FILLING IN THE GAPS - VICTORIA'S REGIONAL FLOOD MAPPING PROGRAM

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Introduction

This paper describes the Regional Flood Mapping Program ("the Program") that is being delivered by the Victorian Government Department of Environment Land Water and Planning (DELWP). This paper describes the context for the Program, Program objectives, how reaches were selected for mapping, mapping methods, the approach to community consultation, and also uses of project outputs and achievements to date.

The context for the Program

Victoria experienced widespread flooding between September 2010 and February 2011. The flooding affected approximately one third of the state. Urban, regional and rural communities were affected. As a result, 56,791 claims were made to insurance companies and gross total costs were estimated to be in the order of $1.3 billion (Comrie, 2011).

In the wake of the 2010-2011 floods, the Victorian Government commissioned Neil Comrie, former Chief Commissioner of Victoria Police, to lead a review of the flood warnings and emergency response efforts. The terms of reference for the review stipulated that Mr Comrie should examine, amongst other things, the adequacy of flood predictions, including technology and modelling techniques used, and the adequacy, timeliness and effectiveness of flood warnings and public information.

Review findings were delivered in December 2011. The findings were far reaching and included recommendations relating to the requirement for flood mapping and also flood mapping standards. For example, Comrie (2011) recommended that the State undertake a strategic review to identify areas at risk from flash or riverine flooding (Recommendation 8). He recommended that flood mapping be undertaken for a range of likelihoods, from frequently occurring events up to the Probable Maximum Flood, and that flood mapping be explicitly linked to stream gauges (Recommendations 9 and 21). Furthermore, he recommended that local knowledge be considered as a critical component of all phases of emergency management, including flood studies (Recommendation 93).

Prior to 2010, Victoria had a history of flood studies and flood data, but much of the available mapping focused on the 1% Annual Exceedance Probability (AEP) flood, which is used in Victoria for land use planning purposes. For example, the Flood Data Transfer projects in the late 1990s and early 2000s yielded indicative 1% AEP flood extents for about 80% of regional riverine floodplains (Michael Edwards, *pers.comm. 31 March 2016*). But the reliability of these flood extents varied with the data and method employed in their delineation. For example, some extents were derived from

historic flood extents, or soil mapping, as this was the best available information at the time.

In line with Comrie's recommendations, since the 2010-11 floods, Victoria has invested extensively in flood studies including flood mapping, flood warning and flood mitigation investigations. Figure 1 shows the location of 36 such studies. These studies have mainly focused on providing flood mapping for a range of exceedance probabilities for towns and cities, especially those which were hit by the flooding. Many studies have been funded through the National Disaster Resilience Grants Scheme (NDRGS) using Commonwealth, State and Local funds.

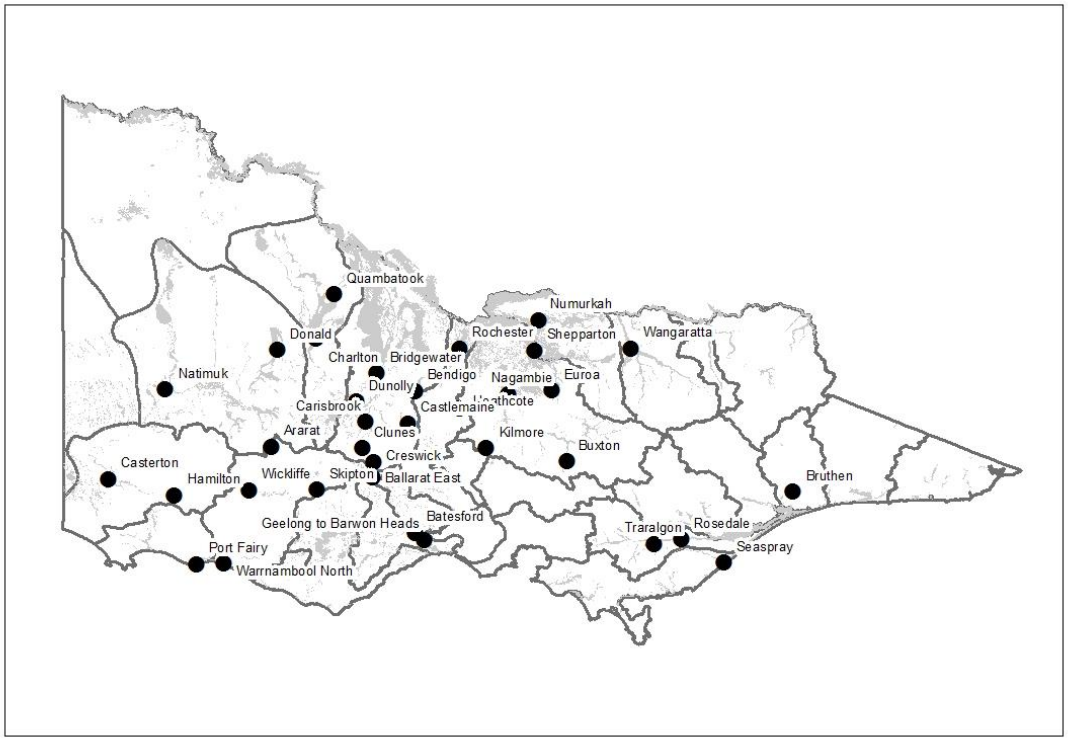

Figure 1 – An indicative 1% AEP flood extent for Victoria and the towns and cities which have been the subject of recent flood studies.

The Regional Flood Mapping Program

Program objectives

The objective of the Regional Flood Mapping Program is to produce flood mapping to "fill in the gaps" between the high quality flood mapping that had been produced for towns and cities.

Outputs from the Regional Flood Mapping Program will be used by Catchment Management Authorities (CMAs), Local Government Authorities (LGAs) and VICSES to meet a range of business requirements. Outputs will be used to define flood related

controls in Municipal Planning Schemes. They will be used to develop flood intelligence products, inform emergency response planning and assist in the preparation of community flood awareness and education products. Furthermore, outputs from the Program will be used to support the assessment of flood risk for insurance purposes. The Victorian Government is funding this Program to support CMAs, LGAs and VICSES in these ways.

In order to satisfy the business requirements outlined above, flood mapping produced through the Regional Flood Mapping Program is required to:

- describe a range of flood magnitudes, from frequently occurring events to the Probable Maximum Flood;
- be developed in consultation with local communities and make use of local knowledge;
- be of a resolution suitable to make planning decisions at a property scale;
- be explicitly linked to stream gauges;
- be quality assured; and
- be stored in Victoria's Flood Database, which is managed by DELWP.

Which reaches to map?

The Regional Flood Mapping Program is funded from the Victorian state budget. Available funds were sufficient to commission approximately ten flood mapping projects, so it wasn't possible to fill all gaps. The question that needed to be answered was – how do we prioritise investment across the State in a way that is rapid, fair, transparent and defensible?

Flood risk is calculated from an understanding of the likelihood and consequences of flooding. The higher the risk, the higher the requirement for quality flood mapping to better plan for and respond to flooding. But the Regional Flood Mapping Program had been established to address deficiencies in available flood information.

Fortunately, Victoria is home to a team of regional floodplain managers who have the professional experience to identify where flood mapping is required based on considerations such as: (i) history of flooding; (ii) risk of future flooding; (iii) availability and quality of existing mapping; (iv) suitability of existing landuse planning controls; and (iv) landuse development pressure.

A long list of about forty rural study areas was created based on the advice of local floodplain managers. There was no minimum or maximum reach or catchment size and catchment areas could extend across municipal boundaries. The only requirement was that the study area was rural and of a regional scale.

Many of the nominated study areas had a history of flooding, but lacked quality flood mapping. In some instances the only flood data available was digitized from historic flood extents or was derived from soil mapping as part of Flood Data Transfer projects. This information represented the best information at the time of derivation, but must be

improved upon in order to satisfy the requirements of the Victorian Floods Review (Comrie, 2011).

Application of the National Emergency Risk Assessment Guidelines

The long list of forty study areas was a good starting point for discussions, but it didn't provide an argument for whether to prioritise one study area over another. The prioritisation method which was applied was based on the National Emergency Risk Assessment Guidelines (NERAG; NEMC, 2010). The October 2010 version was used, but note that the Guidelines have subsequently been updated.

For each of the reaches on the long list, floodplain managers from Victorian CMAs regions were invited to nominate a modelled or historic event for which the likelihood and consequence of the flooding risk could be assessed qualitatively, and the flood risk determined. Likelihood, consequence and risk tables from the NERAG were applied as illustrated by the example in Table 1.

Table 1 – Example application of the National Emergency Risk Assessment Guidelines (NEMC, 2010).

Element	Analysis	Result
Likelihood	A historic flood event occurred in 2010. Later analysis indicated that the event was roughly equivalent to a 1% AEP flood. According to the likelihood definitions outlined in NEMC (2010) the Likelihood is therefore "Possible"	*Possible*
Consequence	Anecdotally, the 2010 flood event was significant, but was managed by the governing body with minimum disruption to other services. No deaths were recorded, but a couple of residents were admitted to hospital with minor injuries. The community and local economy quickly recovered.	*Minor*
Risk	These likelihood and consequence ratings combine to represent a "Low" risk rating.	*Low*

The assessment included riverine flooding only, not overland or flash flooding. Where it was anticipated that there could be future development within a reach or catchment, the risk assessment was conducted for a historic or current scenario, and also for a future development scenario where the consequences of flooding may be more severe.

The ten reaches selected for flood mapping

Based on the assessment, twenty-two study areas had a High risk rating. Eighteen study areas had a medium risk rating. One study area had a low risk rating. Ten reaches from the High risk category were selected for flood mapping. At least one reach was selected per Victorian CMA region (Table 2 and Figure 2).

Table 2 – The ten Regional Flood Mapping projects.

Region	Basin	Reaches	Approx. upstream catchment area	Approx. area of the hydraulic model	Hydraulic modelling method
			sq. kms	sq. kms.	
North East CMA	401 Upper Murray	Murray River upstream of Hume Reservoir, Tallangatta Creek, Cudgewa Creek, Corryong Creek and Thowgla Creek	8,000	480	1D /2D SOBEK
North East CMA	403 Ovens	Upper Ovens River between Harrietville and Eurobin, Morses Creek and Buckland River	1,100	40	1D / 2D TUFLOW
Goulburn Broken CMA	404 Broken / 405 Goulburn	The "Granite Creeks" between the Hume Freeway and Murray Valley Highway, including Hughes Creek, Pranjip Creek, Creightons Creek, Castle Creek, Seven Creeks, Faithful Creeks, Honeysuckle Creek and Baddaginne (Five Mile) Creek	3,320	1,660	MIKE Flexible Mesh GPU
North Central CMA	407 Loddon	Loddon River downstream of Laanecoorie Reservoir to the River Murray	15,480	9,960	MIKE Flexible Mesh GPU
Mallee CMA / North Central CMA	408 Avoca	Avoca River, from Charlton to Lake Boga, including the effluent streams Tyrrell Creek, Lalbert Creek and Back Creek	14,230	4,200	MIKE Flexible Mesh GPU
Wimmera CMA	415 Wimmera	Lower Wimmera River between Quantong and Jeparit	7,390	840	MIKE Flexible Mesh GPU
East Gippsland CMA	222 Snowy	Snowy River, from upstream of Jarrahmond to the Snowy River Estuary	15,800	400	1D / 2D MIKE
West Gippsland CMA	225 Thomson	Avon River to Lake Wellington, Valencia Creek, Freestone Creek and Blackall Creek	1,660	360	MIKE Flexible Mesh GPU
Corangamite CMA	235 Otway Coast	Deans Creek and Barongarook Creek	130	26	1D / 2D TUFLOW
Glenelg Hopkins CMA	237 Portland Coast	Fitzroy River and Darlot Creek below Condah Swamp	1,460	Model not yet built	MIKE Flexible Mesh GPU

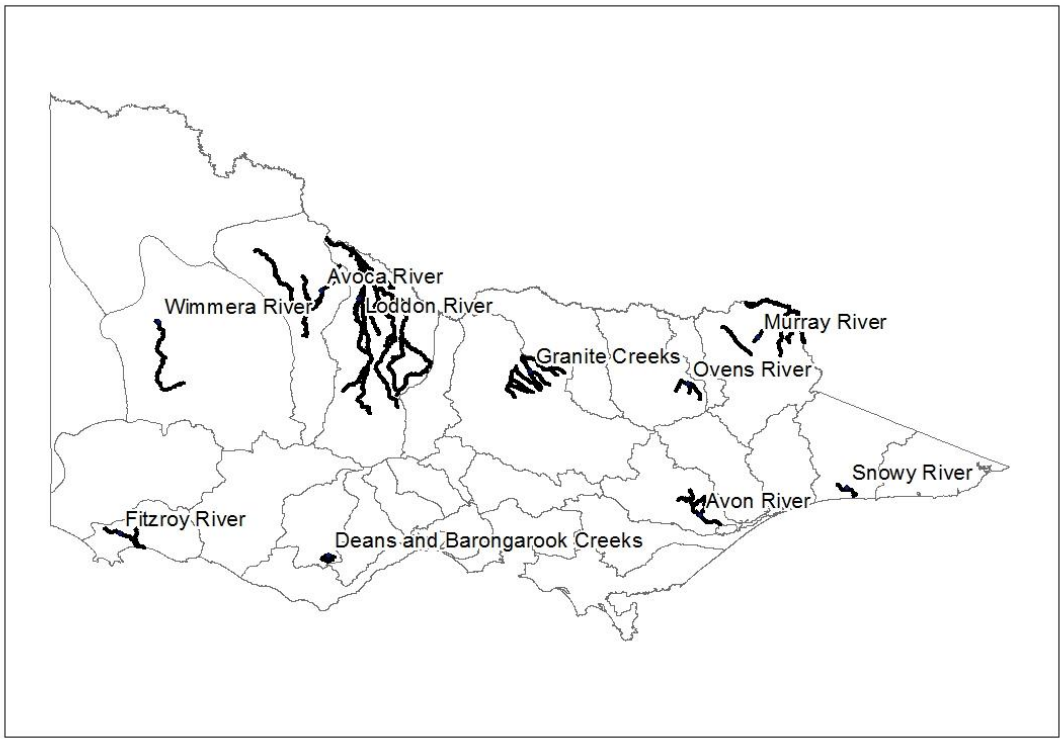

Figure 2 – The ten Regional Flood Mapping projects.

What flood mapping methods to use?

A Pilot Study was undertaken to explore suitable flood mapping methods to deliver reliable flood mapping at a regional scale. Five differing regional flood mapping methods were trialled across five study areas. The methods trialled ranged from routine (calibrated Rainfall Runoff modelling), to emerging (rain on grid), to rapid application (backwater analysis).

The outcomes of the Pilot Study were instructive, indicating that DELWP should not mandate a single approach going forward. Instead, it was proposed, modelling methods should be matched to catchments depending on the availability of data and the characteristics of the catchment – which varied from upstream and confined, to vast floodplains located low in the catchment.

Generally speaking, the modelling methods that were subsequently adopted can be described as reflecting standard industry practice (e.g. Flood Frequency Analysis, Rainfall Runoff modelling and design event modelling, coupled with a 2D hydraulic model). Rain on grid type approaches were not favoured, though this was not by design. As mentioned above, DELWP did not initiate the Regional Flood Mapping Program with a preferred method in mind.

The size of the hydraulic models range from 26 km^2 to 9,960 km^2 (Table 2) and sum to approximately 8% of the State. Due to the vast size of some of the catchments being modelled, adopted hydraulic modelling approaches have also utilized leading technologies, such as Flexible Mesh and GPU processing.

The resolution of the models varies. For example, the hydraulic model developed for the Deans Creek and Barongarook Creek catchment has a 4 m grid resolution (BMT WBM, 2016), while the resolution of the flexible mesh for the Avon River project varies from 15 m^2 in the towns of Stratford and Boisdale, to a maximum of 80,000 m^2 at the model extremity (Water Technology, 2016). In this latter example, the median element size throughout the model is 89 m^2 (Water Technology, 2016). Model run times have ranged from a few hours, to multiple days.

The Program has also been made possible because of the widespread availability of LiDAR data across Victoria. LiDAR is a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. All major rivers in Victoria have been flown for LiDAR, for a range of purposes including river health and floodplain management. DELWP maintains a database of LiDAR products through its Coordinated Imagery Program and this database was a critical input to the Regional Flood Mapping Program for the development of hydraulic models.

Independent technical reviewers were engaged to review project outputs, to comment on the appropriateness of the modelling methods and their application. This has added an extra layer of technical rigour to the Program.

Community consultation

'Shared responsibility' is the notion that all organisations, communities and individuals are jointly responsible for disaster safety. This is an issue addressed in chapter eight of the Victorian Floods Review (Comrie, 2011). The Review suggests that communities that are informed, engaged and prepared are safer and better able to respond to disasters.

Recommendation 93 of the Review recommends that "the State comprehensively pursue the objective of achieving (where possible) the priority outcomes of the *National Strategy for Disaster Resilience* and the imperative of shared responsibility" (Comrie, 2011, p. 221).

For the Regional Flood Mapping Program, this recommendation means that it is imperative that local communities participate in flood studies, so that the flood mapping process incorporates local knowledge, so that local communities are aware of their flood risk, and so that future flood management plans (which draw on project outputs) are more likely to be accepted.

Each of the ten flood studies was managed by a local Project Steering Committee. Membership comprised representatives of CMAs, LGAs, VICSES, local community members and members of local traditional owners groups.

When the Program was conceived, it was thought that two public meetings, at a single location, would be held for each of the ten projects. The purpose of the first meeting would be to collect anecdotes of past flood events for use in the hydraulic model calibration stage. At the second meeting, the flood mapping service provider would present draft mapping for the public to comment on. The meetings would be informal

“drop in” style meetings and would be publicised though normal media channels, such as newspaper and radio, and through existing local networks.

However, because of the geographic size of the study areas, in many cases it was not practical for those with an interest in flooding to travel across the catchment to attend a public meeting at a single location. And, in some instances, it was considered more practical to consult with targeted members of the community who had played an active role in observing and responding to historic flooding and thus had specialist knowledge.

Consequently, the community consultation was tailored to the requirements of each project, based on advice from the local Project Steering Committees. In summary, the three approaches that have been utilized to date have been:

- Two public meetings, at a single location, as was originally planned. This approach works well for small catchments, or where there is a central location which is an obvious meeting place.
- Two public meetings, at multiple points within the study area. This approach has been favoured where the study area is large and community members cannot be expected to travel to a single location.
- Two “by invitation” meetings, where specific members of the community have been targeted. This approach was used for the Loddon and Avoca projects only. The study areas for these projects are large, and there was an established network of experienced flood wardens that could be consulted.

This “horses for courses” approach has worked well to date. For each of the projects for which public meetings have been held thus far, useful information on historic flooding has been collected. However, attendee numbers have varied from meeting to meeting and have been low in some instances (<5 attendees).

The reason for low attendance rates has not been determined, but is likely to be a combination of reasons, for example:

- An absence of controversy - The Regional Flood Mapping Program is not associated with any contentious issues or decisions, such as where to site a town levee.
- Timing – As time goes by, people’s memories of the 2010-11 floods will fade. Also, it didn’t help that some community meetings were held in the peak of summer, during bushfire season, when community concern about flooding is low.
- Complacency or general lack of interest - It is not unusual for community consultation events for flood studies to record low attendee numbers.

Regional Flood Mapping applications

It is probably true that community interest in the outcomes of the Regional Flood Mapping Program will peak when new flood mapping is incorporated into Municipal Planning Schemes. VICSES will also have a role in raising awareness of flooding issues through their Local Flood Guides program. Other uses of project outputs are outlined below.

FloodZoom

FloodZoom is a web based flood intelligence platform that has been developed by DELWP, and which will continue to be improved by DELWP. It is the authoritative source of flood information before, during and after a flood. As it develops, it will be the go to tool to source information for landuse planning.

FloodZoom brings together information from a number of sources: flood mapping stored in the Victorian Flood Database, real time and historic streamflow data, and weather forecast information prepared by the Bureau of Meteorology.

It provides flood-consequence information at a property scale, where available, and will help agencies with flood emergency management functions to quickly and accurately visualise the problems they must manage in terms of both time and space (DELWP, 2016). Further benefits of the FloodZoom application are outlined in the Victorian Floodplain Management Strategy (DELWP, 2016, p. 36):

> "The platform will help improve flood warning, preparedness and response activities for at-risk towns. It will also enable emergency management agencies to share information during floods. It will support them in making real-time interpretations of likely flood behaviour, coordinating flood responses and assessing flood impacts. It will help them provide better messaging to flood-affected communities.
>
> The flood intelligence platform will underpin, streamline and improve the efficiency of the flood interpretative services provided by DELWP, Melbourne Water and the CMAs to VICSES and LGAs. These agencies will use the information coming out of the flood intelligence platform to provide advice to flood-affected communities."

As Regional Flood Mapping projects are completed, flood mapping data will be incorporated into the Victorian Flood Database and made available through the FloodZoom application.

Regional Floodplain Management Strategies & future directions in priority setting

Victoria has recently completed the Victorian Floodplain Management Strategy (DELWP, 2016) which sets the proposed direction for floodplain management in

Victoria. The Strategy aligns with the Victorian Government's responses to the Victorian Floods Review (Comrie, 2011). The Strategy provides the policy basis for assessing flood risk and commits to sharing flood risk information. It sets the framework to prioritise flood mitigation activities based on the level of flood risk and community needs.

Going forward, priorities for flood mitigation activities (including flood mapping) will be documented in Regional Floodplain Management Strategies, which are under development. High quality flood mapping, such as the flood mapping that will be produced though the Regional Flood Mapping Program, will be invaluable for identifying flood risk on a macro and micro scale. It will also inform community discussion on mitigation measures through an improved understanding of the current and potential avoided damages associated with flooding over a range of likelihoods.

The preliminary method for assessing flood risks for the purpose of developing the Regional Floodplain Management Strategies will be a Rapid Assessment Method (RAM) to determine the relative scale of annualised flood risk within defined management units. The RAM will make use of best available flood mapping. Where available, the results of the Regional Flood Mapping Program will improve the reliability of RAM outcomes.

Once the RAM is applied across the state, it will be interesting to compare the results of the NERAG risk assessment described herein to that of the RAM. It is the expectation of this author that the results will not be dissimilar (as they are both based on an appreciation of relative flood risk), but that differences in results can be expected (due to the different assessment methods and study area boundaries, for example).

Flood insurance

Outputs from the Regional Flood Mapping Program will also be provided to insurers, so that they can assess premiums for flood insurance.

Achievements to date

To date, 22 public meetings have been held in 13 locations across Victoria (Figure 3). Two of the ten Regional Flood Mapping projects have been completed: the Avon River and the Deans and Barongarook Creek Flood Studies. The data from these projects has been added to the Victorian Flood Database and is available to VICSES and CMAs through the FloodZoom application.

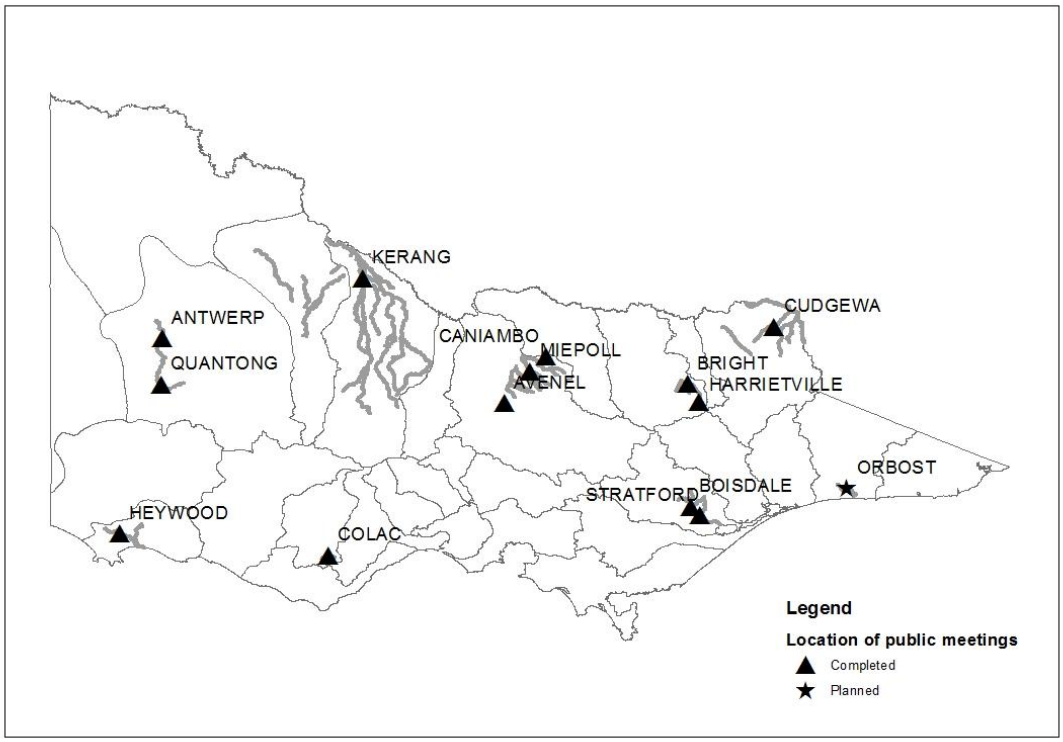

Figure 3 – Location of public meetings.

Conclusions

The Regional Flood Mapping Program has taken advantage of recent advances in flood mapping technology and data availability to deliver regional scale flood mapping that improves upon earlier mapping produced through the Flood Data Transfer projects. The Program consists of ten separate flood studies. The size of the hydraulic models range from 26 km^2 to 9,960 km^2 and sum to approximately 8% of the State.

DELWP has not mandated the flood mapping approach, instead modelling methods were matched to catchments depending on the availability of data and the characteristics of the catchment – which varied from upstream and confined, to vast floodplains located low in the catchment. A similar approach has been taken with the community consultation, which has been tailored to the requirements of the study area and local community. Independent technical reviewers were engaged to review project outputs. This has added an extra layer of technical rigour to the Program.

A flood model is just a means to an end. What is truly exciting about the Regional Flood Mapping Program is that project outputs will make Victorians safer – through better land use planning, improved emergency planning and response, and through the fair pricing of flood insurance.

To date, two of the ten projects have been completed and the data has been incorporated into the Victorian Flood Database and made available through the FloodZoom application.

Acknowledgements

Water Technology, BMT WBM and Cardno have been engaged to deliver the ten flood mapping projects.

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