FAST-TRACKING FLOODPLAIN MANAGEMENT IN AN UNCERTAIN CLIMATE: THE ŌPĀWAHO / HEATHCOTE RIVER STORY

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ABSTRACT (500 WORDS MAXIMUM)

The Ōpāwaho / Heathcote River catchment has a history of flooding and poor water quality. Floodplain management schemes have been developed in the past by the Christchurch Drainage Board (1985) and Christchurch City Council and Environment Canterbury (1992). These identified a range of options including storage in the upper catchment, in-channel works in the mid reaches, raising of some houses, and constructing a large bypass channel, the Woolston Cut. These schemes were partially implemented, but a drier period during the 1990's and 2000's meant that many of the key elements were not installed.

The Canterbury Earthquake Sequence (CES) dramatically changed the flooding situation for the Ōpāwaho / Heathcote River, with a general uplift in the lower reach combined with settlement in the mid and upper catchment. This had the effect of exposing 101 additional dwellings to the risk of flooding above the floor in a 2% annual exceedance probability event (AEP). However, it also increased the number of houses at risk of flooding above the floor in frequent events, and exposed significant stretches of riverside roads to additional flooding. Flood events in 2013, 2014 and 2017 resulted in some houses flooding above floor level multiple times, and repeated deep road and underfloor flooding.

Investigations into potential responses to the increased flood risk throughout the catchment began following the CES. This included asset condition assessment, surveys (landform and floor level), and updating flood models. Throughout this period there was a series of public meetings to update those affected by flooding to communicate the work underway and to convey the effort being expended to identify suitable response options. The focus of this work was on developing long term adaptive pathways focusing primarily on the 10% and 2% AEP events. The work of past studies was heavily relied upon for the likely suite of options suitable for the catchment.

The July 2017 flooding created a situation where the community needed a response plan to deal with the frequent flooding. Utilising the investigations undertaken to date, a floodplain management strategy was developed which focused on frequent (10% AEP) flooding with the current climate and sea level. This enabled rapid approval as it was affordable, could be readily implemented, met the immediate needs of relief from frequent flooding, and also did not compromise implementation of longer term measures. The toolbox of measures responded to a range of frequencies and time scales. It included voluntary purchase of the most affected houses, dredging (which was identified as providing benefit up to 0.25m sea level rise), bank stabilisation, upper catchment storage, and consultation on low stopbanks. The total package of works approved in November 2017 was approximately $80 million over a period of 5 years.

Some of the key findings were: the importance of good communication to allow decision makers and the public to understand the issues; the importance of quick wins to build

confidence; utilising a short term response to achieve long term benefits; communicating the benefits achieved while work is underway; and how to fast-track capital works when uncertainties remain.

KEYWORDS

Floodplain management, adaptive pathways, fast-tracking, community, communication

PRESENTER PROFILE

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1 INTRODUCTION

The Ōpāwaho / Heathcote River has a history of flooding and this became a significant problem when the lower river terraces were settled in the early 20th century. A number of floodplain management works have been enacted within the catchment since this time, but the impacts of the Canterbury Earthquake Sequence (CES) significantly increased the vulnerability of properties along the river to flooding.

This paper describes the fast-track process undertaken from the investigations into the impacts of the CES through to approval and delivery of an $80 million floodplain management scheme.

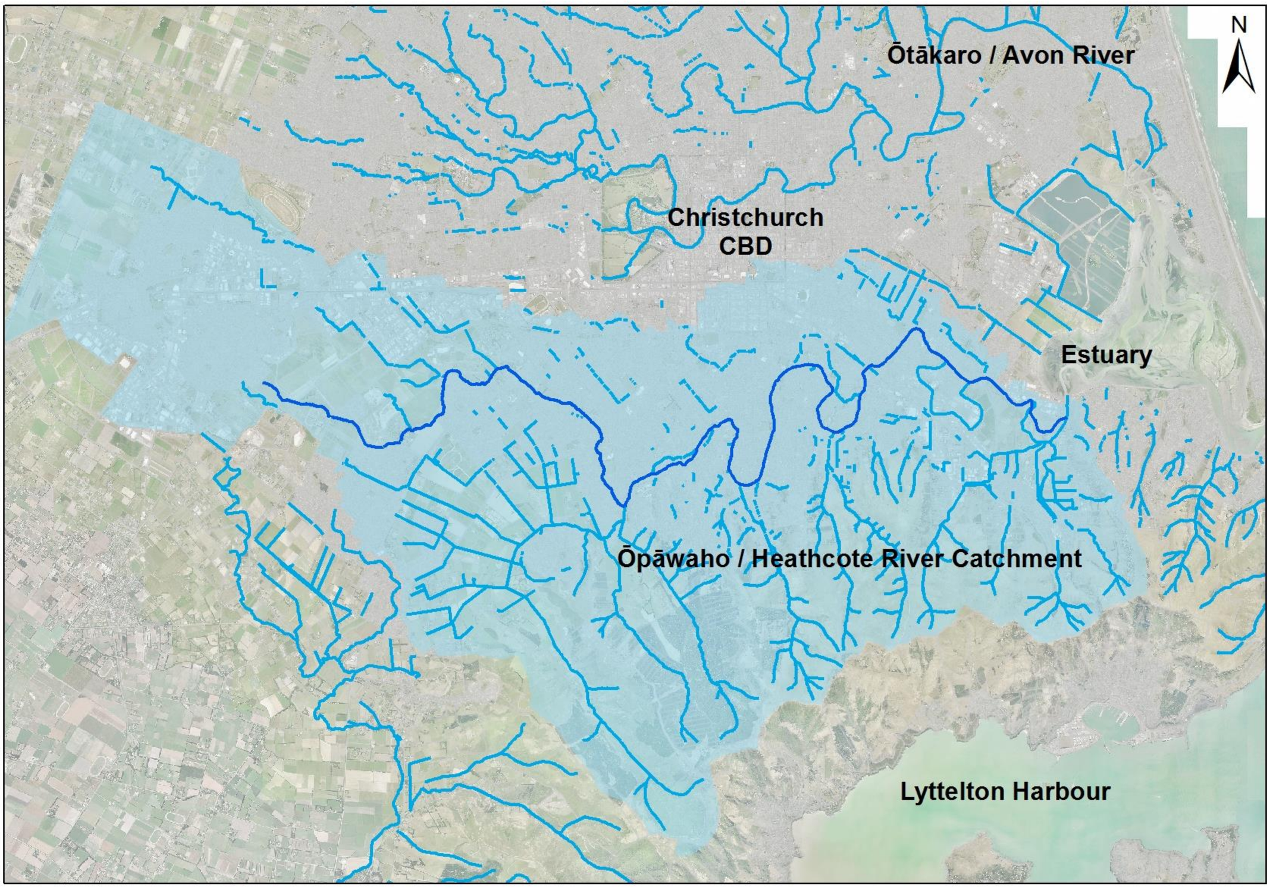
2 FLOODPLAIN MANAGEMENT ON THE ŌPĀWAHO / HEATHCOTE RIVER

The Ōpāwaho / Heathcote River catchment has a length of approximately 25km and covers approximately 103 km² in the south-west of the city (Figure 1). It is bounded in the south by the Port Hills, and flood events are heavily influenced by rainfall in the upper parts of the hill catchments. The upper catchment has both high infiltration areas and old swamp areas with extensive natural ponding. Along the base of the Port Hills the river is terraced, and the dwellings on the lower terraces are most vulnerable to flooding.

The Christchurch Drainage Board (CDB) regularly dredged the lower reaches of the river, raised some houses, and developed a scheme to reduce further flooding, particularly through upstream storage. However, this scheme, conceptualised in the late 1980s, was not fully implemented, and the only works completed were isolated house raising, the Woolston Cut and later, by Christchurch City Council (CCC), part of Wigram Retention Basin was built.

Subsequent to the CDB plan, in addition to ongoing river maintenance, flooding was primarily managed by CCC through stormwater management plans (SMPs), the South-West Area Plan (SWAP) and other planning controls to reduce property damage, such as the District Plan. The District Plan contains a number of controls to restrict development in flood prone areas, identifying Flood Ponding Management Areas, Flood Management Areas, and High Flood Hazard Management Areas. These plans manage flood impacts by setting minimum floor levels, restricting development in flood prone areas, and requiring mitigation of increased runoff from new subdivisions.

Figure 1: Ōpāwaho / Heathcote River catchment



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These works established a pre-earthquake baseline which was largely effective in managing flooding within the catchment. However, as will be discussed in the following section, the impacts of the CES increased flood vulnerability and this was highlighted by a series of low frequency post-EQ rainfall events resulting in flooding of property and dwellings.

3 IMPACTS OF THE CANTERBURY EARTHQUAKE SEQUENCE AND DEVELOPING A LONG-TERM ADAPTIVE PLAN

3.1 IMPACTS OF THE CES

The CES resulted in significant changes to land drainage throughout the city (Christensen and Maclaren, 2017, Cobby et al., 2018). The key effects for the Ōpāwaho / Heathcote River were:

- Loss of channel capacity due to bank slumping, lateral spread, and increased sedimentation due to liquefaction

- Tectonic uplift at the mouth of the river resulting in a reduced capability to drain upstream

- Land settlement in places resulting in a drop of land levels adjacent to the river

Modelling has shown that there was a significant increase in flood risk (Table 1). For example, in the worst affected reach of the river between Colombo Street and Radley Street, with the current climate and level of sea level rise:

1. The number of houses estimated to be at risk of frequent flooding (greater than a 10% AEP) event is now six times greater, and

2. The number of houses at risk of flooding in an extreme (2% AEP) event has almost doubled.

Some houses along the Ōpāwaho / Heathcote River have been reported to have flooded above floor four times since the earthquakes. Other impacts of the post-earthquake flooding are wastewater contamination on property and restriction of access for hundreds of properties.

In Table 1 the total number of houses at risk of flooding in an extreme event (2% AEP) as a result of earthquake effects is 101, which is higher than the difference between pre-earthquake and post-earthquake (47), as the flood risk at a number of houses upstream of Colombo Street actually dropped as a result of the earthquakes.

Table 1: Number of buildings with over-floor flooding pre-earthquake and immediately post-earthquake, and identifying those which were not at risk pre-earthquake

Area	**10% AEP (existing development)**			**2% AEP (existing development)**		
	PreEQ	**PostEQ**	**PostEQ but not PreEQ**	**PreEQ**	**PostEQ**	**PostEQ but not PreEQ**
Radley Street to Hansen Park (lower reach)	0	16	16	27	69	43
Hansen Park to Colombo Street (mid reach)	4	7	4	58	83	34
Upstream of Colombo Street (upper reach)	3	1	1	90	70	24
Totals	7	24	21	175	222	101

3.2 POST-EARTHQUAKE FLOOD EVENTS

The impacts of the CES on land drainage were made apparent during a period of severe weather events that impacted Christchurch in 2013 and 2014. The worst of these for the Ōpāwaho / Heathcote River were in June 2013 and March 2014, but there were other events, noticeably in April 2014, which also caused flooding. These events made very public what engineering analysis had already shown – that the Ōpāwaho / Heathcote River was significantly more vulnerable than prior to the earthquakes.

Photograph 1: Flooding in 2014

3.3 DEVELOPING A LONG-TERM ADAPTIVE PLAN

The Land Drainage Recovery Programme (LDRP) was established in 2012 by CCC to understand the consequences of the earthquakes on the land drainage network within the city limits. Within the Ōpāwaho / Heathcote River catchment, the LDRP undertook investigations to understand the extent of the damage (through asset condition surveys), modelling, floor level surveys, and commissioned a number of issues and options reports.

Past floodplain management investigations, reports and strategies were particularly valuable in developing the post-earthquake response. While the earthquake caused significant change in the catchment, the fundamental issue remains the same – human settlement along a narrow river corridor. As such the potential management options were largely those that were identified earlier.

As well as the investigations, a series of public meetings were held to keep the community informed of the background work being undertaken, and to understand the community needs and drivers. While at the beginning there was frustration that no physical works were being undertaken, these meetings laid the groundwork for subsequent engagement on the options being recommended.

While the aim of the LDRP is to restore flood risk to at least pre-earthquake levels, the work takes place in a changing environment. The floodplain management options recommended needed to take into account not only current flooding, but also to consider the likely impacts of climate change and sea level rise. In addition CCC is undertaking a multi-hazard assessment (Parsons et al., 2018) to answer the question: How do we make decisions about flood management in a multi-hazard environment?

As a result of the longer term considerations and investigation into the impacts of multiple hazards, the Ōpāwaho / Heathcote River floodplain management work needed to find options which would provide benefits to current flooding issues, without compromising potential future management options and did not result in undesirable outcomes – a 'no regrets' approach.

Using past studies and an updated understanding of the catchment, a long list was first developed and refined into a short list (Table 2). The process used to refine the options is described in more detail in Cobby et al. (2018).

By July 2017 the work was progressing toward the development of a long-term strategy to manage both current flooding and future flooding. However, in late July 2017 the Ōpāwaho / Heathcote River experienced the third significant post-EQ flood event as a result of a prolonged period of rainfall. A state of emergency was declared, and the Ōpāwaho / Heathcote River again made national news. As a result of this event there was a need to move rapidly from the investigation phase to presenting a package of recommendations to address post-earthquake flooding. The remainder of this paper describes the fast-track process undertaken and the lessons learnt from this.

Table 2 Options considered in development of the medium term response

Type of mitigation	**Options long list (may still be considered for long term response)**	**Short list of current flooding options**
Source (Reducing or attenuating the flood sources)	• Do minimum (planned storage) • Further upstream storage (i.e. in Hendersons basin) • Catchment-wide micro-storage • Eastern hills attenuation • Tidal suppression (eg barrage)	• Do minimum (planned storage) ~~• Further upstream storage (i.e. in Hendersons basin)~~ ~~• Catchment-wide micro-storage~~ ~~• Eastern hills attenuation~~ ~~• Tidal suppression (e.g. barrage)~~
Pathway (Improving the capacity of the river or keeping the river within the banks)	• Mid-Heathcote storage • Stopbanks (full length and discrete locations) • Dredging (full reach and individual reaches) • Floodplain widening • Channel diversion (i.e. bypass culverts) • River mouth pump station	~~• Mid-Heathcote storage~~ • Stopbanks (~~full length and~~ discrete locations) • Dredging (~~full reach and~~ individual reaches) • Floodplain widening (through bank stabilisation) ~~• Channel diversion (i.e. bypass culverts)~~ ~~• River mouth pump station~~
Receptor (Changing the impact of flooding)	• House raising / purchase (Flood Intervention Policy) • Changing land use ("room for the river" in future) • Reduced level of service	• House ~~raising /~~ purchase (Flood Intervention Policy) ~~• Changing land use~~ ~~• Reduced level of service~~

4 FAST-TRACK RESPONSE

The July 2017 floods created a sense of urgency to address the frequent flooding that many residents along the river had experienced. Since the earthquakes some residents had multiple instances of above floor flooding resulting in them being out of their house a number of times. Others had underfloor flooding and were faced with expensive cleanups and an inability to use insurance to fund this due to increasingly high excesses. Some lost insurance against flooding altogether. The flooding was high profile and there was a sense in both the community and among elected members that urgent action was required.

It was in this space that a package of measures to manage flooding in the medium term was developed which was approved by Council on 23 November 2017. The measures agreed to were ones which addressed current climate flooding, but fitted in to a long term strategy. The process followed to reach this point is described below.

The toolbox of measures responded to a range of frequencies and time scales. The total package of works approved will cost approximately $80 million over a period of 5 years. It included:

- purchase of the most affected houses (using the Flood Intervention Policy)
- upper catchment storage
- dredging (which was identified as providing benefit up to 0.25m sea level rise)
- bank stabilisation, and
- consultation on low stopbanks.

These were described as 'building blocks' and frequently presented as shown in Figure 2. The options are described in brief below, with further details at: https://ccc.govt.nz/services/water-and-drainage/stormwater-and-drainage/stormwater-projects/whats-happening-in-your-neighbourhood/heathcote-catchment/

Figure 2: Floodplain management 'building blocks'

4.1 FLOOD INTERVENTION POLICY

Following the CES, Council approved a flood intervention policy (FIP) which offers assistance to property owns who meet the following criteria (https://ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/policies/sustainability-policies/flooding-intervention-policy/):

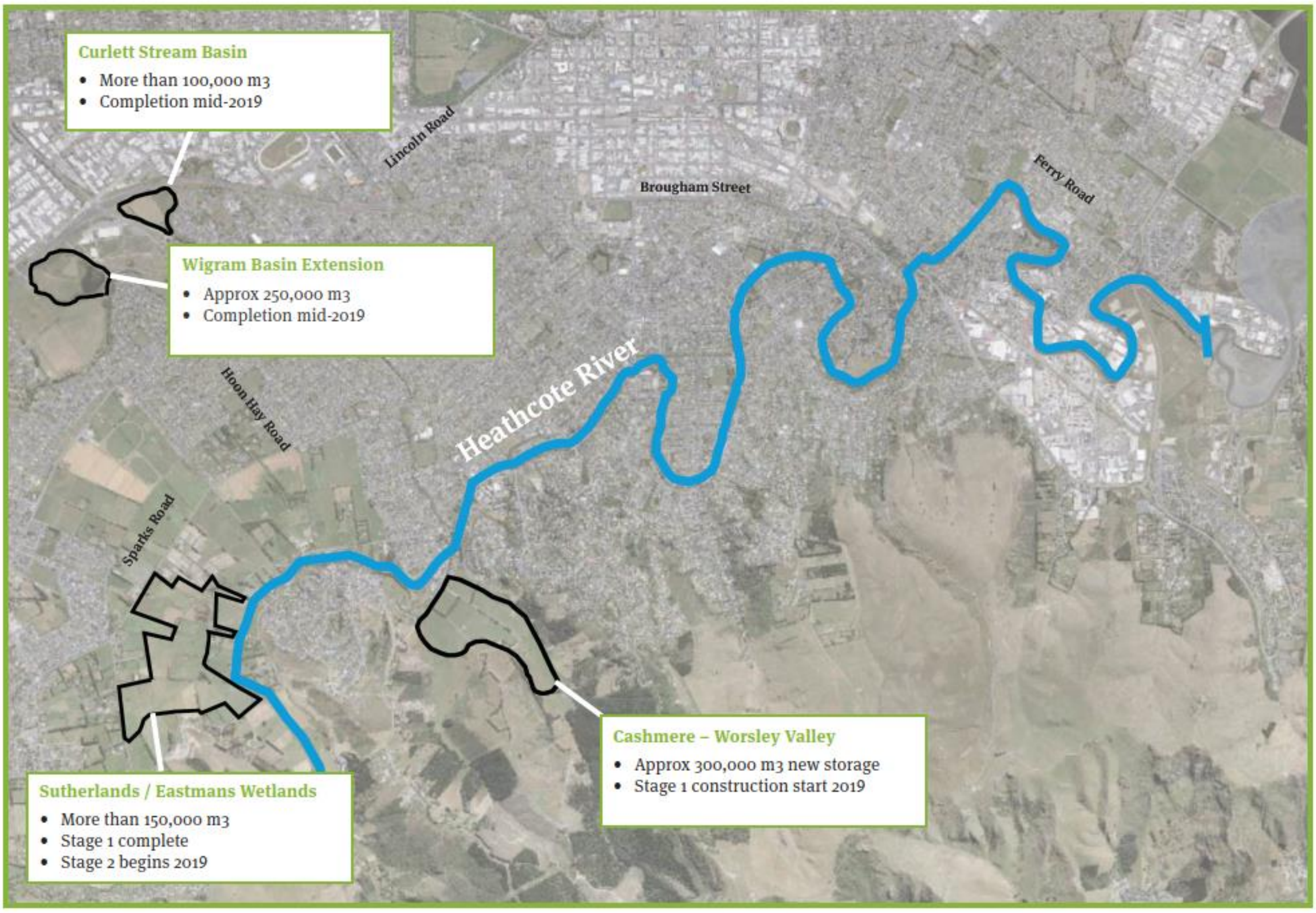
1. The habitable areas of their dwelling have experienced frequent (defined as 10% AEP) above-floor flooding
2. The flooding has been worsened by the effects of the CES and investigations have confirmed this
3. Planned flood mitigation schemes will not offer a timely reduction to their flood risk.

While the FIP allows a range of interventions (including house raising), in the Ōpāwaho / Heathcote River catchment this policy was used to make voluntary purchase offers to eligible properties. If a property is purchased then all buildings on the property are demolished and no future buildings are allowed. The future use of these sites is still being discussed.

Along the Ōpāwaho / Heathcote River 26 properties were identified as eligible, and by early 2019 19 offers had been accepted.

4.2 UPPER ŌPĀWAHO / HEATHCOTE RIVER STORAGE SCHEME

Figure 3: Location of basins within the Upper Ōpāwaho / Heathcote River Storage Scheme



The Upper Heathcote Storage Scheme consists of four new flood basins, with a total combined additional capacity over and above planned projects of 800,000m³. The total cost of the scheme is estimated at over $40M.

The location and timing of each of the basins is shown in Figure 1. Stages of each of these are in construction, with the full works expected to be completed by 2021.

4.3 DREDGING

Until the mid-1980s, dredging was undertaken along the Ōpāwaho / Heathcote River by the CDB. However, no systematic dredging has been undertaken since 1989, although silt removal has occurred in sections along the river. Dredging can increase channel conveyance, reducing water levels and impact of frequent floods. Dredging can also reduce the length of time water occupies the floodplain, which has relevance where flooding displaces people from their homes or forces road closure and access restrictions.

Studies made it clear that the siltation of the channel has increased frequent flood levels, particularly downstream of Hansen Park (Photo 2). However, one of the challenges with dredging was that it provided benefits in frequent events but less so in extreme events. In addition, with rising sea levels over time, the benefit provided by dredging will reduce. However, by re-framing the question to, 'What benefits can dredging provide now?', this allowed the option to move forward, as significant benefits until approximately 0.25m sea level rise and in frequent events could be shown. Approximately 60,000 m³ of material was identified to be removed.

Dredging is currently underway, with approximately one third of the work completed. While there were environmental and cultural challenges to overcome, these have proved less difficult than originally anticipated due to the dredging methods used and the lower than expected contamination levels.

Photograph 2: Siltation of the Ōpāwaho / Heathcote River showing reduced channel capacity

4.4 BANK STABILISATION

Although not primarily a flood mitigation measure, bank stabilisation was presented as part of the overall package as it did serve to maintain or slightly increase conveyance capacity. The works were approved prior to the July 2017 floods, but served to demonstrate that works could be fast-tracked and gave confidence to the community that CCC was serious about undertaking the works. The importance of quick wins will be discussed later in the section on lessons learnt.

Photograph 3: Completed bank stabilisation showing increased channel capacity

4.5 LOW STOPBANKS

High stopbanks or floodwalls could be used to protect buildings at risk of overfloor flooding in more extreme events. However, the heights and widths of stopbanks or walls required are unlikely to be acceptable to the community (or even technical feasible). In some places the stopbanks would be over 1.8m in height. In addition, the cost of stopbanks or walls to provide this level of protection has been previously estimated at several hundred million dollars, well in excess of the value of the property and other assets protected.

As an alternative to stopbanks to protect against extreme flooding, the concept of low stopbanks to mitigate frequent flooding was proposed for consideration. This is because the storage and house purchase options outlined above are aimed at frequent above floor post-earthquake flooding. However, underfloor flooding and deep road flooding also causes significant distress to the community. An example of this was the response to the

July 2017 flood event, where some residents rescued were not flooded above floor, but requested evacuation for medical reasons or due to a fear of the waters increasing.

At the time of reporting to Council in November 2017, staff were not able to make a firm recommendation on this option. As a result it was included to get approval to check technical feasibility (now completed and confirmed) and to consult with residents on whether this was a desirable outcome or not (still to be done).

In addition to providing protection against frequent underfloor and road flooding, consultation with the community on low stopbanks allows the conversation around adaptive management to take place. The community may deem there are more desirable outcomes to adapt to and manage flooding, and it is important to follow a process to allow this discussion to take place.

4.6 OUTCOMES

The combined benefits of the options approved by Council are significant, with benefits provided in both frequent (10% AEP) and extreme events (2% AEP). Figures 3 and 4 demonstrate this benefit for the river section above Radley St (below which it is very tidal), showing how the numbers of dwellings modelled to be at risk of flooding above the floor level has changed as a result of the earthquakes, and then the improvement through the storage scheme and then with the additional options. This results in a substantial improvement over the pre-earthquake situation, although in an extreme event 10 dwellings which were modelled to not be at risk pre-earthquake remain at risk post-earthquake.

In addition to mitigating above floor level flooding, there are substantial other benefits to reducing the severity of both frequent and extreme flooding. These have been described earlier in the report, but it is important to remember that the impacts of flooding extend far beyond the damage to houses, and includes psycho-social impacts for many along the river.

Figure 3: Frequent flood risk along the Ōpāwaho / Heathcote River (10% AEP)

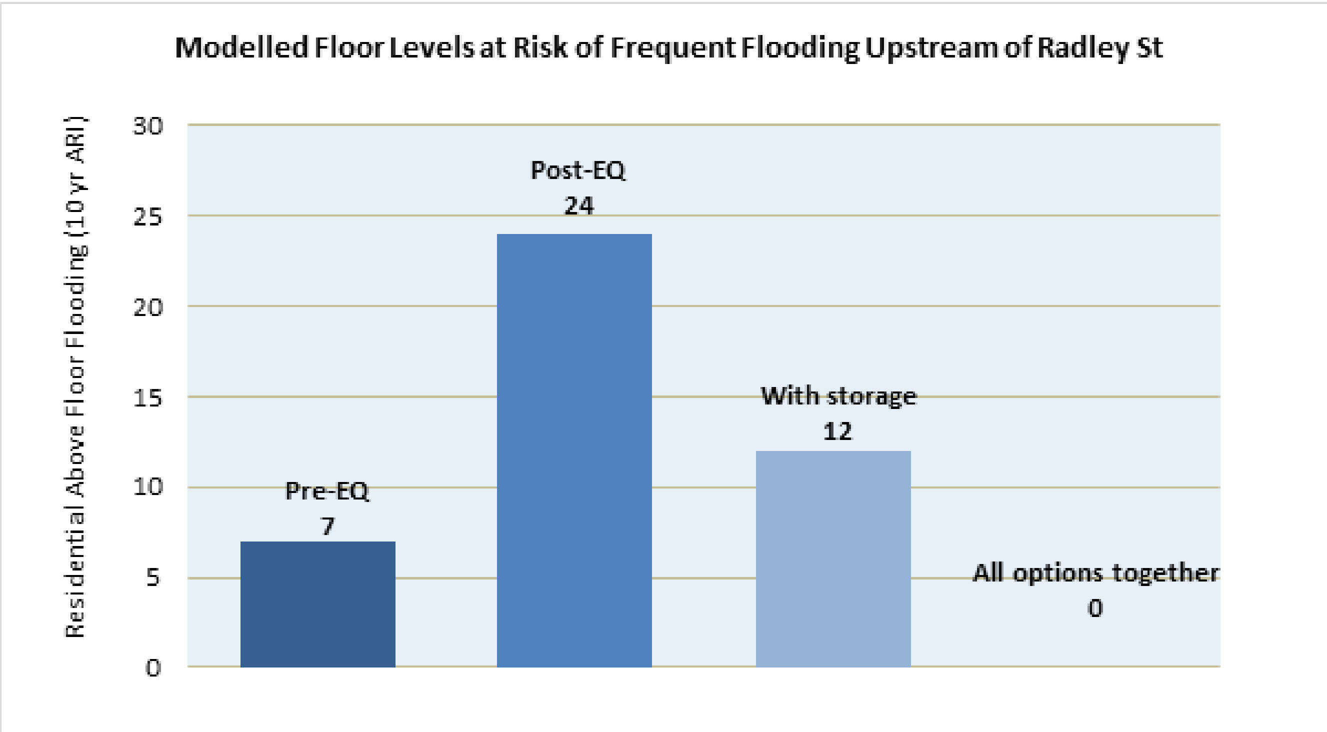
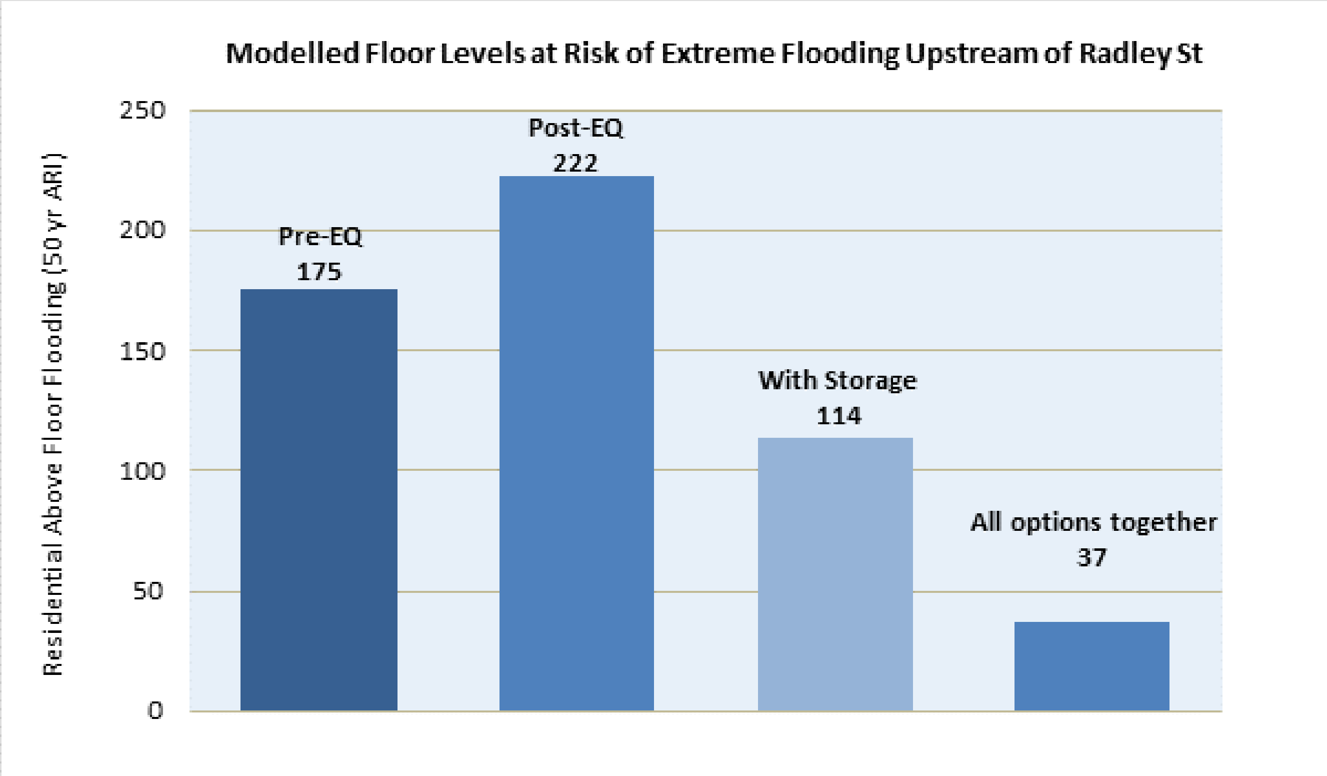


Figure 4: Extreme flood risk along the Ōpāwaho / Heathcote River (2% AEP)



5 LESSONS LEARNT

5.1 RESPOND TO THE URGENCY

As flood management professionals, we need to acknowledge the reality that most investment and policy decisions around floodplain management take place in response to significant events. While we can work towards ensuring decisions are made outside of emergency situations as far as possible, we also need to be able to respond with options that meet both political and community requirements which do not compromise longer term objectives. For example, part of the rationale for undertaking the study into low stopbanks is to ensure that, even if it does not proceed at the current time, the information is available to make informed decisions should there be a call for stopbanks during or immediately after an emergency.

5.2 THE IMPORTANCE OF BACKGROUND STUDIES

The fast-track process was only able to be followed because a significant amount of prior work had been undertaken. This builds on the previous point, in that an urgent response is best undertaken in the context of a sound understanding of the catchment.

In the absence of recent studies, past studies can provide a useful starting point to make recommendations for a response. The response described in this paper is little different to Scheme VB developed by the CDB in the 1980s. It was tested and updated based on new models and post-earthquake topography, but the essential nature of the catchment and opportunities for floodplain management within it have not changed significantly.

5.3 USE REAL FLOOD DATA

The data collected in March 2014 and July 2017 was used to ensure that the measures proposed addressed real problems and areas of high need. There was a need to ensure a high degree of relevance to the issues which were driving the response.

Real flood data also helps to fill in the gaps of modelling or catchment knowledge, and serve as practical benchmarks for the size of the event a scheme may manage. For example, when discussing the difference between 'frequent' and 'extreme' flooding, real events could be referred to which helped the community and decision makers understand the differences between the two types of events.

5.4 THE IMPORTANCE OF CLEAR COMMUNICATION TO ALLOW DECISION MAKERS AND THE PUBLIC TO UNDERSTAND THE ISSUES

Since floodplain management in a changing climate is complex, it is easy to overwhelm people with different options, return periods, etc. Early engagement with key stakeholders provided a lot of information, but it was quickly apparent that too much information was making it harder to make decisions. As such the presentations and messages were simplified, with key messages provided that essentially covered:

- Setting the context: Flooding is not a new issue, and it will repeat again in the future

- Options assessment: Lots of options were considered, but we will only present the key ones

- Building block approach: The selected options were presented as building blocks which addressed different issues, but were essentially one coherent scheme

- Scenarios: The range of scenarios were distilled down to current flooding vs future flooding and frequent (10% AEP) vs extreme (2% AEP). This simplified the message

- Future issues: It was reiterated that future works would be required to address climate change and sea level rise, but importantly, it was also reiterated that the proposed measures could be enacted now without compromising future actions. This simplified the message of adaptive management into more easily communicated terms. Essentially it was, "We can do this now to manage our current issues, but don't forget there are future issues we still need to manage."

A successful communication strategy is one which conveys all the information needed to make decisions, but does not overwhelm people with too much information.

If a scheme is to be successful, it needs to have a vision for the catchment and for improving flooding that matches with people's expectations and experiences. For the Ōpāwaho / Heathcote River in this instance, the vision built on the urgency to address current frequent flooding issues. This is what was on people's minds, and it is this issue that decision makers wanted addressed. While the final scheme does have significant long-term benefits, it was important to convey the core message that the type of flooding that people had experienced recently would be managed more effectively. When discussing the scheme, it was often stated that it would address "the type of flooding that we had experienced since the earthquakes". This could be easily understood by everyone interested in the scheme.

5.5 RAPID OPTIONS ASSESSMENT

It can be overwhelming to reduce a long list to an actionable short list in an emergency response situation. However, there are several criteria that can be used to assist this.

1. All options must be 'no regrets' – that is, they must not compromise long term objectives

2. Short term responses should, as far as is possible, have long term benefits

3. They must address the recent issues experienced by the community

4. The benefits must be quantifiable

5. They must be acceptable to the community and decision makers – you need to understand their drivers and what is likely to be acceptable

If these guidelines are followed then good long term outcomes can be achieved with 'reactive' floodplain management.

5.6 AIM FOR THE ACHIEVABLE

Flood management professionals often talk about schemes to address extreme floods (>2% AEP), but because they are so expensive or the timescales difficult to comprehend they do not always get significant buy in. It is helpful to have shorter term targets instead of just one long-term goal. If the smaller targets are achievable, less expensive, and have lower possibilities of failure, confidence and trust are built which helps achieve longer term outcomes.

In many catchments frequent flooding is actually a larger issue for the community than extreme events. In the case of the Ōpāwaho / Heathcote River catchment, the long term fix for extreme flooding is very expensive and will take many decades to enact. If that had remained the goal, then it is unlikely that a viable scheme would have been adopted. By being willing to aim for something that was achievable and with events more frequent than standard design practice, a scheme with significant benefits was approved.

An example of this is dredging. While it does not provide much benefit in extreme floods or in sea level rise scenarios beyond 0.25m, it does provide significant benefits to the community in frequent events, and will likely do this for a 30-40 year period. This provides relief while options to address longer term issues are investigated further.

5.7 THE IMPORTANCE OF QUICK WINS TO BUILD CONFIDENCE

Creating quick wins early in the process builds the confidence of both the community and decision makers. Quick wins show that works are underway to address flood issues.

An example in the Ōpāwaho / Heathcote River catchment is two relatively small basins built as part of early LDRP works. While these do provide some reduction in flooding, they were also valuable in showing what could be achieved in a fast-track manner. Likewise the bank stabilisation works, although approved prior to the July 2017 floods, were included in the total package of works to show early wins and an ability to deliver within a tight timeframe.

Communicating these early wins is important too. This helps buy-in from the community as they see that there is action taking place and that it is not just studies and talk.

5.8 HOW TO FAST-TRACK CAPITAL WORKS WHEN UNCERTAINTIES REMAIN

Although the project team had the benefit of past studies and more recent investigations and modelling, at the time of the response to the July 2017 floods this process was not completed. There was a need to act with incomplete information, and this was achieved by testing options through modelling and workshop and challenge sessions with a range of stakeholders. This was an ongoing process, where scheme options were re-tested and challenged prior to presenting the final options to the community.

Despite a scheme being approved by Council, uncertainties remained, both in the cost of some of the works (e.g. if contaminated material was encountered in dredging), but also in the feasibility of some options (e.g. low stopbanks). This was made clear to decision makers and different recommendations were made based on the level of certainty.

For some options, rapid modelling was undertaken to test the viability and likely benefits, knowing that additional work would be required to fully test the bounds of the benefits. While this is the case in many projects, the time period was compressed in this instance and greater reliance on engineering judgement and workshop challenge sessions was required than in a standard design process.

In order to deliver the benefits to the community rapidly, projects were often staged to allow some elements to progress while other elements followed after. An extreme example of this was progressing with the bulk earthworks of a basin while the design of the structures followed behind. This improved the delivery outcomes by at least six months. In dredging, a 'quick win' section was identified for early design and physical works, while more complex sections lagged behind. This again allowed for more rapid delivery of the benefits, and improved community confidence in the works.

6 CONCLUSIONS

Professionals working in floodplain management need to be responsive to opportunities to achieve long term outcomes. Political decisions made about floodplain management are often reactive, but with good planning this can be managed to achieve benefits that address current flooding issues without compromising future schemes. This highlights the need to continue to undertake floodplain management studies even when capital projects may be programmed some time into the future.

As well as being prepared, the floodplain management strategy must ensure that the felt needs of the community are addressed, and this needs to be communicated clearly. At times this may mean developing schemes which respond to more frequent current climate events, even when the longer term goal may be to address extreme future climate events.

The Ōpāwaho / Heathcote River catchment provides a case study for this approach, whereby long term benefits are being achieved while addressing the current climate frequent flooding needs of the community. Further work in the future will still be required, but significant gains are being achieved which continue to build on the legacy of past works.

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shared their knowledge and understanding of the nature of flooding along the river and how it affects them.

REFERENCES

Christensen, P. and S. Maclaren (2017) 'Ōpāwaho / Heathcote River Floodplain Management Options', Presented to the Christchurch City Council Infrastructure, Transport and Environment Committee 8 November 2017, http://christchurch.infocouncil.biz/Open/2017/11/ITEC_20171108_AGN_1602_AT_WEB.htm

Cobby, D., Christensen, P., Wiseman, I. and B. van Lammeren (2018) 'The Realities of Adaptive Flood Risk Management', Proceedings of the New Zealand Stormwater Conference 2018

Parsons, T., Todd, D., Cobby, D., Hart, D. and P. Kingsbury (2018) 'Christchurch Multi–Hazard Analysis Approach', Proceedings of the New Zealand Stormwater Conference 2018