submission from the Glenelg Hopkins Catchment Management Authority (CMA) and one (1) submission from the State Member of parliament. Although the non-community submissions supported the amendment, the community submissions opposed the amendment.

Council resolved at the 27 September 2022 Council meeting to refer all submissions to a Planning Panel. Council subsequently engaged Catchment Simulation Solutions (CSS) to undertake an independent review of the floodplain mapping study and the public submissions that were received. The outcomes of the review process are the focus on this expert witness report.

2.2 Project Objectives

The objective of the project was to determine if the proposed zoning changes and flood overlays are appropriate and are based on best practice in floodplain management taking regard to the submissions that were received during the public exhibition of the proposed amendment.

2.3 Information Available

The following datasets and information were made available to CSS to prepare the Expert Witness Report:

- Fitzroy River, Darlot Creek and Heywood Regional Floodplain Mapping Study (Water Technology, 2017):
    - Summary report
    - R01: Preliminary report
    - R03: Hydrology-hydraulics report
- Redacted summaries of submissions
- Mapping and associated public exhibition documents for *the Glenelg Planning Scheme Amendment C108gelg*, as included on the following website: https://www.glenelg.vic.gov.au/Our-Services/Planning-Services/Strategic-Planning/C108gelg-Fitzroy-Darlot-Regional-Flood-Investigation-Implementation/C108gelg-Documents
- Floodway Overlay Delineation (Glenelg Hopkins Catchment Management Authority, 2013)

3 Review of Floodplain Mapping

3.1 Fitzroy River, Darlot Creek and Heywood Regional Floodplain Mapping Study

The flood overlays that form the proposed amendments to the planning scheme are based on flood model outputs produced as part of the '*Fitzroy River, Darlot Creek and Heywood Regional Floodplain Mapping Study'* (Water Technology, 2017). Therefore, it is important that the Floodplain Mapping Study and the flood models that underpin the results documented in the Study are reliable. Therefore, a review of the Floodplain Mapping Study was completed.

The Study was completed by Water Technology, a company that specialises in flood and coastal work. They have completed numerous floodplain mapping studies across Victoria and their work is generally well regarded.

The flood mapping presented in the Study is produced using hydrologic and hydraulic computer models. The hydrologic model is used to simulate the conversion of rainfall into runoff and produces flow estimates at key locations along each watercourse for a variety of flood sizes. The RORB software was used to develop the hydrologic model. RORB is the most commonly used hydrologic software for flood studies in Victoria and is, therefore, well vetted on catchments similar to the Fitzroy River and Darlot Creek. The parameters used to develop the RORB model are considered to be within reasonable bounds.

A flood frequency analysis based on stream gauge records for the Fitzroy River at Heywood was also attempted to supplement the hydrologic model results. However, it was determined that this gauge did not capture all flow from the upstream catchment due to a flow bifurcation (i.e., a flow split) upstream of Heywood which resulted in a proportion of the total flow bypassing the gauge. Therefore, it provided unreliable flow estimates for larger floods and could not be used to generate a reliable flood frequency output. Although this is considered reasonable, a synthetic rating curve (based on the hydraulic model outputs) could have been trialled and potentially used to update the flow estimates for the gauge and provide an additional means of validating the design flow estimates generated by the hydrologic model.

The hydraulic model, which takes the flow estimates from the hydrologic model and is used to calculate key flooding characteristics such as water depths, levels, extents and velocities, was developed using the MIKE21FV software. MIKE21FV is a fully two-dimensional hydraulic software package. Although MIKE21FV is not as commonly used as other hydraulic software packages (e.g., TUFLOW), the underlying model development techniques, inputs and calculations are similar and provide reliable flood estimates providing the software is appropriately applied.

The hydraulic model includes a representation of key drainage features (e.g., bridges) and the model mesh has been aligned to ensure key topographic features (e.g., road embankments) are captured. Key model inputs such as roughness coefficients are within reasonable bounds and were adjusted as part of the calibration process. It does not appear as though a representation of blockage of hydraulic structures (e.g., bridges) was incorporated into the modelling, which is recommended as part of '*Australian Rainfall and Runoff - A Guide to Flood Estimation*' (Ball et al, 2019). However, this would only serve to increase water levels and inundation extents across Heywood, particularly blockage of the railway culverts, which serves as a major flow control in the area.

Computer models are approximations and, often, simplifications of actual river and catchment conditions. Therefore, it is important that the models are calibrated to historic floods to ensure the model setup and underlying assumptions are reasonable and are producing reliable estimates of flood behaviour. Four events were selected for model calibration: 1946, 2007, 2010 and 2013. This includes several flood marks for the 2007 flood around Cameron Street at Heywood. Between the Princes Highway and Bond Street (including Cameron Street), 4 historic levels are reproduced to better than 0.1 metres and the remaining 3 historic levels are reproduced to better than 0.2 metres. This is a reasonable correlation although it's noted that the simulated levels were more commonly higher than the recorded water levels.

The calibrated models were subsequently used to simulate a range of design floods. This includes the 1% AEP flood that forms the basis for the flood overlays. Design flood behaviour was defined based upon the 1987 version of '*Australian Rainfall and Runoff - A Guide to Flood Estimation*' (Engineers Australia). This has since been superseded by the 2019 revision of '*Australian Rainfall and Runoff'* (Ball et al). Although the 2019 revision is now considered modern best practice, the 1987 version was best practice at the time the study was prepared. Nevertheless, the Study did compare updated design rainfall estimates that were in draft format in 2016 and this comparison indicated the new design rainfall was, on average, 8% higher than the rainfall documented in the 1987 version. That is, moving to the updated procedures may actually produce higher design flows and flood estimates. However, as the updated rainfall and updated hydrologic procedures detailed in the 2019 revosion were not finalised at the time the Study was prepared, it is considered that the adopted approach is reasonable. However, consideration should be given to updating the modelling in the future to take advantage of the 2019 revision (e.g., if mitigation options are explored).

A review of the design flow estimates shows the PMF flows documented in Table 4-2 are much higher than the other design flows included in Table 4-1 (i.e. for the Fitzroy River, the peak PMF flow is 10 times greater than the peak 1% AEP flow). This differential is at the upper end of typical ranges and might suggest the PMF flows are too high. A review of the rainfall losses suggests this difference is due to lower rainfall losses being applied to the PMF relative to the other design events, as per guidance provided in '*Australian Rainfall and Runoff'*. Regardless, as the PMF is not used to develop the flood overlays, this not considered to be problematic for the planning amendment.

The Study notes that a hydrologic and hydraulic study of the Fitzroy River at Heywood was completed by Cardno in 2008. However, limited information is provided as to how the updated Study compares to the 2008 study. It is often valuable to include comparisons with past studies as an additional means of validating the model performance and also to assist the various agencies, emergency services and the community in understanding how the flood risk may have changed as a result of the new study.

As part of the expert review, I have reviewed and compared the results documented in the 2008 study. This shows that the updated study produces lower design flow estimates at Heywood. Furthermore, the 1% AEP flood depth map presented in the 2008 study (extract shown in **Plate 1**), shows a larger inundation extent relative to the LSIO. For example, the Cardno 2008 1% AEP inundation extends south of the Hunter/Fitzroy intersection while the LSIO is contained north of the same intersection. It is also evident that the LSIO provides a much better representation of topographic features such as the crowns of roads. Therefore, although there is not an abundance of flood information for validation purposes, the information that is available provides evidence that the revised modelling provides a more detailed understanding of potential inundation and the results for the 1% AEP flood are not overstated.

Overall, my view is that the floodplain mapping study, models and outputs are fit for purpose for developing flood planning controls, including overlays. However, it could be of benefit in the future to update the design flood estimates based on the 2019 version of Australian Rainfall and Runoff and to take advantage of an updated flood frequency analysis to further verify the design flow estimates.

3.2 Translation to Flood Overlays

Glenelg Hopkins CMA has prepared a standardised approach for the derivation of Floodway Overlays (FO) and Land Subject to Inundation Overlays (LSIO) (GHCMA, 2013). Both overlays utilise modelled outputs for the 1% AEP flood, which is standard practice across Victoria as well as Australia for flood planning purposes. This standardisation approach ensures that the flood overlays are processed in a consistent manner.

Areas within the 1% AEP extent are defined as floodways if they meet the following criteria:

- The peak depth exceeds 0.5 m; and,
- The peak velocity x depth exceeds 0.4 m^2/s.

The remaining area (i.e., areas located outside of the floodway but within the 1% AEP flood extent) is defined as LSIO.

The GHCMA approach combines floodway and flood storage into the FO. This is achieved using the peak depth filter to capture areas that are deep but slow moving (i.e. flood storage). This conforms with the Department of Environment, Land, Water and Planning (DEWLP) definition of floodways, which states that it includes areas of temporary storage of floodwaters.

GHCMA (2013) also outlines a number of processing steps that may be completed to refine the overlays. This includes:

- Smoothing of gridded flood model results to provide a more realistic representation of flood extents
- Removal of disconnected "puddles"
- "Filling" of low hazard areas surrounded by high hazard areas

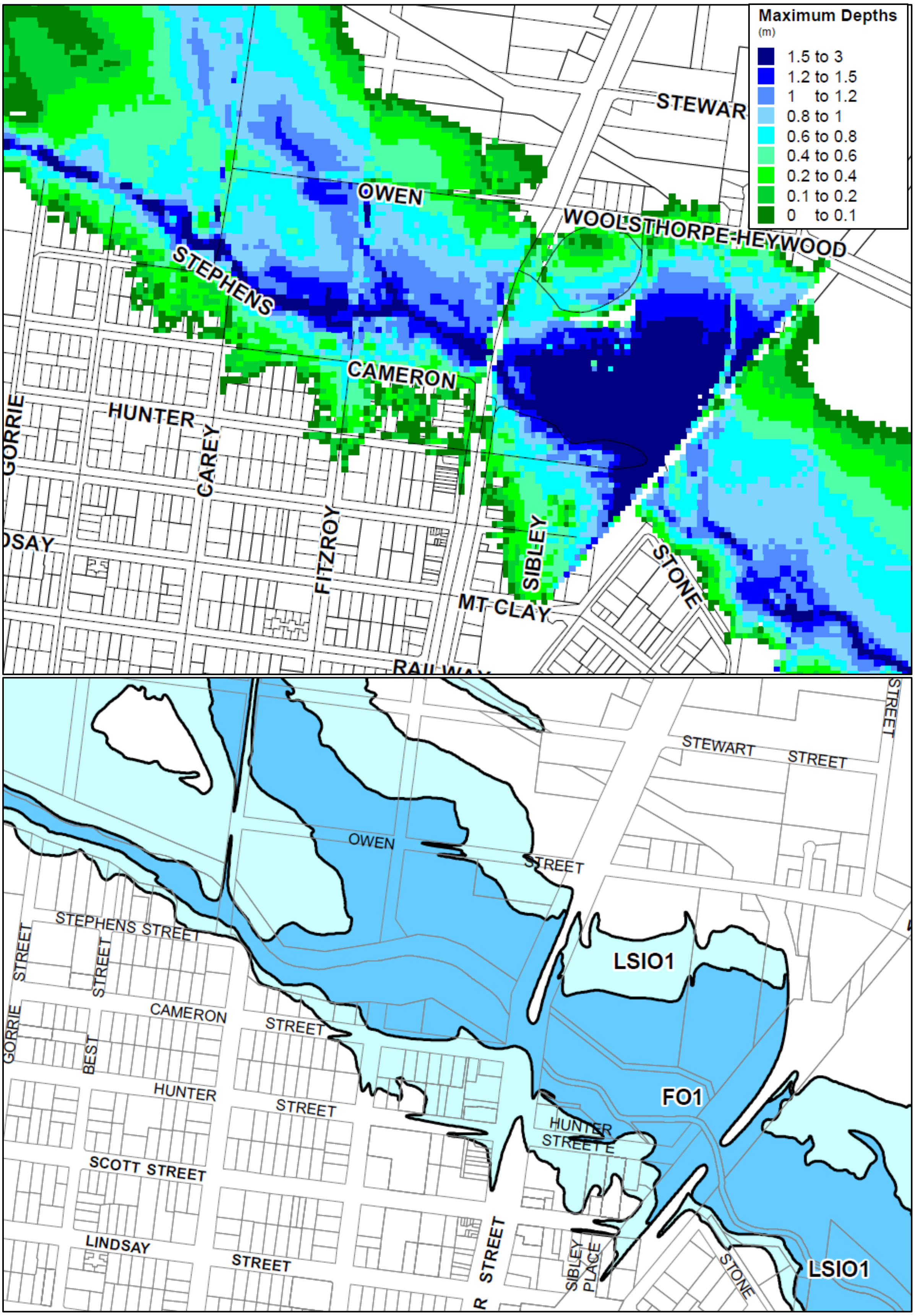

Plate 1 Comparison between Cardno (2008) 1% AEP water depths (top image) and flood overlays (lower image)

- "Filling" of flood islands that may not have direct flood risk but may not be appropriate for development due to evacuation difficulties. A maximum area threshold of 1,000 m^2 is nominated for the filling of "islands".

It should be noted that Catchment Simulation Solutions prepared the flood overlays based on the flood mapping results produced by Water Technology. Therefore, we cannot undertake a completely independent review of the process despite the flood overlays being prepared by a person independent of this report within the company.

However, based on the authors review, the proposed overlays suggest that the processes outlined above have been completed accurately and appropriately. It is acknowledged that in some areas the smoothing process will locally increase or decrease the flood extent compared to the raw model results. However, these are generally small and will be unlikely to change the impacts on individual properties.

In summary, the 1% AEP flood outputs from the flood modelling completed for the '*Fitzroy River, Darlot Creek and Heywood Regional Floodplain Mapping Study*' (2017) appears to have been appropriately translated to create the flood overlay layers.

4 Review of Community Submissions

4.1 General Comments

A review of the six (6) community submissions that were received by Council following the public exhibition of the planning amendment was completed and the general nature of each submission is highlighted in green in Table 1.

Table 1 Summary issues raised within the submissions

<table>
<tr><th rowspan="2">Submission Number</th><th colspan="5">Issue</th></tr>
<tr><th>Modelling or Mapping Issue</th><th>Increases Insurance Premiums</th><th>Reduced Property Values</th><th>Impact from Infrastructure</th><th>Lack of Mitigation Measures</th></tr>
<tr><td>1</td><td bgcolor="green"></td><td bgcolor="green"></td><td bgcolor="green"></td><td bgcolor="green"></td><td bgcolor="green"></td></tr>
<tr><td>2</td><td></td><td bgcolor="green"></td><td></td><td></td><td bgcolor="green"></td></tr>
<tr><td>3</td><td bgcolor="green"></td><td bgcolor="green"></td><td bgcolor="green"></td><td bgcolor="green"></td><td bgcolor="green"></td></tr>
<tr><td>4</td><td colspan="5">Supports the amendment</td></tr>
<tr><td>5</td><td></td><td></td><td></td><td></td><td bgcolor="green"></td></tr>
<tr><td>6</td><td colspan="5">Supports the amendment</td></tr>
</table>

As outlined in Table 1, the issues raised within the submissions cover a number of different aspects of floodplain management. This includes issues related to property values and insurance costs which are outside of the area of expertise of this reviewer. However, a discussion on the general issues that were raised as part of the submissions is provided below based on information that is readily accessible.

A more detailed review of individual submissions is provided in Section 4.2.

Lived Experience of Flooding

Three of the submissions cite lived experience (ranging from 6 to 23 years) as their evidence that the flood model over-estimates flood levels and extents. As noted in the Executive Summary of the 'Fitzroy River, Darlot Creek and Heywood Regional Floodplain Mapping Study' (2017), the three most significant floods over the past two decades (i.e., 2007, 2010 and 2013 floods) were relatively small (i.e., a frequency of between 10% AEP and 5% AEP is referenced in the report). This tends to be confirmed by the recorded discharges for the Fitzroy River stream gauge at Heywood which shows the recent floods comprised flows that were lower than other floods during the 1970s, 1980s and 1990s.

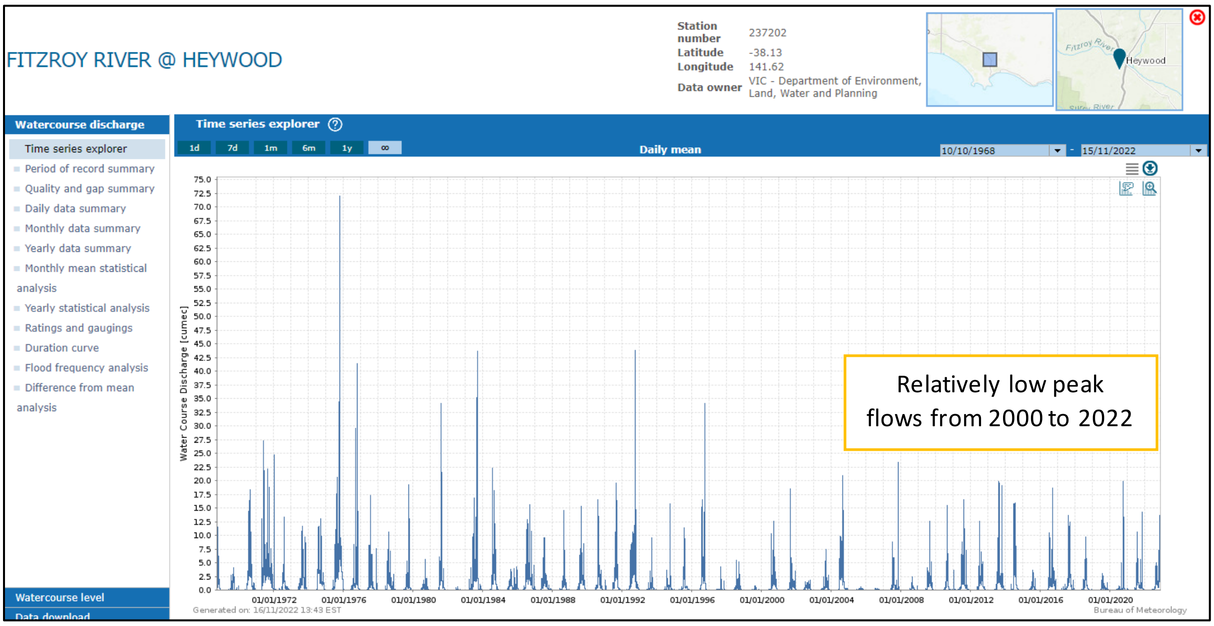

Plate 2 Historic discharges for the Fitzroy River at Heywood

The design flood that forms the basis for the flood overlays is the 1% AEP flood. Therefore, the flood that forms the basis for the overlays is larger than what has been experienced over the past 20 and it is, therefore, not possible to directly compare the flood observations with the flood overlays.

However, it is possible to compare the performance of the flood model and the flood mapping against the specific calibration simulations that were completed for the 2007, 2010 and 2013 floods. This shows that the hydraulic flood model reproduced recorded flood levels in the vicinity of Cameron Street to better than 0.2 metres.

Therefore, the available information confirms that the flood model is providing a reliable reproduction of historic flood levels and that a 1% AEP flood (i.e., the flood that forms the basis for the flood planning overlays) is likely to be much larger than any experienced by the contributing community members.

Increases in Insurance Premiums

As the author does not work for the insurance industry, information on how flood insurance premiums are calculated are included in **Appendix A**. The information presented in Appendix A shows that premiums for flood insurance are typically calculated by insurance companies based on flood modelling results either developed internally or where available, from publicly available flood studies including those uploaded to the Victorian Flood Database.

The planning scheme amendment is based on flood modelling results that were completed in 2017. Our understanding is that this information is already available on the Victorian Flood Database. Therefore, it is likely that this information is already being used to inform insurance premium quotes and changes to the planning scheme should not directly impact on insurance premiums.

Reduced Property Values

There is very little literature available describing the impact of flood overlays/flood liability on property values. However, one such paper is enclosed in **Appendix B** and indicates that it is very difficult to "distil" the impact of flood disclosure on property values due to the fact that market prices are driven by a range of factors. The paper does provide evidence of property discounting in some situations (e.g., Brisbane in 2008). However, the paper concludes that there is 'scant evidence of sustained decreases in the value of houses with a flood risk'.

It should also be reinforced that the objectives of the flood overlays are to protect life and property. Without the inclusion of flood overlays, uncontrolled development may occur which leads to situations where lives are at risk and inappropriate development is damaged or exacerbates damage on existing development. Therefore, any impacts on property prices cannot be placed in front of the risk to property damage and/or risk to life as a result of flooding.

Impact from Infrastructure and Lack of Mitigation Structures

Several submissions raised a lack of appropriate infrastructure, and the lack of flood mitigation works as a reason for exacerbated flood overlay extents. The capacity of the railway bridge, the lack of maintenance of vegetation within the Fitzroy River and the potential to construct a new levee adjacent to the river were highlighted as part of the submissions.

The flood overlays reflect the flood risk as it currently exists. In this regard, it is not possible for the flood overlays to be modified to reflect potential future mitigation measures. If flood mitigation options are investigated and ultimately implemented, there will be opportunity to modify the flood overlays at that time.

4.2 Review of Submissions

A review of each submission that opposed the planning amendment was completed and is documented in the tables below.

Table 2 Review of Submission 1 (16-18 Cameron Street, Heywood)

Submission Summary	CSS Comments
Land is built up over 3 feet higher than the surrounding blocks. In the 6 years the river has broken its banks sometimes twice a year and at the highest would need to rise a further 1.5m to enter the backyard and reach the back patio. A further rise of 12cm to reach the back door. Questioning if this has been taken into account?	The topography of this area is represented in the digital elevation model, and this is reflected in the simulated 1% AEP flood extent which presents this area as an "island" (as extract from the GHCMA flood information portal is provided below showing this). Therefore, the terrain and the impacts on inundation extents are taken into account.

	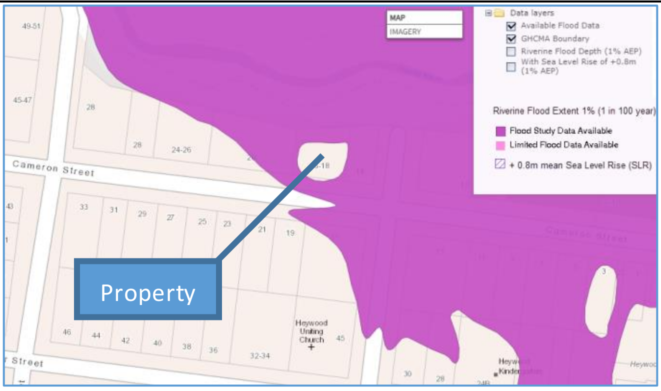 As discussed, the floods that have been experienced recently have not approached the size of the 1% AEP flood which forms the basis for the flood overlays.
Why has there been no action to install addition culverts under the railway line as it appears to have a dam effect and puts the town at higher risk. Why has there been no clearing of the river system to prevent the overflow effect? Who is responsible for this? How often has it been cleaned and cleared of debris and reeds?	The floodplain mapping and flood overlays are concerned with the existing flood risk. Therefore, potential future mitigation measures cannot form the basis for modifications to flood overlays. If mitigation measures are implemented in the future, the flood overlays will be updated to reflect the revised inundation extents.
The Flood Information Property Report from GHCMA shows the 1% AEP (1 in 100yr ARI) outside of the property.	A review of the Glenelg Hopkins online flood mapping (as shown above) shows the site in question falling partly within the 1% AEP flood extent, with the higher sections of the site excluded. Therefore, although most of the site is not impacted by the 1% AEP flood, parts of the property do fall within the 1% AEP extent.
Concerns about insurances and effect on mortgage. Will the property be devalued and if so will rates be reduced?	As discussed in Section 4.1, insurance premiums should not be impacted as insurance companies are likely already utilising flood information from the 2017 Study. Although there is potential for impacts on property values, the limited amount of information suggests that there is no clear evidence of sustained decreases in the value of houses with a flood risk.
Request a revision of the boundaries to exclude the property.	Although most of the property is elevated above the peak 1% AEP flood level, a flood risk remains (notably potential evacuation difficulties/isolation). Therefore, it is considered appropriate to retain the property within the LSIO to ensure any future development is cognisant of the risk and does not increase the flood exposure of the site in question or adjoining properties.

Table 3 Review of Submission 2 (3 Cameron Street, Heywood)

Submission Summary	CSS Comments
Concerned about residents affected by the amendment. House was built in 2014 and required an extra $40,000 on engineering due to the floodplain level requiring approx. 800mm foundation above street level.	It appears that the property has been constructed with consideration of the potential for flooding of the site. Although this is an added construction cost it will reduce the potential for above floor flooding which will significantly reduce the potential for flood damages costs to be incurred during future floods. It should be recognised that the flood overlay does not prevent development/re-development; it ensures development occurs in a way that recognises the flood risk and minimises the potential for adverse flood impacts on the community.
Obtaining affordable insurance is difficult with mandatory flood cover despite being built above the flood plain. Further amendments will mean insurance increases along with the added increase in Council rates and general living costs.	As discussed in Section 4.1, insurance premiums are already likely to be using the flood information from the 2017 Study. Therefore, the amendment should not increase insurance premiums.
Council should construct a 1.5m levy bank as suggested by a professional town planner. The levy bank would provide year-round access to walk along the river and access to Apex Park. Another option would be to dredgethe river of reeds/weeds that hinder the flow.	The floodplain mapping and flood overlays are concerned with the existing flood risk. Therefore, potential future mitigation measures cannot form the basis for modifications to flood overlays. In the event mitigation measures are implemented in the future, the flood overlays will be updated to reflect the revised inundation extents.

Table 4 Review of Submission 3 (13 Cameron Street, Heywood)

Submission Summary	CSS Comments
The summary report appears to have a lot of hypothetical theories (hydrological and hydraulic modelling) and no actual or very little data to base their study on. Quotes included from 2.1 Flood related Studies and 12.2 Historic Flood Information.	Hydrologic and hydraulic models are the most common method of quantifying flooding. A review of the modelling approach has been completed and this determined that the models were developed in a robust manner. A common limitation of flood models is a lack of historic information to calibrate against to confirm the models are providing reliable flood estimates. Fortunately for this study, the models have been calibrated against recorded flood information for 4 historic floods. This includes multiple historic water levels within Heywood. The models were shown to reproduce these historic flood levels to better than 0.2m. Therefore, the models do appear to have utilised all available information as part of the model validation process.

Under the Rainfall Data (2.5.1) they have listed daily rainfall sites within the catchment area and how many years they have been recording. But they have not provided how much rain was recorded prior to each flood event. That information would be vital in determining the severity of flooding to be expected in the township of Heywood by knowing how much rain fell in the catchment area prior to any flood event.	Section 2.5.1 is concerned with the location and recording period of the gauges only. This information is then used to inform which gauges were active during each calibration event. The preceding/antecedent rainfall is then accommodated as part of the calibration simulations. The study acknowledges that flooding in the catchment is different under dry versus wet catchment conditions. Based on guidance provided by the project steering committee, a wet catchment was adopted as part of the design flood simulations, given wet catchment conditions have produced some of the largest floods on record (e.g., 1975). Therefore, the study has reviewed the historic flood record, including the dryness/wetness of the catchment and has made a reasonable assumption for the design flood simulations.
The highest level reached since started living at 13 Cameron Street in 1999 where Heywood received 4 inches (100mm) of rainfall over a 96 hour period (4 continuous days of rain) prior to the flood event of 2010. The land was not inundated from that event, but there was a build-up of storm water on the south side of Cameron Street. Was caused by the storm water in the stormwater culvert under the road not being able to get away quick enough.	This observation is generally consistent with the flood mapping that is presented in the hydrology/hydraulic report for the 2007, 2010 and 2013 events. The mapping shows 13 Cameron Street being clear of floodwaters but water is shown extending across the public reserve/park and onto Cameron Street. As noted earlier, the 2007, 2010 and 2013 floods are smaller than the 1% AEP flood which forms the basis for the flood overlays.
Totally impossible to reach the Probable Maximum Flood stated at 4.2.4 and question how much rainfall would be needed in to reach that level in a 24 hour period.	The PMF is not used to inform the flood overlays. The PMF information presented in Section 4.2.4 documents peak flows/discharges, not flood level. The PMF reflects the biggest flood that is possible. For a 24-hr storm, a total rainfall depth of around 530mm would be required.
The study forms the basis for the local floodplain development plan prepared for the planning scheme. No doubt that the amendment will be implemented by Council and need to discuss what this means for the residents of Heywood that have developed properties in the new LSIO. The incorporated document talks about future development, but all the residential blocks have been developed except for 20 Cameron Street that would need to be subdivided first.	The planning amendment will ensure future development (both new development and re-development) occurs in a way the recognises the flood risk and ensure that this development does not increase the flood risk. By identifying land with a flood risk, it helps to ensure the risk to the broader community is reduced through application of appropriate development controls and ensuring high risk/inappropriate development does occur.

The only outcome is increased insurance premiums and uncertainty for people to totally replace a dwelling.	As discussed in Section 4.1, insurance premiums are already likely to be using the flood information from the 2017 Study. Therefore, the amendment should not increase insurance premiums. Planning requirements for properties falling within the flood overlays are detailed in the Glenelg Planning Scheme.
There is no mention of Heywood under 2.1 Flood History, 2.2 Flood Impacts, and 2.3 Flood Information in the incorporated document.	Section 2.1 summarises past flood investigations. It contains limited flood information for Heywood due to the lack of previous studies (one of the motivations behind preparing the 2017 Floodplain Mapping Study). However, Heywood is discussed in the final paragraph. Heywood is mentioned multiple times under Section 2.2, including the relative magnitude of historic floods at Heywood in Table 2-1. Section 2.3 is concerned with topographic information which covers broader geographic areas (but, again Heywood is discussed).
Quote from 3.0 Land Use and Development Objectives. Does this mean that Council will undertake a similar approach to protect developed properties in the new LSIO to historical clean-up efforts of the Shire of Portland and Shire of Heywood in 1977 and 1986 respectively?	I cannot provide commentary on potential Council-related actions.
If there is no action from Council to dredge the river allowing more trees and reeds to restrict the flow of the river, build a levee bank, or add culverts at the railway bridge the only outcome will be more frequent flooding with less rainfall in the catchment. This is concerning despite no current concern of the land being flooded.	While it is acknowledged that there is a flood risk across part sections of Heywood, the flood overlay is concerned with the current/existing flood risk. Therefore, potential future mitigation measures cannot be reflected in the flood overlays. Any modifications to flood behaviour/extents that arise due to implementation of flood mitigation measures will be reflected in future flood overland amendments.

Table 5 Review of Submission 5 (11 Cameron Street, Heywood)

Submission Summary	CSS Comments
Agree with the submission of neighbour at 13 Cameron St, Heywood. Build a 1.5m levy bank for approx. 1km from Bonds Lane (Bond St) to behind Stone St.	As discussed in Table 4, the flood overlay is concerned with the current/existing flood risk. Therefore, potential future mitigation measures cannot be reflected in the flood overlays. If the levee (or other mitigation options) is implemented in the future, the flood overlays can be amended to reflect the revised inundation extent.

5 REVIEW FINDINGS

Mr David Tetley of Catchment Simulation Solutions has completed a review of the floodplain mapping study used to inform the proposed planning amendment, how the information from this study has been translated into the flood overlays, and the submissions received following public exhibition of the planning amendment.

Although some potential improvements to the Floodplain Mapping Study were identified, these modifications would not reduce the predicted flood levels and extents. Therefore, none of these are likely to have a significant impact on the outputs that form the basis for the planning overlays. Furthermore, the revised 1% AEP design flows, flood levels and flood extents appear to have reduced relative to a study completed by Cardno in 2008. Therefore, there does not appear to be any evidence to suggest that the 1% AEP flood results and the flood overlays that are derived from these results are overstated.

Based on our review of the public submissions, there does not appear sufficient evidence to support modifying the flood overlays. Although mitigation measures could be potentially implemented in the future to reduce the extent of the flood overlays, the flood overlays that are the subject of this planning amendment must reflect the current flood risk.

Overall, the review concludes that:

- The Floodplain Mapping Study appears to have been developed in accordance with modern best practice and the 1% AEP flood extent that form the basis for the flood overlays does not appear to overstate the extent of inundation
- Community engagement and education is recommended to assist the community in understanding the potential flood risk and how this risk can be managed in the short term.
- Opportunities to further validate the hydrology for the Fitzroy River at Heywood should be explored in the medium term through development of a synthetic rating curve. The flood estimate approach could also be updated in the future to reflect the 2019 revision of Australian Rainfall and Runoff.
- Flood risk mitigation options that have been suggested by the community could be explored. If these options are found to be feasible and are implemented, the flood overlays should be updated to reflect the revised extent of inundation/flood risk.

6 REFERENCES

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Appendix A

Flood Insurance Pricing Information

Local Government and Insurance

Flood Insurance Pricing

As of March 2015, more than 93% of home building and contents insurance policies contain flood cover as a standard inclusion. This is largely due to rapid improvements in access to flood information, as well as insurers' ability to understand and price the risk of flood damage to properties across Australia. Prior to 2007, information about flood risk in Australia was considered so poor that most insurers were unable to provide flood cover.

Things have changed. We now know approximately 15% of properties in Australia are at some risk of flooding. For these properties, insurers may charge an additional flood insurance premium in order to collect sufficient premiums to meet the cost of future claims as they arise.

Whilst all insurers approach premium calculation in different ways, this fact sheet outlines the common approaches and generic process followed.

General insurance pricing in Australia

General insurers take on their customers' risk, turning them into a 'policyholder', allowing them to manage the financial burden of damage resulting from a specific event such as a flood. Insurers identify and then manage the costs of these risks to make sure there is enough money coming in through premiums to pay claims.

Broadly speaking, general insurance in Australia is risk rated. In a risk rated insurance market, an insurer calculates the premium payable on the basis of various factors specific to an individual property, such as the likely frequency and size of a claim and the estimated value of such claims during the term of an insurance policy.

Why flood risk is assessed separately to other risks

For events such as house fire, earthquake and hail damage, the chance of an event occurring is fairly evenly distributed – neighbouring properties will have roughly the same risk of being affected by an event and making an insurance claim.

Flood risk is different – most properties in Australia have little or no risk of being flooded. While around 15% of properties in Australia have some level of flood risk, only 2-3% of properties have a high risk.

The minority of properties which are at high or extreme risk of flooding contribute disproportionately to the claims paid out by insurers, and are more likely to make repeated claims. To ensure they are able to continue offering flood insurance in a sustainable manner, insurers need to charge an additional flood insurance premium that reflects the level of flood risk at each property.

What is a 'flood'?

Since 2014, all home building, home contents, small business and strata insurance policies have adopted a common definition of "flood":

> *"The covering of normally dry land by water that has escaped or been released from the normal confines of any lake, or any river, creek or other natural watercourse, whether or not altered or modified; or any reservoir, canal, or dam."*

Events such as a ruptured hot water system, water entering through windows and eves during a storm, sea level rise and storm surge are not considered "flooding" for insurance purposes. These events may be covered under other elements of an insurance policy.

Consumers should always read their Product Disclosure Statement (PDS) when entering into an insurance contract, to understand which events are covered under their policy.

Factors that affect a flood premium

Flood insurance premiums generally reflect the level of flood risk at a property and the cost of repairing or rebuilding the property. In practice, this can be broken down to three factors which would be assessed by all insurers when setting a flood premium for a property:

- ✓ Likelihood of flooding;
- ✓ Expected depth of flooding relative to the insured building; and
- ✓ Expected cost of recovery.

Likelihood and depth of flooding are assessed at an individual address level, using results from computer flood modelling which simulates how water flows through a catchment. Expected cost of recovery includes repair, rebuild and replacement costs, temporary accommodation, and other factors such as the potential shortage of materials and labour after a flood event.

Some insurers may also consider property-specific information such as number of storeys, floor levels, building materials used and construction type

Information insurers use to assess the level of flood risk at a property level

Insurers prefer to use the highest quality flood modelling available - this usually means a local or state government flood study. Where government makes flood hazard data available to the industry, the raw data is:

- incorporated into the industry's National Flood Information Database (NFID) which provides an assessed depth of flooding (if any) for all addresses in Australia in a format usable by underwriters; and

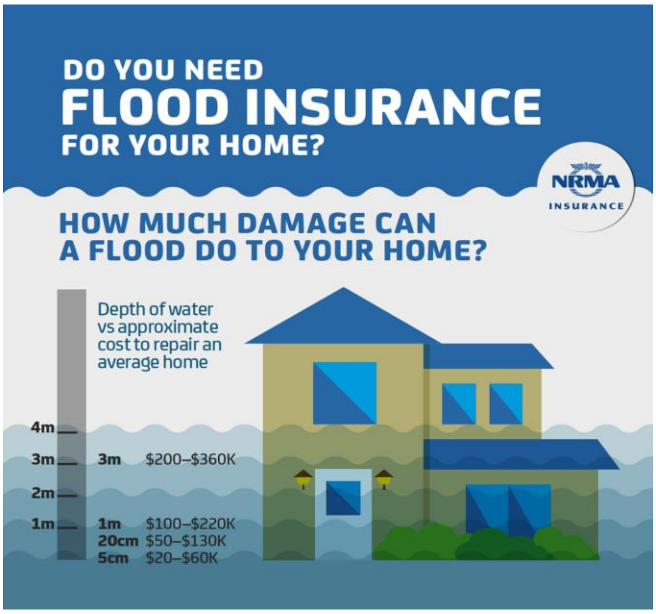
- shared with all participating insurers.

In areas where a government chooses not to share data with insurers or where government flood data is not available, insurers are often forced to refer to alternative sources of flood data including historical flood extents and non-government flood modelling datasets. You can read more about this in the ***Sharing Flood Risk Information*** fact sheet.

The cost of damage caused by floods

Flood damage can range from just ruining carpets and contents, to destroying entire kitchens, electrical wiring and even causing structural failure requiring a complete rebuild - the cost of recovering from even minor flooding can be surprisingly high.

The diagram below shows indicative costs to recover from floods of various depths, from one insurance company:



Flood insurance premiums are proportional to the flood risk at a property – this high cost of recovery can unfortunately result in high premiums in areas with a high likelihood of flooding.

Why insurers charge a flood premium for properties outside a Council's flood risk zone

Most local governments only apply planning controls in areas identified as 1-in-100-year flood zones (i.e. a 1% chance of flooding per year).

Flood insurance covers ALL flood events, including much larger (or less-likely) floods than the 1-in-100-year event. In some parts of Australia, extreme flood events can occur with depths 8-10m higher than the 1-in-100 year event, affecting properties well outside the 1-in-100-year flood zone.

In reality, if you live in a 1-in-100-year flood zone there is a 55% chance that you will experience a flood event larger than the 1-in-100-year flood within an 80-year lifetime. As insurers cover all flood events they have to take all flood risk into account when setting flood premiums, not just the flood risk up to the 1-in-100-year event.

Insurers do not assess flood risk based on postcodes

Flood hazard is very location-specific and insurers understand that it is not possible to make confident estimates of flood risk based on a postcode. To ensure that insurance premiums reflect the risk at each individual address, insurers have access to address-specific flood hazard data through the National Flood Information Database (NFID) and other sources.

Insurers don't include climate change or sea level rise in the cost of premiums

You may have seen media reports about projected sea-level rise or climate change scenarios leading to higher insurance premiums. This is a myth. Insurers are not covering risk in 25, 10 or 5 years time. They are covering the next 12 months from when a policy begins. This means insurers are interested in current risk and set premiums based on the current risk, not the risk under any projected future climate scenarios.

What to do if you think an insurer has assessed flood risk incorrectly

The insurance industry makes significant investments in sourcing the best quality up-to-date flood information. However insurers do not have access to all information relevant to every property. This is more likely for newer subdivisions which have been raised to reduce flood risk, for houses elevated on piers to reduce flood vulnerability, and for houses built on the high part of large rural blocks.

If you have evidence that an insurer has incorrectly assessed risk of flooding (e.g. a Council flood study, floor level survey, site-specific flood report or similar), please contact the insurer directly to discuss. Many major insurers have dedicated flood premium review processes in place and welcome information that helps improve the accuracy of their flood risk assessments. The Insurance Council of Australia (ICA) can also assist in reviewing information if an insurer cannot. Providing the insurer or ICA documentation will assist in this discussion.

It is also important to shop around if you are not satisfied by the premium or cover offered by your insurer.

Go to insurancecouncil.com.au or floods.org.au for further information including contact details.

Appendix B

Effects of Disclosure of Flood-Liability on Residential Property Values

EFFECTS OF DISCLOSURE OF FLOOD-LIABILITY ON RESIDENTIAL PROPERTY VALUES: AN UPDATE

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Abstract

This paper provides a review of the international and local literature assessing the impact of flood risk information on residential property values. We extend the findings of a previous review conducted over a decade ago when flood risk disclosure regimes in Australia were quite different. After a brief discussion of methods typically used for assessing the value of flood risk and their strengths and weaknesses, we examine three questions. On the question of the effect of being located in a floodplain there exists considerable heterogeneity in the empirical results, though flood-prone land is often discounted. The degree of discounting may be associated with the degree of risk, and the discount can often be traced back to a flood event. But sometimes positive attributes of a waterfront or coastal location outweigh any discount. On the question of the effect of an actual flood event on property values, the characteristic effect is discounting in impacted areas, exacerbated by multiple floods in a short time-span and even extending to areas not flooded. Property values typically recover in time. On the question of the effect of floodplain designation and its disclosure, we find it can initiate or increase discounting, or have no effect, or even reduce discounting. This relates to the different forms of disclosure, particularly whether it is mandatory and at what point in the transaction process the flood risk is revealed. We conclude with implications for flood risk managers in Australia.

Introduction

A common complaint against the release of flood information is a presumed adverse effect on housing values. In an attempt to shed some light on this vexed issue in an Australian context, Risk Frontiers reviewed international and local literature (Yeo, 2002; 2003; 2004). The review found the evidence equivocal with some studies, particularly from the United States, finding flood-prone properties discounted compared to equivalent flood-free properties, with others finding no significant difference. Actual flooding of a property was more likely to adversely affect property values than a floodplain designation. The balance of evidence suggested that fear of adverse impacts was over-rated.

It appears that the Risk Frontiers' review has had some influence in helping Australian flood managers respond to a sometimes hostile public concerned about the disclosure of flood risks. Figures 1 and 2 present extracts from two education resources intended to allay residents' fears that the release of flood maps or plans could lead to a loss of property value. The first is from the Flood Victoria website and the second is from a fact sheet developed by the Floodplain Management Association (FMA) in partnership with the Insurance Council of Australia (ICA). Both have drawn either explicitly or implicitly on that research conducted over a decade ago.

Figure 1: Extract from Flood Victoria website

What will flood mapping do to my property value?

Research in Australia* indicates that such policies do not have a noticeable effect on property values, particularly in high value markets such as Melbourne where other factors are more dominant.

If your property has been identified as having a flood risk, the real flood risks on your property have not changed, it's only that flood information is now more transparent through planning scheme flood overlays and planning certificates contained in Section 32 (Vendor's) statements when selling a property (required under the *Sale of Land Act 1962*). A prospective purchaser of your property could have previously discovered this risk if they had made enquiries themselves.

** Dr Stephen Yeo, "Are Residential Property Values Adversely Affected by Disclosure of Flood Risk?" Proceedings of the 44th Annual Floodplain Management Authorities Conference, Coffs Harbour May 2004.*

Figure 2: Extract from 'Flood, Insurance and Your Property' fact sheet (FMA)

Will Council's flood plan affect the value of my property?

Many factors affect the property market and the individual choice of buyers, including interest rates, the health of the economy and the desire to live in a particular location. Studies on the value of properties in flood-affected areas here and overseas show some consistent patterns:

- There is already a discount built into the market for properties that are known to flood
- Even in known flood areas, other factors such as aspect, views, and direct water frontage are strong drivers of value
- In some particular cases prices may drop after a major flood or other disaster prices (typically five to 10 per cent) but generally recover after one or two years

But do the conclusions reached in the previous studies remain valid? And are the public education messages that draw upon that work, still legitimate? Certainly much has changed in the intervening time. Public outcries after damaging floods—including Wollongong in 1998, Newcastle in 2007 and, particularly, Brisbane in 2011—has led to a marked change in the availability of flood insurance, with (as of March 2014) 93% of home building and insurance policies including flood cover either as a standard inclusion or on an opt-out basis (FMA, 2014). Insurers have become progressively better informed about flood risks through the development of the National Flood Information Database (NFID), since its first release in December 2008 (Leigh et al., 2010). Together with Risk Frontiers' Flood Exclusion Zones, insurers now have a form of flood information for some 93% of Australian addresses. In theory we would expect insurers' use of risk-adjusted premiums to send a clear signal to homeowners, potential purchasers and local councils.

In keeping with the National Strategy for Disaster Resilience (COAG, 2011), there has also been increasing emphasis on communicating information and educating people about flood risks. State and Local governments, for example, are increasingly making flood maps or property level risk data publicly available to consumers on their websites, mostly in respect to the extent of flooding in a design flood with a 1-in-100 ARI (henceforth the ARI 100 extent). The Queensland Government, for example, has recently developed a Floodcheck Map Portal.[1] Brisbane City Council has provided on-line Flood Wise Property Reports since 2008 (Dobes et al., 2013).

Economic theory suggests that if the information is readily available, flood risk should be reflected in property values, as purchasers are willing to pay a premium for flood-free properties. Studies from the USA suggest that the discounted value of flood-prone land is similar to the present value of future insurance premiums, implying that the market has efficiently priced the costs of occupying such land (Bin & Polasky, 2004; Bin & Kruse, 2006).[2] Whether via insurance or the progressively wider availability of flood risk information, a more informed population should translate to the capitalization of flood risk.

This study re-examines issues pertaining to the impact of floods and the disclosure of flood risk on property values in the light of contemporary studies and the recent Australian flood experience mentioned above.

Methods

Three broad methods have been used to assess the impact of flood risk on property values:

1. Hedonic modelling is the most common. This attempts to describe the price of a house statistically using regression variables such as structural attributes (size, number of bedrooms and bathrooms, etc.), neighbourhood characteristics (household income, demographic composition) and accessibility characteristics (proximity to transport and amenities) (Zhang et al., 2010). Flood risk can be included as a subset of the neighbourhood characteristics. Most often location within the ARI 100 extent is used as a proxy for flood risk, although this is not a true risk metric (van den Honert and McAneney, 2010). To adequately explain the variation in house prices from one property to another requires large numbers of causal variables and large numbers of observations (selling prices) (Lamond et al., 2007). Two types of hedonic models are commonly employed: standard hedonic models that assess the implicit price of risk and difference-in-difference (DND) models that assess how the implicit price of risk changes after a flooding event or disclosure of a floodplain designation.

   Two studies merit special mention: the Daniel et al. (2009a) meta-analysis and meta-regression analysis of 19 US hedonic studies, an analysis subsequently expanded by Beltran et al. (2014).[3]

2. Repeat sales analysis. This method assesses repeat sales of the same properties to ascertain the effects of flooding or floodplain designation, provided that a property's structural characteristics remain constant over the period between sales and that the influence of inflation and major changes in locational variables are controlled for (Lamond et al., 2007). An advantage of this approach is the reduced data requirements since most of the variables are constant for the same house.

3. Interpretation of raw sales data over time. Since controlling for the host of factors that influence house values is not easily accomplished, these studies are more susceptible to extraneous and sometimes unknown factors including seasonal trends, which arguably limit their explanatory power. But they may provide a useful first step or enable examination of specific flood events on well understood sub-markets (Lamond et al., 2005).

The results of any study need to be judged according to the robustness of the method employed and data utilised. With much of the literature employing econometric techniques, this is a difficult task for a 'lay' reader. Nevertheless, we can observe three general reasons for caution.

Assumptions and choices shape the results

A study's assumptions and modelling choices self-evidently exert an influence over the result (Rambaldi & Fletcher, 2014). Spatial definition is also important. Most studies adopt the ARI 100 floodplain for their assessments, whereas Lamond et al. (2010) adopted the ARI 1000 floodplain for several iterations. It is possible that the failure of these authors to detect differences in housing prices was due to their defining 'floodplain' so broadly. Temporal definition is also important. Pope (2008) critiqued an earlier study (Bin & Polasky, 2004) for its limited temporal control, which may confound efforts to explain observed differences in housing values.

Attribution is not straight-forward

Attributing an observed difference in housing values to a particular cause is not straight-forward. Bin and Polasky (2004) examined pre-1999 housing sales data for Pitt County in North Carolina and detected a discount for houses located in the ARI 100 extent compared to those that were not. The reason for this discounting was not articulated, but it was loosely connected with low risk perception preceding flooding in 1999. In a subsequent study, Bin and Landry (2013) re-examined the data and found that the discounting was linked to earlier flooding in 1996, with no discount prior to that. The later study made clear that the discounting prior to 1999 was not associated with floodplain maps utilised for the National Flood Insurance Program (NFIP).

Doupé et al. (2014) argued that the prices of Brisbane houses with a flood risk fell by -2.6% as a result of the on-line release of Flood Wise Property Reports (FWPR) in July 2008.[4] Just how confidently the modelled decrease in the value of flood-prone properties for the 2008–2010 period can be identified with easier access to flood risk information is debatable. Another likely explanation for the fall in value of flood-prone properties after mid-2008 is the Global Financial Crisis, which Rambaldi and Fletcher (2014) suggest contributed to a depressed and volatile housing market in nearby Moreton Bay Regional Council in 2008. Given Eves and Wilkinson (2014) found that the greatest impact of the 2011 flood was on high-value flooded suburbs, it is possible that the GFC also had uneven impacts, with higher-value (flood-prone) riverside properties particularly affected. Also, anecdotal evidence from local real estate agents and valuers suggests that very few Brisbane residents would have been aware of flood risk information before the 2011 flood (Dobes et al., 2013). The modelled result may also be exaggerated by the decision to include in the dataset 50 riverside properties sold in June 2008 (prior to the release) at an average of $3.27 million (Dobes et al., 2013). We cannot categorically reject attribution of the observed fall in selling prices of dwellings with a flood risk to the on-line release of FWPR in July 2008, but for the reasons set out above, we suggest that the reason for the decrease is not clear cut.

Beware publication bias

A third reason for caution in interpreting the literature describing the effect of flood risk on housing values is publication bias. Formally, this means that 'published study results may not be an adequate representation of all possible study results because of selection effects' (Daniel et al., 2009a, p.358). Selection effects may include self-censoring of authors with respect to undesirable or implausible results and the tendency for reviewers and editors to prefer papers consistent with conventional economic theory. Daniel et al. (2009a) guardedly concluded that 'publication bias is likely not entirely absent' from their meta-analysis of hedonic models, while Beltran et al. (2014) detected a tendency for over-reporting of negative impacts of flood risk on property prices.

Results

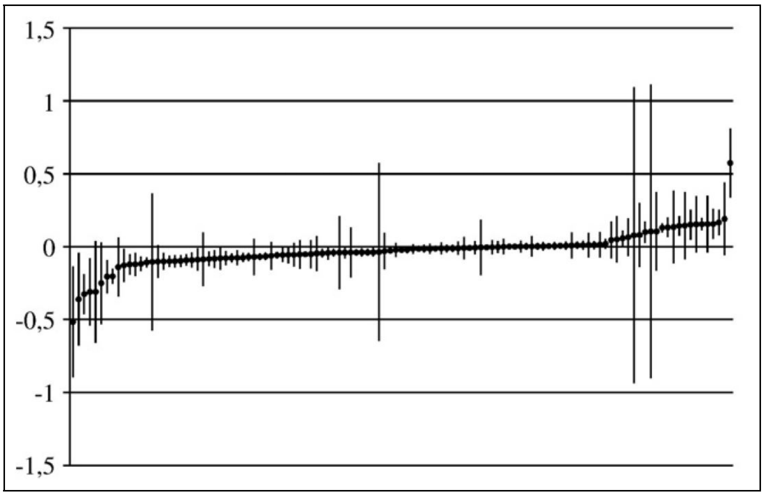
In what follows we extend our earlier literature review of the effect of flood risk on housing values in respect to three questions.

Question 1: What's the effect of being in a floodplain on property values?

Answer 1A: There is considerable heterogeneity

Daniel et al.'s (2009a) meta-analysis found considerable heterogeneity in the results of the 19 US studies summarised, with the implicit price of flood risk varying from –52% to +58% (Figure 3). Similarly, Beltran's (2014) meta-analysis, drawing on 37 studies, found a range from –75% to +61%.

Figure 3: Distribution of the effect on property values of location within a floodplain compared to outside floodplain, with meta-analysis observations ordered along x-axis from discounts to premiums, and showing 95% confidence interval. The vertical axis is percentage differences in prices (source: Daniel et al. (2009a)).



Answer 1B: There is often a discount for flood-prone land

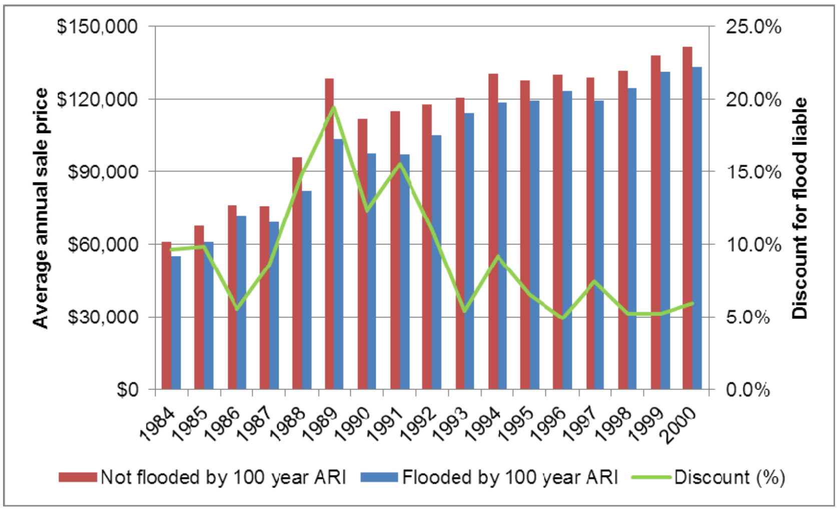
Both Daniel et al. (2009a) and Beltran et al. (2014) found that about 70% of available meta-observations reported a discounting of the value of properties associated with flood risk. Daniel et al. (2009b) found the median discount for being in a floodplain was -7.6%. Beltran et al. (2014) reported a mean difference of about -6%.

In Beltran's meta-analysis, with weights allotted for each study relative to the amount of information they provided, a discount of -2.7% was determined for properties within the floodplain (either ARI 100 or 500 flood extents) compared to equivalent properties outside the floodplain.

Using sales from 1970–2010 for an inner-city suburb of Brisbane subject to minor, tidal floods as well as occasional larger floods from the Brisbane River, Rambaldi et al. (2013) found that properties subject to flooding in an ARI 100 event were discounted by about -1.3% relative to those that were not.

Eves (2002) used raw sales data to estimate a discount for properties in south-west Sydney subject to flooding in an ARI 100 event of between -5% and -19% over the period 1984 to 2000 (Figure 4).

Figure 4: Average annual sale prices for properties in 44 streets in Fairfield LGA, 1984–2000 (based on data presented in Eves (2002))



Answer 1C: The degree of discounting may be associated with the degree of risk

For riverine floodplains, Beltran et al. (2014) found a discount of -5.1% for properties located within ARI 100 extent, and a lesser -2.1% discount for properties impacted by an ARI 500 event.

Rambaldi et al. (2013) calculated an additional discount of -5.5% per metre below the 100-year level.

Answer 1D: The discount can often be traced back to occurrence of a flood

Beltran et al. (2014) found a discount of -3.1% prior to a flood for properties within the ARI 100 extent. This suggests that the discount of -5.1% observed above for the undifferentiated 100-year river floodplain includes a discounting due to actual floods. Similarly, the fact that no discount was detected for properties within the ARI 500 extent before a flood, yet -2.1% for the global ARI 500 grouping, points to the influence of actual flooding.

Rambaldi et al. (2013) attributed the -1.3% discount for properties within the ARI 100 extent to frequent, minor floods in the study area.

Answer 1E: The positive attributes of a waterfront or coastal location may outweigh the discount

Beltran et al. (2014) found that properties exposed to ARI 100 *coastal* flooding enjoyed a +14.1% *premium* over areas outside designated flood-prone coastal regions. One of the studies using data from North Carolina found a premium of +61% for properties at risk to ARI 100 flooding due to wave action. The price premium was attributed to views and boating access (Bin & Kruse, 2006).

Daniel et al. (2009b) found that in a general context of significant discounting following floods in the Netherlands, properties located within 500 metres of the river enjoyed an offsetting positive effect of +2.7%, though this was not sufficient to entirely negate the discount.

After flooding in Rockhampton, Queensland, Small et al. (2013) suggested that the resilience of property values in Park Avenue could be due to its waterfront location.

Question 2: What's the effect of a flood event(s)?

A relatively prolific literature addresses the question of the impact of actual flooding on housing values. In what follows we summarise recent findings.

Answer 2A: Floods may have no effect

Floods may have no effect on property values if the flood risk is already capitalized. Kousky (2010) found that the 1993 flood in Missouri had no impact on property values in the ARI 100 extent but had significant impact on those situated beyond the ARI 100 and within the ARI 500 flood extents where no prior capitalization of flood risk had taken place.

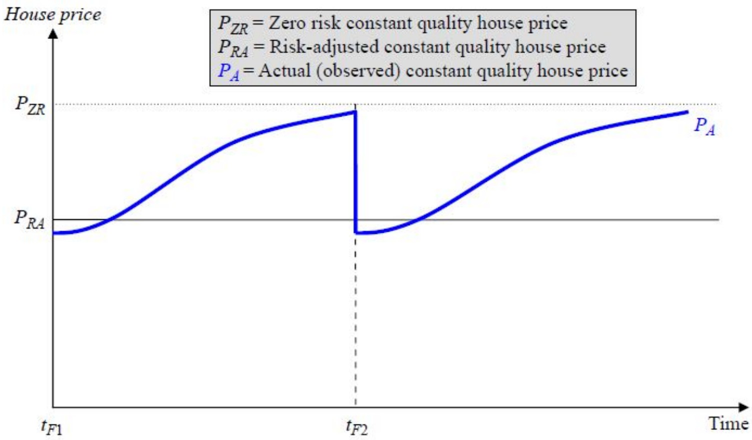
Answer 2B: Floods often discount property values in affected areas

One of the main findings in the literature is the discounting effect of actual flooding and how this changes with time since the last flood. Pryce et al. (2011) relate this to people's tendency for *amnesia*—forgetting past floods—and *myopia*—disregarding future risks that may be perceived with scepticism. Figure 5 presents a model of this pattern in which a flood causes prices to fall to about a true risk-adjusted price. This implies pre-flood 'imperfect capitalisation due to imperfect risk assessment' (p.261), which is then corrected as the flood teaches the market. But in time, amnesia and myopia recommence and prices return above their true risk value.

Beltran et al. (2014) calculated that floods triggered an *additional* discounting of -3.8% for houses located within the ARI 100 extent (such that the after-flood discount totalled -6.9%) and a discounting of -6.2% for houses located within the ARI 500 extent. This result incorporates the findings of Kousky (2010) mentioned earlier.

Hurricane Katrina increased the discounting in Greater New Orleans based on ground elevation. Prior to Katrina, each additional foot below sea level in flood-prone areas resulted in a discount of -0.9%. After Katrina, this increased to a discount of -4.5% as the value of elevation was recognised (McKenzie & Levendis, 2010).

Figure 5: House prices influenced by amnesia and myopia: the case of infrequent floods (source: Pryce et al. (2011))



In the UK, Lamond and Proverbs (2006) found that the price of flooded properties in Barlby, North Yorkshire, did not fall but failed to keep up with the growth in value of the rest of the market. Lamond et al.'s (2010) investigation of price effects in 13 locations showed that the impact of the year 2000 flood on growth was highly variable, from no impact to -30% immediately after the event. But some locations saw floodplain property outperform the rest of the market.

In Brisbane, where major flooding had not been experienced since 1974, the 2011 flood caused an average -6.2% fall in property prices for flood-affected properties (Dobes et al., 2013). Using repeated sales, Doupé et al. (2014) found a decline of -18.9% for the first year after the flood and -7.1% for the first two years after the flood. Eves and Wilkinson (2014) examined trends in the median sales prices of houses in Brisbane suburbs grouped according to their socio-economic status. In the year following the flood, the greatest fall in median price was -15.9% for flooded high-value suburbs, compared to -8.1% for flooded low-value suburbs.

Answer 2C: Multiple floods in a short timespan may exacerbate discounting

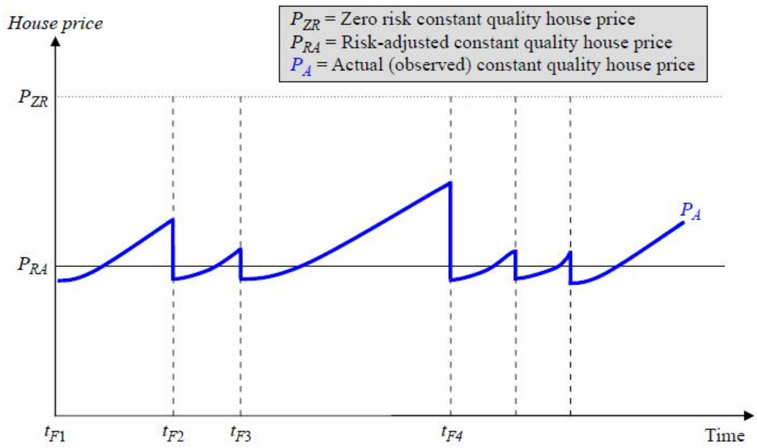
Frequent floods may remind the market of the risk, limiting the influence of amnesia and myopia. The actual price might then be expected to follow more closely the risk-adjusted price, with deviations based on the length of time between floods (Figure 6) (Pryce et al., 2011).

Lamond et al. (2010) found *multiple* floods over a few years did have an effect on property markets in the UK, particularly for properties in the 'significant' risk category.

Daniel et al. (2009b) found that the 1993 Meuse River flood (Netherlands) led to a decrease in house value in the flooded areas of -4.6%. This discounting, when compared to non-flooded houses, increased to -9.1% after a second flood in 1995. The authors posit that:

> *the second flood underscored the necessity for people to account permanently for the risks associated with river flooding. The subjective perception of floods merely constituting a once-in-a lifetime event was corrected and probably brought much closer to the objective level of risk, which implies that a flood can happen several times in a row* (p.574).

Figure 6: House prices influenced by amnesia and myopia: the case of frequent floods (source: Pryce et al. (2011))



In Sydney, Eves (2002) linked the increased discounting of flood-prone property in Fairfield LGA in the late 1980s and early 1990s to a series of damaging Georges River floods (Figure 4).

Answer 2D: Areas not flooded can also experience a downturn

Kousky (2010) reported that *all* property prices in municipalities located along the Missouri and Mississippi Rivers fell after the 1993 flood by -6% to -10%, even those that weren't inundated, a result that was attributed to damaged infrastructure and stigmatization of the area.

Doupé et al. (2014) described a weakly significant result in which property values in areas of Brisbane that were *not* flooded in that particular event, but were still considered as flood-prone, fell by -9.6% in the first year after the 2011 flood, but that this effect disappeared after two years. Eves and Wilkinson (2014) found that the median price of properties in high value suburbs that were not flooded fell by -7.1% in the year after the flood: this less than in the flooded areas but still significant.

Hallstrom and Smith (2005) investigated how a 'near miss' can update risk perception and thereby influence property values within ARI 100 extent. They estimated that Hurricane Andrew's near miss reduced the rate of appreciation by -19.8% in Lee County, Florida.

Answer 2E: Property values often recover in time

Atreya et al. (2013) found that the flood risk discount caused by the 1994 flood in Dougherty County, Georgia, disappeared between four and nine years after the flood.

The impact of the Barlby, Bewdley and Mold (UK) floods on house prices lasted less than three years at all sites (Lamond & Proverbs, 2006; Lamond et al., 2010).

Although the Brisbane post-flood datasets are not long enough for a full assessment, there was evidence of a recovery in sectors of the market one year after the 2011 flood (Eves & Wilkinson, 2014). Doupé et al. (2014) found that the discounts taken for the two years after the flood were much less pronounced than for the first year.

Possible reasons for only temporary impacts include turnover of the population, strong demand, prospects of improved flood defences, optimism and a lack of any restriction on purchase (mortgages and insurance available) that overrides lingering memory of the flood (Lamond & Proverbs, 2006).

Question 3: What's the effect of disclosure of floodplain designation?

One way in which flood risk could conceivably be capitalized, overcoming tendencies towards amnesia following actual flooding, is through clear and permanent disclosure of flood risk via insurance, regulation and/or mapping. This section explores the recent literature examining the impact of floodplain designation on housing values.

Answer 3A: Floodplain designation can initiate or increase discounting

For Alachua County, Florida, Harrison et al. (2001) found a weakly significant result that, under the disclosure mechanisms of the National Flood Insurance Program (NFIP) prior to 1994, properties in the ARI 100 extent were priced nearly $1000 less than equivalent housing units located beyond this demarcation.

Pope (2008) estimated that the introduction of North Carolina's Residential Property Disclosure Act in 1996, which required sellers to disclose statutory flood risk, led to a discounting of between -3.5% and -4.5% for houses in the ARI 100 flood extent. Similarly, Troy and Romm (2004) estimated a discounting of -4.2% for houses in the ARI 100 extent compared to equivalent houses outside following the introduction of the California's Natural Hazard Disclosure Law (AB 1195) in 1998.

Doupé et al. (2014) argue that the on-line introduction of Brisbane's Flood Wise Property Reports reduced a flood-prone property's sale price on average by -2.6% over the two years after the release of the Reports but this interpretation is contestable (see earlier discussion).

Answer 3B: Floodplain designation may have no effect

Before the introduction of the disclosure laws in North Carolina and California, buyers could still learn about flood risks via the floodplain maps used for the NFIP, but in both cases, there was no significant difference in selling price between comparable properties on or beyond the floodplain (Pope, 2008; Troy & Romm, 2004).

Lamond et al. (2010) assessed property values over a period that included the launch of the UK Environment Agency's maps (2004) as well as flooding. They concluded that 'the impact of flood risk designation on growth in residential property price is … non-existent in the absence of flood events' (pp.348-9).

A change to the official 100 year ARI flood level at Penrith in western Sydney in 1994 might have had a short-term impact on affected properties, but an examination of sales prices in 1999–2000 detected little variation (Egan National Valuers, 2000). The authors conclude, 'The market has seemingly absorbed the information about the potential flood problem and has decided that the flood risk is not considered high enough to be reflected in changes in property value' (p.30).

Answer 3C: Floodplain designation can reduce discounting

In an interesting study from North Shore City, New Zealand, Samarasinghe and Sharp (2010) found that the discount for houses in the ARI 100 flood extent *reduced* from -6.2% to -2.3% after floodplain maps became available to the public in mid-2006. Prior to this, only a binary 'in' or 'out' of flood zone was available. Samarasinghe (pers. comm.) argues that the maps enabled buyers to see more clearly the risk of flooding to a property in a flood zone, giving them opportunity to make more informed decisions.

Answer 3D: Not all forms of disclosure are equal

A key to understanding the variable impact of non-natural disclosure of flood risk on housing values is the variable nature of forms of disclosure.

Much has been written about deficiencies of the United States' NFIP (e.g. Burby (2001); McAneney et al. (2013)), which may explain the mixed results for studies exploring the relationship between location within statutory ARI 100 flood extents (as specified on NFIP maps) and housing values. These deficiencies include:

- Flood maps may be old and relate poorly to the true flood hazard (Kousky, 2010);
- Assessment methodologies struggle to accurately gauge the valuation consequence of floodplain location (Harrison et al., 2001);
- Premiums are subsidized and relate poorly to true actuarial risk (Bagstad et al., 2007);
- Participation rates in NFIP have been relatively low. While there have been amendments to legislation to increase participation including to require maintenance of insurance for the life of a federally-funded or backed mortgage, less than one-half of all structures located in ARI 100 flood extents are insured against flooding (Harrison et al., 2001). Of course, not all properties have mortgages, and so often only the most at risk properties take out insurance;
- People's risk perception and risk preferences exert important influences on participation in the NFIP, irrespective of requirements (Petrolia et al., 2013);
- Buyers often learn of a property's flood risk and the required insurance premium very late in the purchasing process (Chivers & Flores, 2002).

Harrison et al. (2001) found that following passage of the National Flood Insurance Reform Act in 1994, there was increased participation in the NFIP and the price differential for houses located in the ARI 100 flood extent increased.

Pope (2008) found that North Carolina's Residential Property Disclosure Act was a more effective mechanism for informing potential buyers of flood risk than the NFIP, and detected a significant discounting of house prices within the floodplain under the Act. Troy and Romm (2004) found something similar upon passage of California's Natural Hazard Disclosure Law, especially for Hispanic communities. It is understood that both of these State Acts require sellers to disclose a property's statutory flood risk earlier in the sales process.

An investigation of the price impact of floodplain designation for condominiums and standalone properties in Boulder, Colorado, found a strong impact for condominiums (-14%) but none for standalone properties (Meldrum, 2012, 2015). This was attributed to information asymmetries, with better pre-transaction provision of flood insurance cost information for condominiums.

In the UK, Lamond et al. (2005) described the normal disclosure regime as 'ad-hoc discovery of flood risk' (p.634). There, buyers are said to behave in an entirely reactive manner, evaluating risks based on recent experience (Lamond et al., 2010). In the absence of mandatory disclosure of flood risk, Lamond found that floodplain designation alone produced no impact.

Implications for Australia

Empirical evidence for the effect of flooding or floodplain designation on housing values from the Australian market remains limited. Several researchers have investigated the effects of flooding around Brisbane, yielding findings that are congruent with the wider international literature showing that floods often have a short-lived discounting effect. One study argues that the public release of flood risk information in Brisbane led to a small discounting effect.

Since our last review (Yeo, 2003) there has been considerably more work undertaken in the USA, Europe and the UK, plus an interesting study from New Zealand. The results must not be applied unthinkingly to the Australian scene, since there may be considerable differences in hydrological regimes, and particularly, disclosure regimes. But it does provide a context in which we can make some inferences about the effect of flooding or other forms of flood risk disclosure on housing markets in Australia. Just as there are variations within the United States (e.g. Troy and Romm, 2004, cite different styles of flooding in California for the inefficiency of the NFIP in capitalizing flood risk into property values prior to 1998), there are likely variations within Australia, which lie outside our current scope.

The human attributes of amnesia and myopia are likely to be fairly prevalent here in Australia as elsewhere, with the result that housing values for flood-prone locations may typically ride well above their true risk-adjusted price.

At least for Australian capital cities, local supply and demand equations may be akin to some of the energetic UK markets described by Lamond, which will tend to suppress any flood risk effect. There is also evidence for an increasing proportion of auctions to total sales, led by the Melbourne and Sydney markets,[5] which could trump buyers' consideration of flood risk in that especially competitive and even emotional environment.

Considering whether the changes in the availability of domestic flood insurance may capitalize flood risk into housing values, the evidence is equivocal. Insofar as premiums in Australia may be more truly risk-based than under the NFIP, there is potential for greater impact. And current participation rates sound high (93% according to FMA, 2014), despite flood insurance generally not being mandatory. But what we do not know is how participation rates vary for different degrees of risk: for instance, what is the participation rate for properties located within the ARI 100 flood extent? Many other questions remain to be answered including are there communities where no insurers offer cover? And what is the proportion of policy-holders who *know* they have (or don't have) flood cover, or have made a conscious decision about the appropriate cost of insuring flood risk? Plus, to what degree do prospective buyers investigate the cost of flood insurance *prior to making an offer of purchase*, and shape their decision accordingly? Flood insurance has potential to increase the capitalization of flood risk into property values, but at least in Australia it is too early to assess whether this has begun to be realised.

For the most part, reference to flood risk information is at the behest of the individual buyer. The disclosure regimes at work in Australia appear to be broadly similar to the ad-hoc discovery of flood risk Lamond describes for the UK, where floodplain designation was found to have no impact.[6] As Pope (2008, p.570) observed, 'simply placing environmental information in the public domain does not guarantee that the information will be noticed and used'. Zhang et al. (2010) emphasised the need not just to make information available but to ensure it is understood.

In a way the uncertain impacts of flood risk disclosure may make interactions with the public more palatable for a Council flood engineer. The advice included on the FMA's information sheet (Figure 2) is still more or less appropriate. It could be amended to be a little more even-handed by adding an acknowledgment that Council's flood mapping *could* have an impact on property values, allied to the important message that the real risks of flooding on the site have not changed (after Figure 1). The New Zealand study finding that better flood risk information can *reduce* impacts on housing values is also worthy of further consideration. The availability of more up-to-date flood information in NFID for some communities has also reduced the number of properties believed to be at risk.

But from a broader perspective of building a flood-resilient Australia, floodplain managers need to consider whether the lack of a clear market signal for flood risk in property transactions is desirable. Clear market signals can promote real flood risk reduction. An example of this was when Suncorp, the primary insurer in Queensland, placed an embargo on new polices following three floods in the town of Roma in quick succession from 2010 to 2012. Existing policyholders were offered renewals with vastly increased premiums. Following community pressure and efforts from all levels of Government, the Maranoa Regional Council began building a levee in September 2013. Suncorp announced that its embargo on new business would ease. Initial estimates indicated an average reduction in household premiums for a $300K home of about 30% and as high as 80% in some of the most flood prone areas as soon as the levee was completed.

In time, risk-based pricing of insurance premiums may show through more clearly in house prices, particularly for high-risk areas. *Mandatory* requirements to disclose plain-English, readily understood, property-level flood risk information *early* in the property transaction process would also promote market signals of risk.

Conclusion

Much has changed and is changing in the Australian market. We anticipated seeing more evidence of discounting of housing values as a result of changes in disclosure regimes including the availability of flood insurance and expanded delivery of flood information. But as yet, there remains scant evidence for a sustained decrease in the value (or in growth rate) of houses with a flood risk. There is scope for considerably more empirically-based, robust research of this issue in an Australian context. Acting against capitalization of flood risk may be the tendency for people to soon forget previous flood events and be over-confident about the impact of future floods. This is suggested by the pronounced but short-lived discounting after the Brisbane flood. Strong housing markets will also tend to diminish any impact. From a broader disaster resilience perspective, one might wish for a stronger market signal of a property's flood risk, which could trigger mitigation interventions to actually reduce the risk by building a levee, raising floor levels or removing an uninsurable house. This could happen as risk-based premiums incrementally influence prices. Requiring the disclosure of transparent flood risk information to prospective purchasers early in the transaction process would also promote market signals.

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[1] https://www.dnrm.qld.gov.au/mapping-data/maps/flood-mapping-program/floodcheck-map (accessed 8/5/2015).

[2] A number of studies found that the discounted value of flood-prone property is *greater than* the capitalized insurance premiums, which is often explained by non-insurable costs of flooding on housing such as disruption (Macdonald et al., 1987; Donnelly, 1989; Speyrer & Ragas, 1991). One study shows the opposite—the discounted value of flood-prone property is *less than* the capitalized insurance premiums (Harrison et al., 2001). Here, the author draws attention to the non-mandatory nature of participation in the NFIP.

[3] While to our knowledge Beltran's work has yet to be formally published, our current paper draws upon draft results presented at the Meta-Analysis of Economics Research Network 8th Annual Colloquium held at the University of Athens, Greece, in September 2014 (Beltran et al., 2014).

[4] Doupé et al. (2014) updated a previous assessment by Dobes et al. (2013), confining the dataset to two years after the release of the FWPR in July 2008, so that it wouldn't be compromised by also picking up the effect of the major January 2011 Brisbane flood.

[5] Tim Lawless, 'How important are auction clearance rates in the housing market?', *Property Observer*, 25/8/2014, http://www.propertyobserver.com.au/forward-planning/advice-and-hot-topics/34858-how-important-are-auction-clearance-rates-in-the-housing-market.html (accessed 8/5/2015).

[6] In NSW, one mechanism that could alert a potential purchaser to a property's flood risk is a Section 149(2) Certificate, which is required to be attached to a contract for sale and describes whether any flood-related development controls apply to a property. Egan National Valuers (2000) used a small sample of sales data to investigate the impact of S149 notifications on housing values in western Sydney. They detected 'isolated' incidences of variations in property values up to 5% for properties affected by a recently-instituted increase to the 100 year ARI flood level in South Windsor. No impact of Probable Maximum Flood notifications was detected. They comment that 'a purchaser unfamiliar with the workings of property will often see [a Section 149 Certificate] as pure legalese with the prevalent point of view being that such a document is only decipherable by a solicitor or a conveyancer' (p.11).