FLOOD INTELLIGENCE IN MANAGING FLOODPLAIN A WIMMERA PROSPECT

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Abstract

Wimmera Catchment Management Authority (CMA) believes best practice floodplain management revolves around firm planning, preparedness and response information and processes. Wimmera CMA's approach to achieving this includes participation in adequate planning controls to ensure new developments are not subject to flooding and do not increase the flood risk profile of those developments already in existence, the development of well-built flood knowledge though flood investigations and finally the coordination of adequate flood warning systems to inform the community in an accurate and timely manner.

Salient features Wimmera CMA has employed in developing its flood intelligence include state of the art computer modelling flood investigations, updating to improve LiDAR data, real-time monitoring of flood gauges with telemetric warning gauges to improve community warning, and the capture of regular and thermal aerial photography during major flooding. Local knowledge is another key to flood understanding and Wimmera CMA collects from the community, stories, photos, floods flow characteristics, high water flood marks for recent and other historical floods.

Although technological advances have created many opportunities for flood intelligence; community consultation and local knowledge are major components in implementing and interpreting this intelligence along with building community confidence in CMA and other emergency services during flood events. Dealing with technological difficulties was a key learning during the January 2011 flooding. Automated flood intelligence gauges, when damaged and unable to operate effectively pose a large risk to our ability to prepare for and inform the community of impending floodwaters. A continual upgrade of flood intelligence equipment and processes is required to meet future challenges while recognising that not every part of the catchment is likely to be fully understood in terms of flooding in the short to medium term. Wimmera CMA's future challenges include improving the organisations in diverging directions based upon our learning from recent floods.

This paper identifies areas to improve flood intelligence and especially key learning's after January 2011 flooding within the Wimmera. The importance of updating and upgrading flood modelling, improving the automated gauge network, analysing impacts due to changes in the landscape, technological redundancy, conveying flood information to the community with understandable language will ensure that Wimmera CMA provides the best available information to emergency services and the community for all future floods".

Key Words: *Flood Intelligence, Wimmera CMA, Recent Learning, Floodplain Management*

Introduction

Wimmera Catchment Management Authority (Wimmera CMA) believes understanding flood behaviour through gathering flood intelligence greatly improves planning and preparedness in floodplain management. We recognise that flood intelligence is the centre around which all whole floodplain management revolves. Better intelligence will lead to better planning and preparedness to produce effective management on the floodplain.

The Wimmera CMA is located in Western Victoria and extends from the Grampians National Park in the south to Lake Albacutya near Rainbow in the north, and from the South Australian border in the west to Navarre in the east. The region's population is about 49,000 covering 23,500 square kilometres, or 13% of Victoria.

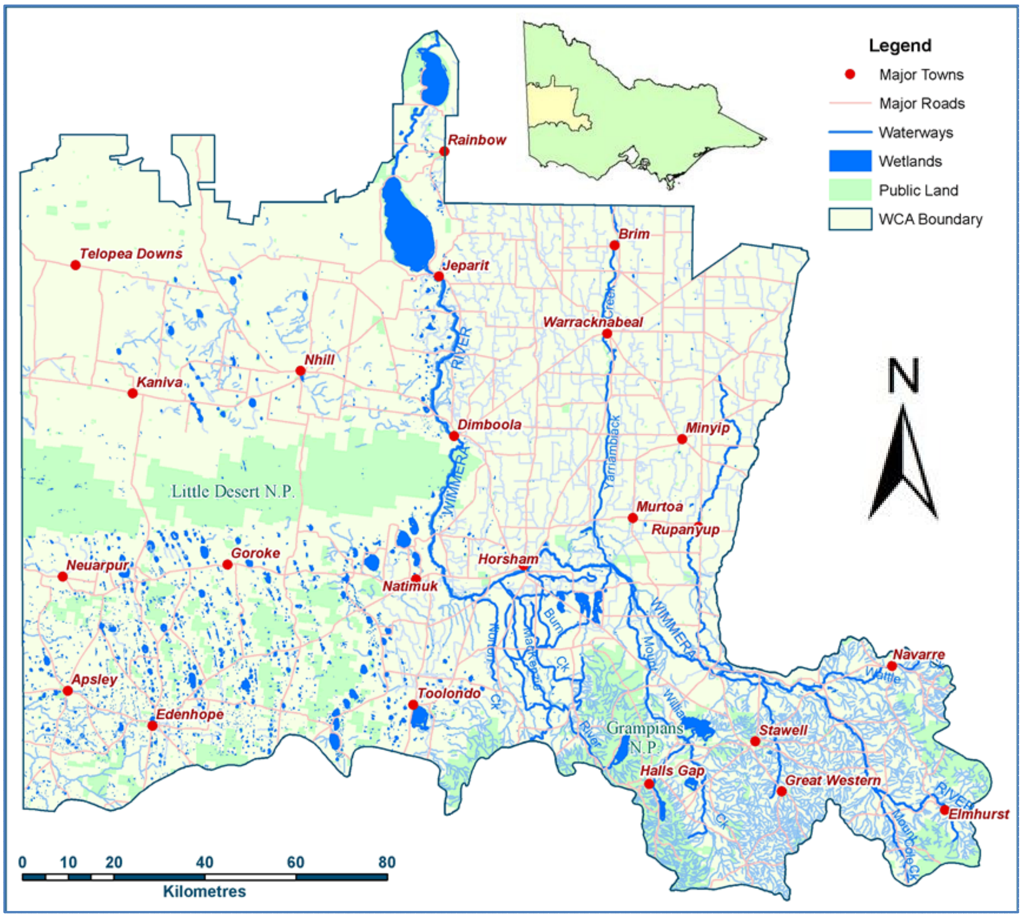


Figure 1: Area of Wimmera Catchment Management Authority.

Wimmera CMA is responsible for the development of floodplain management strategies, floodplain statutory planning, flood data management and community flood awareness education. Wimmera CMA considers best-practice floodplain management to encompass a suite of functions to reduce the likelihood of potential loss of life, risk to health, and damages to property. To fulfil these objectives, flood intelligence plays a significant role in understanding the catchment, analysing flood behaviour, predicting flooding impacts and preparing municipal emergency plans so as to manage the Wimmera floodplain in an integrated fashion. Wimmera CMA's approach to achieving strong flood intelligence includes the development of computer based flood models using community knowledge, radar information, satellite imagery, aerial flood photography and coordination of adequate flood warning systems with telemetric gauges to provide real-time river information to the community during major flooding, all relevant flood maps available with all invaluable flooding information for different magnitude flooding. This approach, which has grown slowly over the community past decade, combined with the efforts of the community and agencies enabled a very strong flood response to the events of January 2011. This ensured that, although there was significant damage to property and infrastructure, comparatively few houses were flooded and, most critically, no injuries or fatalities occurred.

Background

Flood events of the Wimmera River have been a regular feature throughout European settlement and history highlights, for example, that Horsham has experienced 18 large floods events in over the last 100 years. Past flood experiences and recent flood intelligence have formed a basic understanding of the catchment's flood behaviour. There is a need for greater acceptance by the community that floodplains are a permanent and important part of our landscape and activities whether they be building or farming on a floodplain have inherent risks.

With the improvement of technology, especially with the complex and powerful computational facility, radar and satellite technology, and accurate aerial photographic information in the last decade has enabled us to produce an improved understanding of regional flood behaviour.

Summary of Flood Modelling from Previous Studies in Wimmera

Wimmera CMA has undertaken a number of flood investigations for priority townships like Horsham, Dimboola, Jeparit, Warracknabeal, Halls Gap and Glenorchy that are affected by flooding. These assessments are invaluable in terms of educating the community about the likely flood impacts for certain events, to prevent inappropriate development that would be subject to flooding and also for agencies to assist in the identification of the locations where people need to be warned and property protected from floodwaters pre and during flooding events.

Flood Intelligence from Other Sources

Stream Gauging and Rainfall Gauges:

Across the Wimmera catchment there are a number of recognised flood warning stream flow gauging stations. Locations are given in table 1. The region has many additional gauges that are primarily used for water distribution management purposes that are also able to provide information for collective waterway understanding during flooding events.

Real Time Flood Monitoring Using Environmon System:

Wimmera CMA uses the Bureau of Meteorology Environmon computer software system where real time updates of the stream flow gauges and rainfall gauges at different stations within the Wimmera are available.

Location	Gauge No.	Catchment area (km²)	January 2011			Highest gauge level on record	Highest level on record prior to 2011		
			Peak level (m)	Peak flow (ML/d)	Date/Time of peak level		Height (m)	Date	Start of record
Wimmera River at Eversley**	415207C	304 [1]	5.837	30,845	14/01/2011 0815hrs	Y	4.74	04/09/2010	1963
Mt. Cole Creek at Crowlands**	415245A	144 [1]	3.440	3,451	14/01/2011 0915hrs	Y	2.64	04/09/2010	1985
Wattle Creek at Navarre	415238A	141 [1]	4.68	5,542	14/01/2011 9:23	N	4.72	27/01/1993	1976
Wimmera R at Glynwylln*	415206B	1,357 [1]	8.630	34,983	14/01/2011 1745hrs	Y	8.31	05/09/2010	1956
Concongella Creek at Stawell**	415237A	239 [1]	5.050	6,839	14/01/2011 630hrs	Y	4.85	31/03/1988	1976
Wimmera River at Glenorchy Weir (Tail Gauge)	415201B	1,953 [1]	5.026	31,522	15/01/2011 0730hrs	Y	4.99	04/09/1975	1975
Fyans Creek at Lake Bellfield	415214C	101 [1]	1.175	413	13/01/2011 1745hrs	N	2.57	01/10/1996	1973
Fyans Creek at Grampians Rd Bridge ***	415217A	34 [1]	-	-	-		1.66	27/10/1973	1973
Fyans Creek at Fyans Creek	415250	-	4.230	4,140	13/01/2011 23:11hrs	Y	1.21	20/12/1992	1988
Mt William Creek at Lake Lonsdale (Tail Gauge)	415203D	1,026 [1]	2.654	38,527	14/01/2011 2145hrs	Y	0.91	28/01/1993	1975
Mt William Creek at Mokepilly**	415252B	-	4.798	5,216	14/01/2011 0800hrs	No historic information available			
Yarriambiack Creek @ Wimmera Highway Bridge	415241	-	1.72	1294	19/01/2011 16:43:46	No historic information available			
Wimmera River at Drung Drung**	415239A	-	4.710	22,944	16/01/2011 1815hrs	N	4.82	07/09/2010	1978
Burnt Creek at Wonwondah East	415223B	80 [1]	1.070	1,596	14/01/2011 0545hrs	Y	1.05	10/10/1992	1983
Mackenzie River at Wartook Reservoir****	415202C	80 [1]	1.993	-	13/01/2011 1815hrs	Y	1.73	20/12/1992	1975
Mackenzie River at Mckenzie Creek **	415251A	-	2.357	2,594	15/01/2011 0830hrs	Y	1.96	10/10/1992	1988
Wimmera River at Horsham (Walmer)	415200D	4,066 [1]	4.277	32,971	18/01/2011 1130hrs	Y	3.64	13/09/1983	1975
Wimmera River at Quantong *****	415261A	-	7.364	-	18/01/2011 2130hrs	Y	5.00	19/08/2010	2009
Wimmera River US Dimboola	415256A	-	5.752	23,788	19/01/2011 1600hrs	Y	5.45	06/10/1996	1989
Wimmera River at Lockeil Railway Bridge	415246A	-	4.617	22,639	20/01/2011 1500hrs	Y	4.33	06/10/1996	1987
Wimmera River at Tarrenyurk ****	415247B	-	5.752	-	21/01/2011 1415hrs	Y	5.20	08/10/1996	1987

* Gauging station failed to record levels during peak of January event
** Water level exceeded rating curve, peak levels recorded, flows displayed are the highest rated flow
*** No flows available
**** No flows have been determined
***** No rating curve
[1] Catchment area from Victorian Data Warehouse, all other manually calculated

Table 1: Historic and January 2011 peak level and flow information.

Rating Curve and Flood Frequency Analysis Information

We have rating curves for 15 flood gauging stations including flood frequency analysis (FFA) completed for 5 stations. Other stations are too new to analyse flood frequency with reasonable accuracy.

Aerial and Thermal Flood Photography

Infra-red technology was used to map flood extents during January 2011 flooding. Using aerial line-scan, which is popularly used in analysing heat in bushfires, images were used to obtain the extent of water at specific points in time. A collection of these have been summarised within Wimmera CMA's GIS system to determine the overall extent of waters in the catchment (shown in figure 2).

Local Knowledge

Wimmera CMA understands that local knowledge is a key source of intelligence in flooding. Wimmera CMA has collected stories, photos, high water flood marks for recent and other historical floods. Staffs also gather suggestions from the community for flood mitigation works during flood studies. Damage information is also collected after the flood during the community flood information recovery sessions. While this flood information is valuable, its reliability is often uncertain in application.

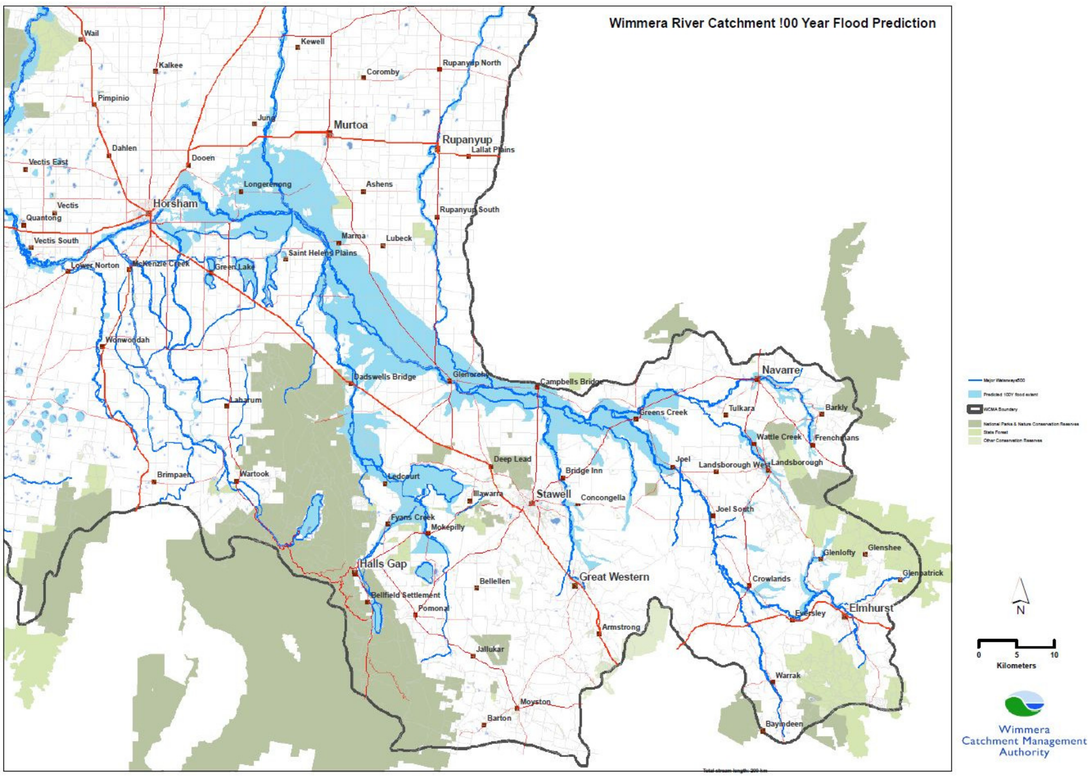


Figure 2: Flood affected area within the Wimmera CMA

Our Experience in January 2011 Flood

In 2010 Victoria recorded its wettest year since 1974, with part of the Wimmera region suffering major flooding during September. Additional to the wet conditions in 2010, the Wimmera region received heavy rainfall across the 9th -14th January 2011 setting rainfall records at nine rainfall gauging stations. The resultant streamflow caused all but two Wimmera catchment stream flow gauges to record their highest recorded levels. The recorded maximum peak flow in the Wimmera River at Glenorchy, Wimmera River at Drung Drung and Wimmera River upstream of Dimboola as shown in Figure 3 shows a record-breaking flood extent in January 2011.

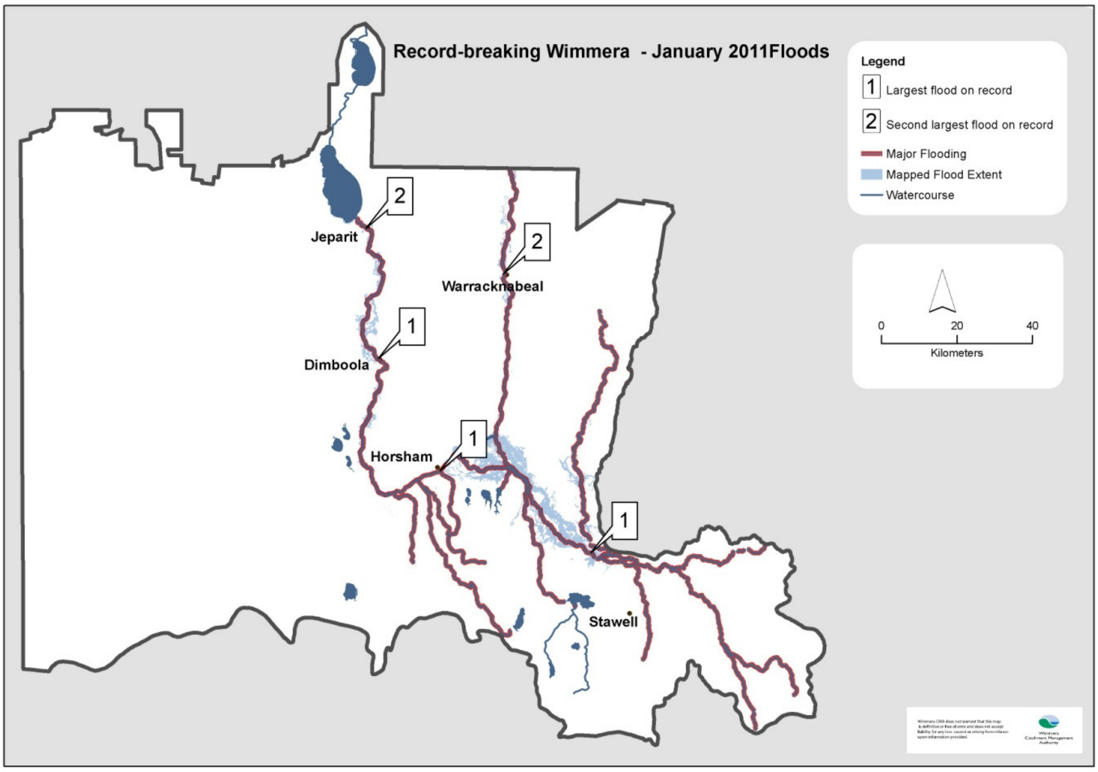


Figure 3 Shows record breaking flood extent in January 2011.

Discussion about Learning's from the Flood Event

Active involvement in gathering flood intelligence and undertaken flood studies over the last ten years, proved to be invaluable during the January 2011 flood. It should be noted that no loss of life or critical injuries occurred, however there was significant damage to individual property, infrastructure and assets, including houses. Wimmera CMA has identified areas of improvement as key lessons were learned before, during and after flooding to manage the floodplain more effectively in any future major flood events.

Learning in Regard to Priorities Areas of Flood Intelligence

Lesson 1: Improve the extent of flood intelligence by conducting more flood investigations in towns which are subject to frequent flooding but have limited or no flood intelligence available like Rupanyup, Dadswells Bridge, Great Western etc.

Learning in Regards to Flood Modelling

Lesson 2: Update and upgrade existing flood models based on recent experience in regards to flood mitigation options. Townships located in the lower catchment had sufficient warning of the approach of a large flood event to undertake preparations which included construction of informal 'levees' which were lines of earth pushed up by earthmoving machinery along the edge of waterways. This most notably took place in Warracknabeal (Figure 4.) which helped prevent flood damage to houses in the township but did so at significant risk. During the construction of the levee there was no understanding of the potential implications of its construction, either positive or negative. Should the 'levee' have failed floodwaters would have rushed in, trapped on the inside of the levee to flood houses to a greater depth than would have been the case otherwise and would have flooded other houses that were previously not at risk of flooding. It could be argued that those who had undertaken the flood mitigation works may have been legally liable for damages. Furthermore other communities saw the success of the efforts with positive media coverage to help Warracknabeal and sought to replicate it at their localities.

Figure 4: Informal embankment along Yarriambiack Creek in Warracknabeal. Note it has artificially raised the water level on the right-hand side.

After two major floods in September 2010 and January 2011, landholders, are concerned about future flooding impacts which is leading to the construction of illegal informal levees that will increase flooding in adjacent areas.

Figure 5: This illegal levee was constructed after the January 2011 flood to protect agricultural land.

Wimmera CMA is currently working with councils and the regional Water Authority to ensure flood storage capacity is not compromised by protection works post the floods, while at same time educating the community about the adverse impact of levee construction on adjacent properties and the potential legal ramifications of their actions. Illegal levees also reduce the accuracy of flood mapping which is widely used widely in managing flood emergency by all government agencies.

Wimmera CMA is also working with councils to reverse irresponsible illegal land filling, especially within urban areas which reduces flood storage and intelligence, causing potential threats to the adjacent properties within the floodplain.

Figure 6: Aerial Photo overlapping with 100 years ARI mapping shows illegal filling on properties and the impact of reduced flood storage in the adjacent areas and properties.

Lesson 3: Council municipal emergency plans should be updated regularly incorporating agreed flood mitigation options. The mitigation plan should also clearly mention where and when to execute the plan. A number of road crossings of waterways were excavated out during the floods (Figure 7), leading to limited reductions in water level. Such an approach would therefore need to be reconsidered to determine if they are an effective part of an overall response or cause unnecessary costs and inconvenience with the need to reinstate them. Digging out a road crossing to improve channel capacity that might marginally reduce flood levels in farmland will be costly to reinstate, provide an obstacle to emergency response agencies and cause extensive public inconvenience once floodwaters drop.

Lesson 4: Capacity building within the CMA to analyse, update and upgrade existing flood models. It is not likely the money will be available for updating and, upgrading the existing models created for previous flood investigations, moreover it involves significant time and cost to complete the process. In addition to this, Government funding is always based on risk and population which always make it difficult to get funding for flood investigations affecting small communities. As the flood modelling is resource intensive in terms of funding and labour, Wimmera CMA can build its capacity to conduct flood investigations in small catchments for small communities.

Lesson 5: Flood investigation recommendations should be carried out otherwise it will be very difficult to improve floodplain management. A case in point within the Wimmera was the township of Jeparit where a flood study for the town completed in 2008 highlighted that due to widespread concerns about the size and integrity of the town's levees it would be worth investigating their refurbishment and raising. A lack of resources prevented the local shire from undertaking these works and as a result, incident management was conducted on the basis that the levee would fail.

Figure 7: Road cut-out crossing Yarriambiack Creek during January 2011 flood.

Learning in Regards to Water Storage

Lesson 6: Historic floods have typically occurred following on from wet periods where water storages are typically very full due to significant inflows and low demands. Recent experience has shown that when inflows are sufficient to cause storages to spill the local community are significantly impacted due to a sense of complacency that the storage will buffer any flood. These water storages were not design for lessening flooding so communities should not overestimate the flood mitigation options afforded by water storages when under taking individual flood planning and preparation actions.

Learning in Regards to Monitoring Gauges

Lesson 7: There is a need for more gauging of both rainfall and streams to better understand catchment response to different weather conditions. Flood warning gauges are expensive to establish and maintain. Moreover few rural cities experience storm-water flooding very frequently. Improving rainfall gauges could improve the understating of rainfall patterns, intensity and extent which might improve existing planning for communities like Halls Gap, Navarre, Natimuk etc.

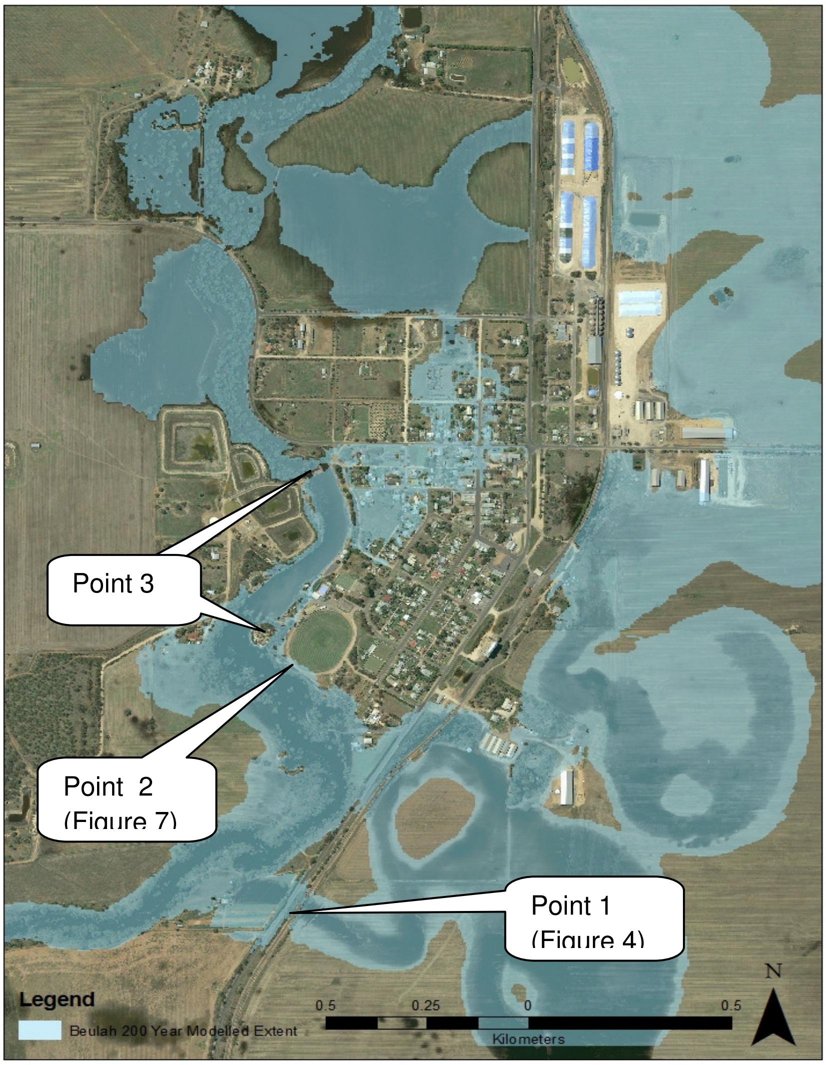
Flashy floods coming off small and/or rocky catchments would be better served by warnings from automated rainfall gauges and rainfall radars rather than streamflow gauges. Therefore there is a need to carefully consider the number, type and location of flood warning gauges to ensure a comprehensive, effective and efficient network is established.

Lesson 8: Flood warning gauges are expensive to establish, maintain and the heavy reliance on electrical sensor technology means they can be subject to failure if the power fails or gauges are inundated. As the technology become more sophisticated it may create more complications so redundancy of technology in the contingency plan is an obvious lesson after losing so many gauges during last January 2011 floods. The EnvironMon system requires a functioning gauge and on-ground visual observations are dangerous during flood periods and impossible to undertake when access is prevented. However technology has advanced sufficiently so that it is worthwhile investigating the feasibility of remote camera technology stationed at gauges that can transmit live images of river heights as measured at gauge boards to another safer location as a redundancy should measurements from water level sensors fail. Moreover statistical methods calibrated with gauge hydrograph and linked with nearby gauges could provide some valuable information if the flood warning gauge failed in an extreme weather event.

Lesson 9: Improved radar coverage will assist towns like Natimuk, Hall's Gap and Navarre as they are susceptible to flash flooding. As Mt Gambier and Mildura are the closest weather radars, at least 200 km from these locations, a weather radar should be constructed in the Wimmera to improve the confidence of the magnitude and timing of oncoming heavy rainfall events and enable these towns to be better prepared.

Learning From Flood Mitigation Works

Lesson 10: Every single flood is different in terms of flow dynamics, intensity, duration and the extent of flooding. However flood mapping is an invaluable tool in designing mitigation options. Map 1 shows Beulah, a small township in the southern Mallee affected by flooding from the Yarriambiack Creek. Several key points (1 to 3) and the modelled flood extent of a 1 in 200 year flood event are included. The following description highlights additional issues with flood mitigation during the flood event.



Map 1: 0.5% Annual Exceedance Probability (AEP) (1 in 200 year) flood map for Beulah with locations of interest identified.

At Point 1, modelling shows that the blockage of the bridge under the railway line that was undertaken (Figure 8, before authorities requested it be reopened) clearly would have reduced flooding to the east of the bridge but would have exacerbated flooding through the town by up to 0.3m (Map 2).

Point 2 is where earthen embankments were constructed on the south side of Beulah Recreation Reserve (Figure 9). However Map 1 shows that even in a 1 in 200 year flood, it is not at risk as it is an elevated point, thereby wasting resources that could have been effectively used elsewhere.

Pont 3 as in Map 3 shows the impact of increasing the capacity through the town weirs, an effective approach for flood mitigation that ideally should be undertaken during the long intervals between floods but happened during the floods, cutting an important road. The flood of January 2011 did not result in flooding in the township, in part due to mitigation actions (increasing capacity through town weirs).

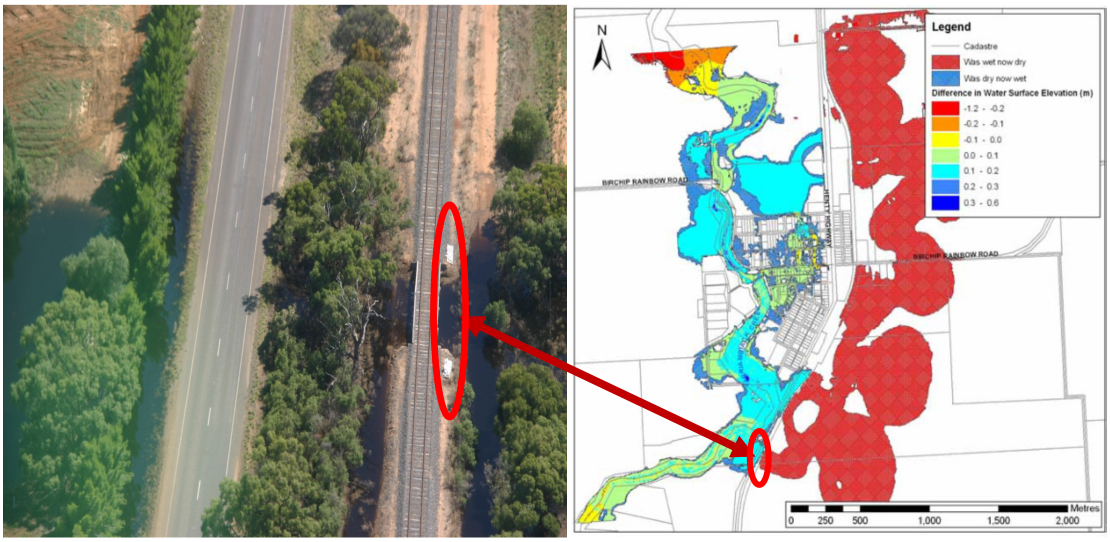


Figure 8: Note piles of sandbags ready to be used to block the flow of water under the railway bridge. Map 2: Flood mapping showing flood height differences for a 1% AEP event based on blocking of flow at the railway bridge.

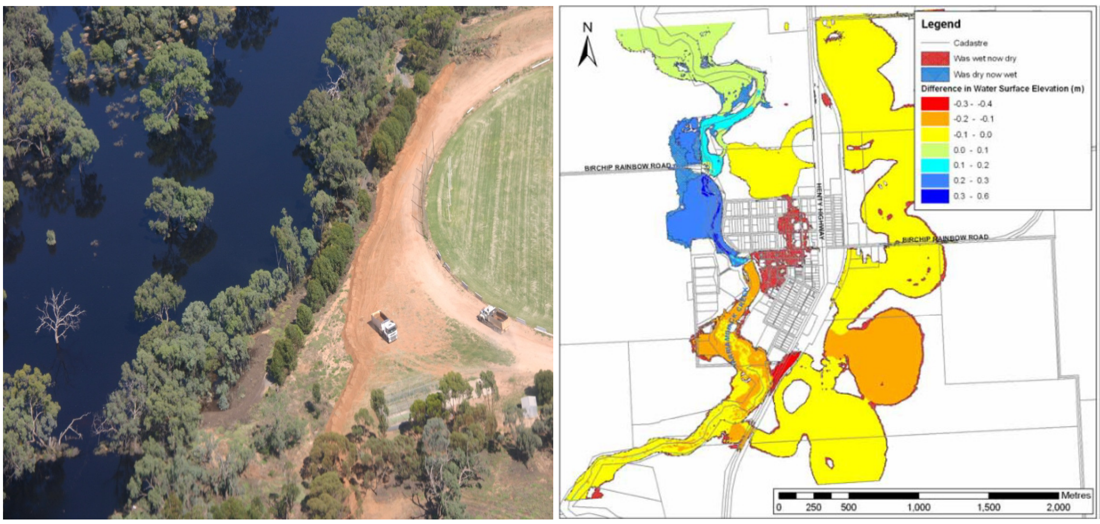


Figure 9: Note embankment created on southern edge of Beulah Recreation Reserve where there is no identified risk of flooding as it a local high point. Map 3: Flood mapping showing flood height differences for a 1% AEP event based on enlarging capacity of weirs.

Lesson 11: There was a great deal of uncertainty amongst the community with what constitutes appropriate flood defences for their property. Urban residents sandbagged driveways and front yards to prevent floodwaters even entering their property instead of just sandbagging around buildings (Figure 10). This displaced floodwaters elsewhere, creating additional problems for their neighbours. Similarly culverts were blocked in a number of locations, preventing floodwaters spreading and artificially raising local flood levels.

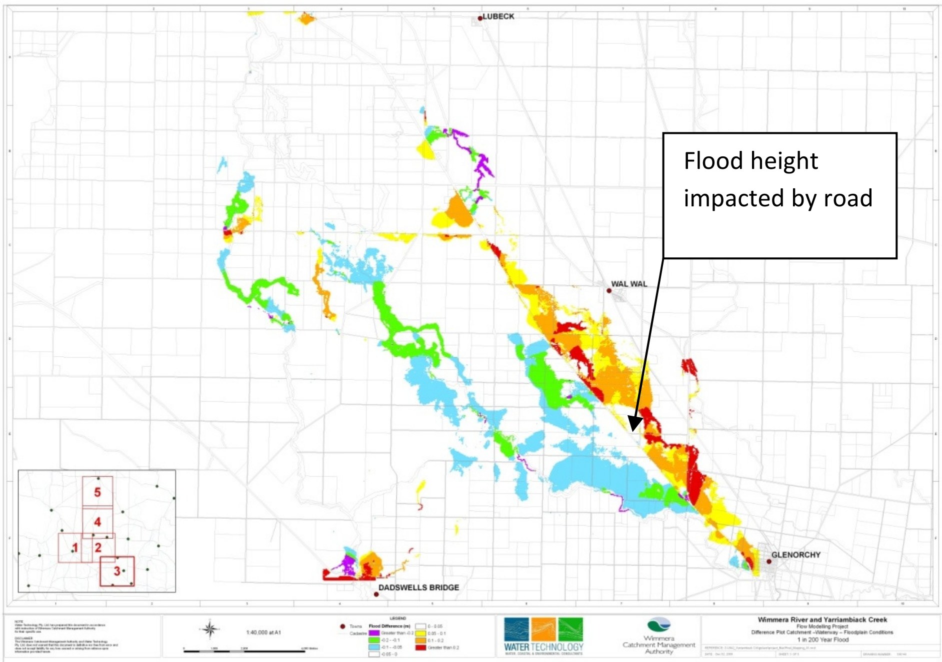
Figure 10: Sandbagging property boundaries instead of houses such as this one in Dimboola was common and reduced overall floodplain capacity.

Learning in regards to management of levees

Lesson 12: With our limited understanding of the natural processes we try to manage major flooding which causes more and more concern in recent years. Unfortunately at times we believe engineering answer is the solution without reading nature properly. Mother Nature can take its own care, by following its own course. On the flipside of the coin, guiding the nature with our limited understanding could create more concern in the longer term. An analogy to demonstrate this point is that snakes love to follow their own meandering path however if we create a meandering path for snake and restrict their sideways movement without knowing the potential consequences, we may not achieve our desired result and consequently receive the venom from the snake bite. Recent events from around the world have shown that where infrastructure is constructed to mitigate a natural hazard the infrastructure inevitably fails in extreme events and the consequences are devastating.

As a general rule, flood mitigation infrastructure should only be developed as a last resort to protect development that currently exists on floodplains. Levees are expensive to construct and maintain and are susceptible to failure or overtopping, trapping floodwaters and causing greater impact than if they were not constructed in the first place. Levees also reduce the local floodplain storage, artificially raising floodwater levels elsewhere and inundating additional areas than would otherwise be the case.

It should be noted that a number of other artificial features such as raised roads, channel embankments and inadequately sized and located bridges/culverts act as levees and provide a degree of flood mitigation in some areas whilst exacerbating flooding in others.



Map 4: Flood impacts caused by constructed features on the floodplain near Glenorchy

Learning from waterways management

Lesson 13: It is misleading for the community to believe that clearing waterways would address flooding issues. Research has demonstrated that vegetation plays an important role as a relief valve through slowing and lowering flood peaks. This reduces the extent of flood impacts and gives agencies and the community additional time to prepare for flood peaks. Although extremely thick in-stream vegetation or debris may have marginally exacerbated flood heights at <u>a local scale,</u> research has conclusively demonstrated that at a <u>catchment scale</u> riparian vegetation and snags lower flood peaks through slowing floodwaters as they pass around trees through long grass and broadacre crops grown upon floodplains.

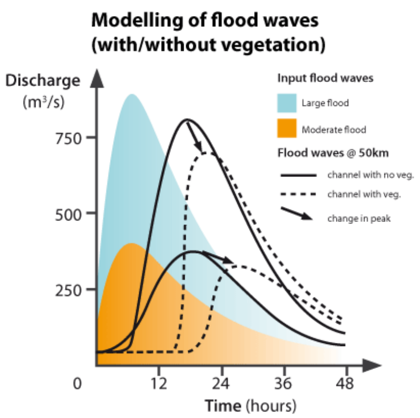


Figure 11: Modelled flood waves down a 50 km reach, with and without vegetation. (From Anderson *et. al.*, (2007))

The experience of January 2011 validated this in terms of observing that the most severe flooding impacts were located immediately downstream of eroded gullies with no vegetation to speak of where water rushed out onto the floodplain immediately downstream (Figure 12). Contrast this with areas that were well vegetated where flood impacts were lessened as high flows continued for a longer period but not at such a large peak volume.

Figure 12: Flooding near Navarre on 14th January 2011, just after heavy rain, note the difference in water on the floodplain in the vegetated areas (right) compared to the eroded gullies (left).

Learnings regarding drainage and channel management

Lesson 14: The Wimmera Mallee stock and domestic channel system is now obsolete. Over the last 18 years the earthen channel-supplied stock and domestic water distribution system has been progressively converted to a reticulated piped supply system, first through the completed Northern Mallee Pipeline (NMPL) system and continuing with the Wimmera Mallee Pipeline (WMPL). These works are resulting in significant savings in distribution losses from the existing channel system, which have historically had losses of around 85%, and will allow flows to be returned to the Wimmera, Glenelg and Richardson River systems (WMPPG, 2004). There are many calls for government agencies to build and develop drainage systems to ameliorate flooding. A pragmatic approach to manage drainage could be where landholders impacted by drainage issues develop community-based schemes to deal with flooding with oversight by responsible authorities where relevant to ensure that there are no third party impacts from the proposal and a holistic floodplain response is achieved. Given the lack of public benefit from such schemes, they should be established and maintained by the parties affected by the drainage problem under state wide frameworks and standards. This could be through developing a community committee of management with a rating base to fund works for the maintenance of these schemes.

Learning in regards to community education

Lesson 15: The community need to be educated to understand floods especially in interpreting information. Moreover people under stress find it difficult to interpret statistical concepts like 1 in 100 year flooding so community education is of high importance. In recent years Wimmera CMA has provided property-specific flood information to at risk areas of the community so that people could interpret the nature and intensity of floods, related to nearby gauge information. It also helps them to take critical actions including when, how and where to evacuate during a major flood.

Continued and prolonged education with respect to flood impact expectancies, mitigation opportunities and emergency language will always be needed to ensure the public is adequately prepared for future events.

Conclusion

Wimmera CMAs approach to gathering flood intelligence through flood investigations, coordination of adequate flood warning systems to provide adequate planning controls worked wonderfully well in the January 2011 flood. Wimmera CMA will continue to analyse the strengths and weaknesses which help the organisation to improve its performance for future flood management. A continual upgrade of floodplain management information is required to meet future challenges. Some of the key learnings include that there is a need to:

- Update and upgrade existing flood models based on our recent learning and updated in council's flood action plan.
- Build up the capacity to perform small catchment floodplain modeling for small community within the catchment.
- Educate the community about flood model results, reservoir capacity, monitoring gauges etc.
- Working with local and state government agencies in improving gauging, redundancy in measuring gauges especially at major flooding.
- Implementing key recommendations from flood studies
- Understand the nature before try to guide the nature. Special attention should be given in managing levees and vegetation in water ways.

In summary every flood is different with different intensity, magnitude, extent and flow behavior. So Wimmera CMA keep on learning from all different floods over the years and improve our intelligence to provide best available service for the community and environment to get a sustainable growth of this region.

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