MOLINO STEWART

ENVIRONMENT & NATURAL HAZARDS

Victorian Floods Review

Examination of the Total Flood Warning System in Victoria

Report

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REPORT

for

Victorian Floods Review

by

Molino Stewart Pty Ltd
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CONTENTS

APPENDICES

LIST OF TABLES

List of Figures

1 INTRODUCTION

1.1 BACKGROUND

In 2005, the Victorian Flood Warning Consultative Committee released the Flood Warning Service Development Plan for Victoria to determine flood warning service development priorities. The development plan contained 22 recommendations that collectively identified improvements to flood warning.

In 2008, Molino Stewart Pty Ltd provided the Victorian State Emergency Service (VICSES) with a series of recommendations to improve total flood warning systems across Victoria in relation to its role in the delivery of the Flood Warning Service Development Plan. The recommendations were made after an extensive study including stakeholder consultation with emergency agencies, catchment management authorities (CMAs), local councils and others in 2007.

It is critical that all components of total flood warning systems are regularly evaluated, particularly soon after major floods, to enable continual improvement. As part of such a review in Victoria it is important to gauge progress in the adoption and use of the Flood Warning Service Development Plan, and the Molino Stewart recommendations, and in the light of recommendations regarding community warnings made by the 2009 Victorian Bushfires Royal Commission.

Flooding around the state of Victoria during September and October 2010 and January 2011 caused widespread damage and disruption to numerous communities.

From September 2010 through to February 2011, the Bureau of Meteorology (BoM) issued more than 1,500 flood watches and warnings in Victoria. Several communities experienced flooding two or three times in less than four months.

The Victorian Government commissioned a Review of the 2010-11 Flood Warnings and Response soon after the floods. The Premier announced the following terms of reference for this review:

- The adequacy of flood predictions, including technology and modelling techniques used
- The adequacy, timelines and effectiveness of flood warnings and public information
- Emergency services command and control arrangements utilised to manage the emergency
- The adequacy of evacuations of people at greatest risk including health and aged care facilities
- The adequacy of clean-up and recovery arrangements
- The adequacy of service delivery by State and Federal Government agencies, local governments and volunteer-based organisations
- The adequacy of funding provided by the State and Federal Governments in the form of emergency grants in their various categories.

The interim report of the Review was recently released. It details review activity already carried out including extensive consultation with communities, local government and other government agencies through ‘operational debriefs’. According to the report, the Review has mapped out a broad range of further activities over the next few months including an examination of the total flood warning system in Victoria. The components of the total warning system are:

- Monitoring of rainfall and river flows that may lead to flooding
- Prediction of flood severity and the time of onset of particular levels of flooding
- Interpretation of the prediction to determine the likely flood impacts of the community
- Construction of warning messages describing what is happening and will happen, the expected impact and what actions should be taken
- Dissemination of warning messages
- Response to the warnings by the agencies involved and community members
- Review of the warning system after the flood events.

These components are interdependent and linked.

1.2 PROJECT AIM AND SCOPE

The Victorian Floods Review engaged flood consultants Molino Stewart Pty Ltd to undertake a detailed examination to determine the status of the total flood warning system within Victoria and to understand what is required to achieve best practice in a total flood warning system in the State.

The examination should consider all types of flooding that occurred between September 2010 and February 2011. It should focus in particular on the strategic aspects of the following components of the total warning system:

Prediction

- The accuracy and timeliness of flood predictions
- The coverage of flood prediction systems in Victoria including systems for the prediction of flash flooding
- Strengths and weaknesses of current flood prediction systems
- Communication between key stakeholders in relation to flood prediction
- Current technologies and modelling techniques used in flood prediction
- Liaison with dam owners in regards to the impact of dam operations on flood predictions, specifically information flow between dam owners, VICSES and the Bureau of Meteorology (BoM).

Interpretation

- Current requirements and responsibilities for flood intelligence and its use in Victoria
- Adequacy of available flood intelligence and its use
- The speed at which interpretation occurred and impacts on the speed of community warnings and information
- The role and effectiveness of flood intelligence cells within the Incident Management Teams (including the State Control Centre and Incident Control Centres)
- Adequacy of systems for the collection, analysis and storage of flood intelligence.

Message Construction and Communication

- Adequacy and timeliness of flood information and warnings to the community
- Adherence to best practice including the Victorian Warning Protocol
- Adequacy of systems to construct and communicate messages
- The role and effectiveness of information units within IMTs (including SCC and ICCs)
- Influence of Social Media
- Communication with Culturally and Linguistically Diverse (CALD) and vulnerable groups.

Community and emergency response

- Community response and attitudes to flood information and warnings
- The influence of prior community education
- Community expectations for flood information and warnings
- Effectiveness of warnings in reducing flood damage
- Community behaviour in response to evacuation warnings
- Adequacy of evacuation decision making and warnings

Furthermore, the examination will:

- Involve relevant and applicable consultation with VICSES, BoM, CMAs, VICROADS, Department of Health, Department of Human Services, Department of Primary Industries, Department of Sustainability and Environment (DSE), other Emergency Services, the Office of the Emergency Services Commissioner (OESC), Water Authorities, local councils and other stakeholders.
- Involve analysis of community consultations and community surveys already undertaken and sought public submissions.

- Not include an examination of command and control related to the floods.
- Include an examination of the status and efficacy of the recommendations of the Flood Warning Service Development Plan in the light of the 2010/11 flood events.
- Include consideration of previous reports relation to components and/or aspects of the Total Flood Warning System.

1.3 REVIEW PLAN

The Australasian Evaluation Society is the peak evaluation and review professional body in Australia and New Zealand (see www.aes.asn.au). This review was conducted following the Society's 'Guidelines for the Ethical Conduct of Evaluations'. These guidelines cover:

1. Commissioning and preparing for an evaluation
2. Conducting an evaluation
3. Reporting the results of an evaluation.

The guidelines promote negotiation between client and evaluator to develop an agreed evaluation or review plan. The guidelines identify the following four areas about which negotiation can take place within an evaluative activity:

1. Overarching principles of the evaluation or review
2. Key player/stakeholder involvement within the evaluation and the role of the evaluator
3. Details of design and methodology
4. Recommendations, findings and utilisation.

A project meeting was held to discuss and negotiate the four areas listed above in relation to the project scope (see Section 1.2). The meeting was held on 10 August 2011 between the Victorian Floods Review Project Team and Molino Stewart.

As Owen (2006, p.67) stresses, 'a major milestone that needs to be reached through negotiation is an evaluation plan. While there may be differences in emphasis in the degree of planning, effective use of evaluation findings is heavily dependent, in all arrangements and settings, on the degree to which the evaluator and clients agree on a plan for the evaluation. This is the up-front agreement that determines the directions the evaluation will take'.

A review plan was drafted by Molino Stewart for negotiation with the Project Team at the project inception meeting. After this meeting, the draft review plan was amended by Molino Stewart based on comments at the meeting, and the final plan was then endorsed by the Project Team.

The final review plan is provided in Appendix A.

1.4 METHODOLOGY

As outlined in the review plan, this examination of the Victorian Total Flood Warning System involves both qualitative and quantitative review methods.

It should be noted that due to the widespread flooding, particularly in January 2011, it was decided to focus the examination on the following Victorian catchments:

- Ovens
- Goulburn-Broken
- Loddon
- Avoca
- Campaspe
- Mount Emu Creek
- Bunyip River.

1.4.1 Qualitative Methods

Twenty five interviews were conducted by Molino Stewart with a range of stakeholders that could provide opinion and data related to the review plan. Stakeholders interviewed included representatives from:

- BoM
- VICSES (e.g. Incident Controllers, Intelligence Officers, Information Officers)
- CMAs
- Independent consultants involved in Intelligence Units

- Water authorities
- Local councils
- Other State Government agencies (e.g. DSE, CFA)

The interview questions for each stakeholder were derived directly from the review plan.

1.4.2 Quantitative Methods

Molino Stewart obtained access to a range of data as outlined in the review plan. This data included:

- BoM directives
- Melbourne Water directives
- Official flood warnings issued by the BoM
- Hydrographs
- Social research e.g. surveys
- Reports on community meetings held during and after the floods
- Multi-agency debriefs
- Warning information disseminated by Incident Control Centres e.g. Flood Bulletins
- Reports on Emergency Alert

1.4.3 Analysis

The results of the qualitative and quantitative research were analysed and compared in relation to the review plan. This analysis is summarised in the findings (Sections 2 to 5) of the report.

In the discussion section (Section 6), the findings are compared with the recommendations of the Flood Warning Service Development Plan. Other issues pertinent to the findings are also discussed throughout the report.

1.5 LIMITATIONS

There are some limitations to this review that should be acknowledged. Firstly, Molino Stewart conducted none of the social research (e.g. community surveys, community meetings) that is referenced in this report. Other quantitative data such as Emergency Alert reports were also provided. Molino Stewart is thus dependent on the findings of these 'secondary' data sources and has had no input into the original collection and analysis of the data.

Secondly, the timeframe for the interviews was quite narrow and thus only a sample of those agency staff involved in the 2010/11 floods could be accessed. All attempts have been made by Molino Stewart to obtain adequate representation of interviewees across the study catchments.

Lastly, this examination is limited to those catchments listed in Section 1.4. However, if data or opinions were obtained from outside these catchments they have been included in the report if relevant to the review plan.

2 FINDINGS - PREDICTION

2.1 ACCURACY AND TIMELINESS

The accuracy and timeliness of the flood predictions were extremely variable. They ranged from many accurate, timely predictions to forecasts which under- or over-estimated flood levels by considerable depths, and others which anticipated arrival times which were much earlier or later than those with occurred.

The reasons for some of the warnings not being as accurate or as timely as desirable were manifold and were at times due to a combination of factors.

In summary:

- It was generally acknowledged by almost all interviewees that the warnings in the north-east of the state are the best overall in terms of both timeliness and accuracy.
- There were mixed opinions about the Wimmera warnings, with some saying that for operational purposes they were both timely and accurate, while others felt there was some confusion, particularly with regard to what information was available to the public.
- Almost everyone said that significant improvements are needed in the timeliness and accuracy of warnings in the north-central catchments. Opinions varied as to what is a timely and accurate warning in the context of flooding in the lower parts of these catchments.
- All acknowledged that timely warnings were difficult to provide in the Mt Emu Creek catchment in the south-west of the state and accurate warnings were not possible.

The following elaborates further on the above observations by comparing the BoM forecasts and actual flooding for selected events at selected gauges in catchments which experienced major flooding at least once between September 2010 and February 2011. It also compares them to benchmarks set by directives, MOUs and performance indicators.

It has not been practical within the time available to compare all events at all gauges in the catchments of interest.

2.1.1 BoM Self Evaluation

The BoM undertook its own analysis of the performance of the following three of its four warning products at selected locations:

- Flood scenarios – a table of possible flood scenarios based on different future rainfall combinations. This is a new product which is only produced if severe rainfall is expected across a wide area. This product is only sent to organisations involved in emergency response.
- Flood Watch – a heads-up that significant flooding is likely in a CMA region
- Flood Warning – a specific warning for a river. It may include quantified warnings at some locations and some of these locations may also have the flood classified as ‘minor’, ‘moderate’ or ‘major’.

Its fourth product - a ‘severe weather warning’ - which can include warnings of flash flooding was not included in the analysis. It should also be noted that not all warning products are available in each catchment and in some events the warnings were provided but the flooding did not eventuate.

The results of the BoM analyses for September 2010, January 2011 and February 2011 are shown in Figure 1, Figure 2 and Figure 3.

2.1.2 Molino Stewart Evaluation

Molino Stewart undertook a more detailed analysis of the quantified Flood Warning product at key gauges in each catchment and compered the forecast height and timings to actual gauge readings for selected events.

The results of these analyses are presented in Figure 4 to Figure 13

2.1.3 Comparison with KPIs

This section compares the warning product analyses described in sections 2.1.1 and 2.1.2

with relevant published key performance indicators for each location.

No evaluation was made of the flood scenarios as this product is not currently covered by any service level agreement and so there is no key performance indicator for this product. However, it should be noted that in September 2010 and February 2011 this product was provided about 24 hours in advance of a flood watch in each river, where it was available.

By contrast, in January 2011, with the exception of the Ovens and King, the flood scenarios were not available until about four hours after flood watches had been issued.

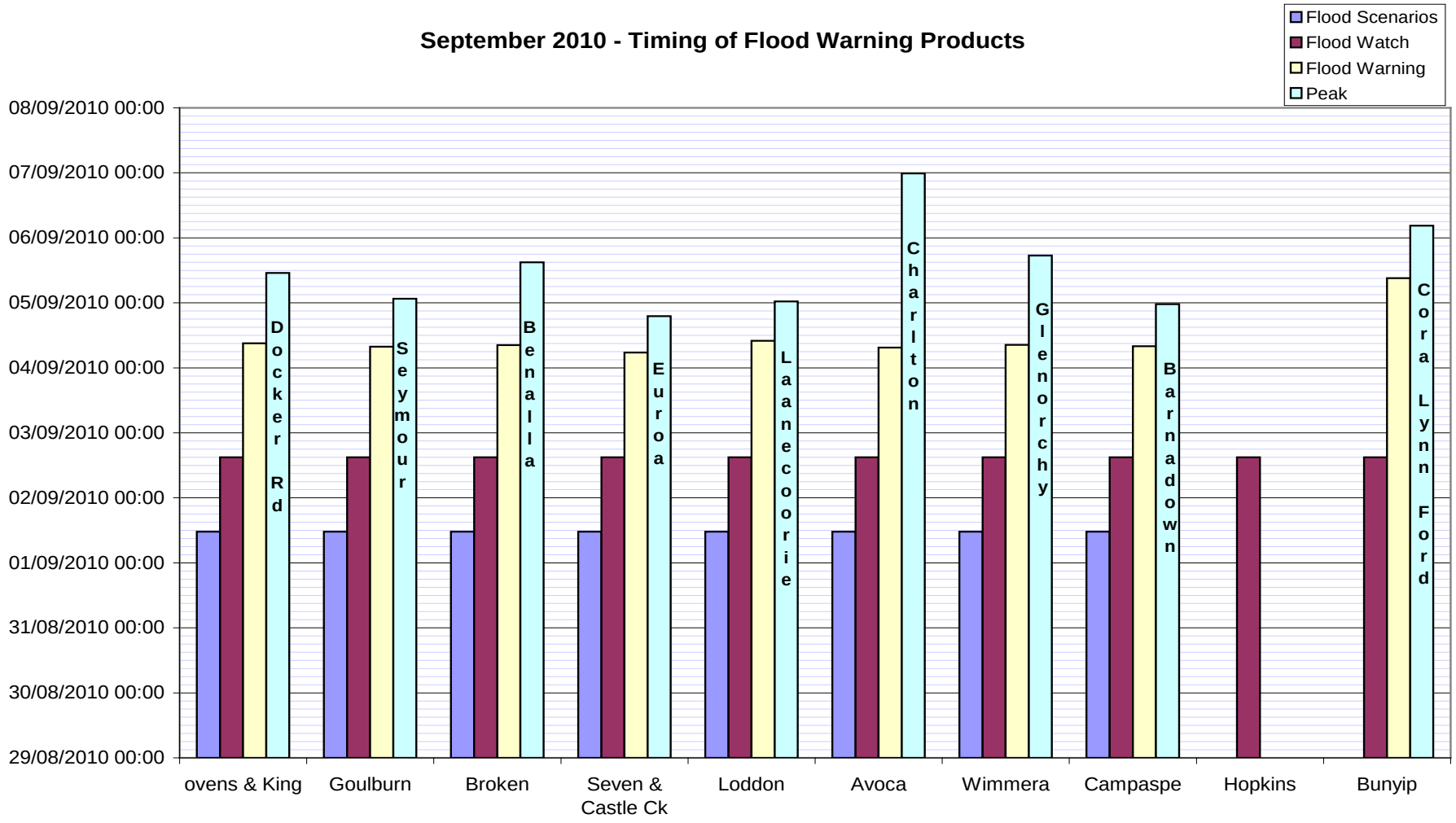

Figure 1: Timing of September 2010 Flood Warning Products

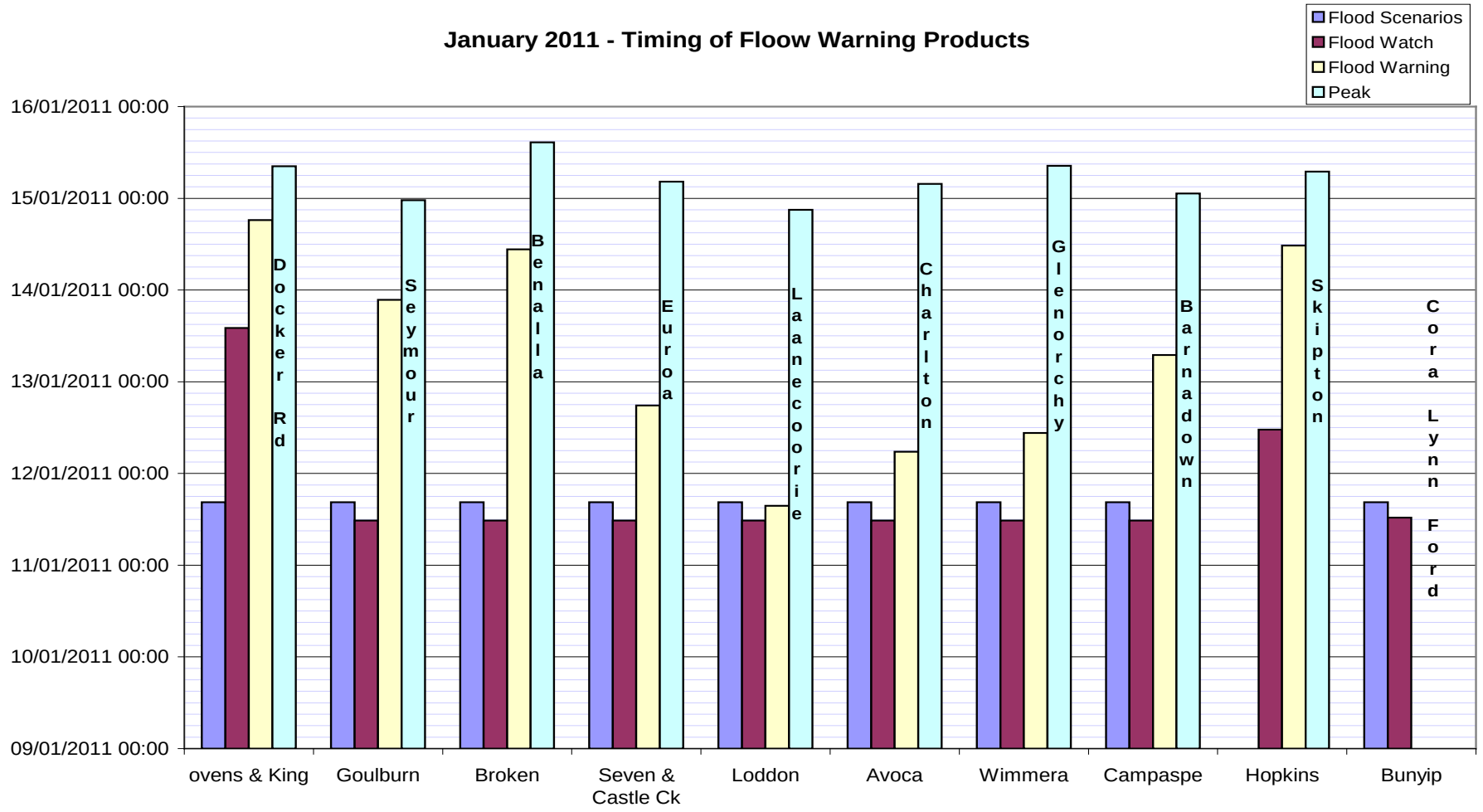

Figure 2: Timing of January 2011 Flood Warning Products

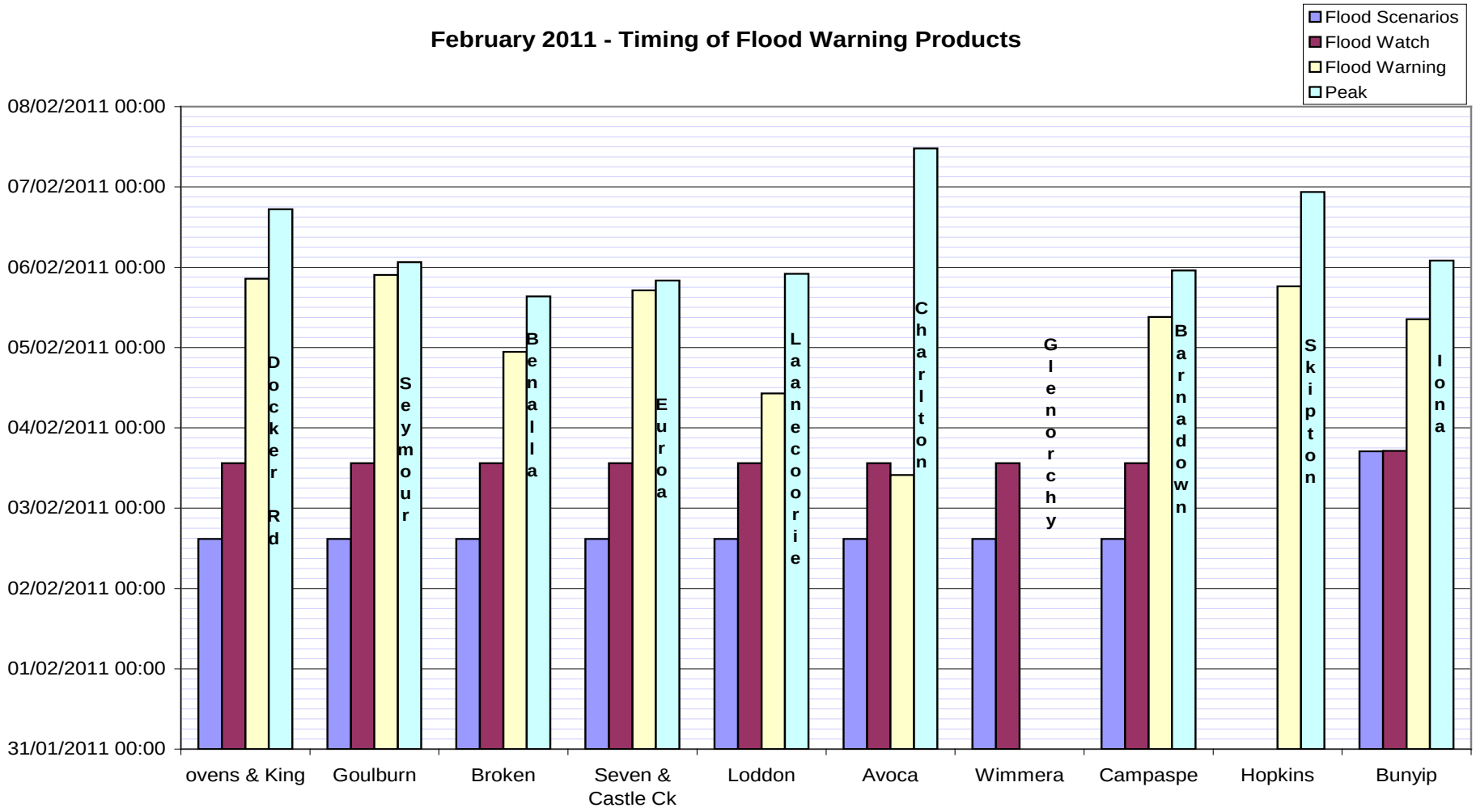

Figure 3: Timing of February 2011 Flood Warning Products

a) Ovens

According to the BoM analysis, a Flood Watch was issued between 1.5 and three days before floods peaked at Docker Rd gauge and a flood warning issued between 15 and 27 hours before the flood peak. The January floods had the shortest warning times.

The Ovens Flood Warning Manual (also referred to as the Ovens Directive) stipulates that flood watches should be issued 24 to 36 hours in advance of flooding. While this target was met in relation to a comparison of Flood Watch versus Flood Peak, it is arguable that the onset of minor flooding should be the point at which a Flood Watch is measured from for benchmarking performance.

It is noted that generally the Flood Watch preceded the first Flood Warning by between 24 and 48 hours.

The Manual also sets out expected forecast model accuracy with regard to levels and timing and states that minor and moderate flood warnings should be given at least twice daily and major flood warnings at least every six hours.

Figure 4 shows the gauge readings at Wangarratta for the September 2010 flood over which has been superimposed lines showing the time that warnings were issued and the forecast height and timing. Where there are dashed lines the forecast omitted that parameter or gave a range.

Figure 4 shows that moderate flood warnings were given at least twice daily and major flood warnings at least every six hours. The first flood warning was given 24 hours before the minor flood level was reached and the first flood watch a further two days earlier. At this location therefore the Manual target of Flood Watches being issued at least 24 hours ahead of flooding was met.

The Manual suggests that a level accuracy of 0.1m should be achievable with a timing accuracy of about three hours. These levels of accuracy were achieved with a warning time of almost 24 hours and the exact peak was forecast 18 hours in advance. In this regard, this warning met these performance indicators, although it must be noted that these are not agreed levels of service, but rather estimates of model accuracy.

The Manual recommends that it is desirable to include in the flood warnings a comparison with historical events. The major flood warning included a note that 'the expected flood levels will generally be the largest since September 1998' which fulfilled this requirement. This flood was smaller than other historical floods, so 1998 was an appropriate comparison.

Intelligence Officers and Incident Controllers who were involved in the September 2010 floods in Wangaratta said that from their perspective the flood forecasts were very timely and accurate for Wangaratta.

b) Goulburn Broken

The Broken River and Seven and Castles Creeks are part of the Goulburn Basin but are considered in separate flood warning manuals. The Broken River Manual dates from 1985 and does not include any key performance indicators, The Seven and Castles Creek Manual was not provided by the BoM for this review.

The Goulburn Basin Flood Warning Manual (also referred to as the Goulburn Directive) makes reference to Shepparton on the Goulburn River amongst many other locations but states that predictions for Orrvale on the Broken River and Kialla West on Sevens Creek should also be included for flood response at Shepparton'. The copy provided to Molino Stewart had many handwritten notes throughout, suggesting that more work is needed on the document to make it more useful during a flood.

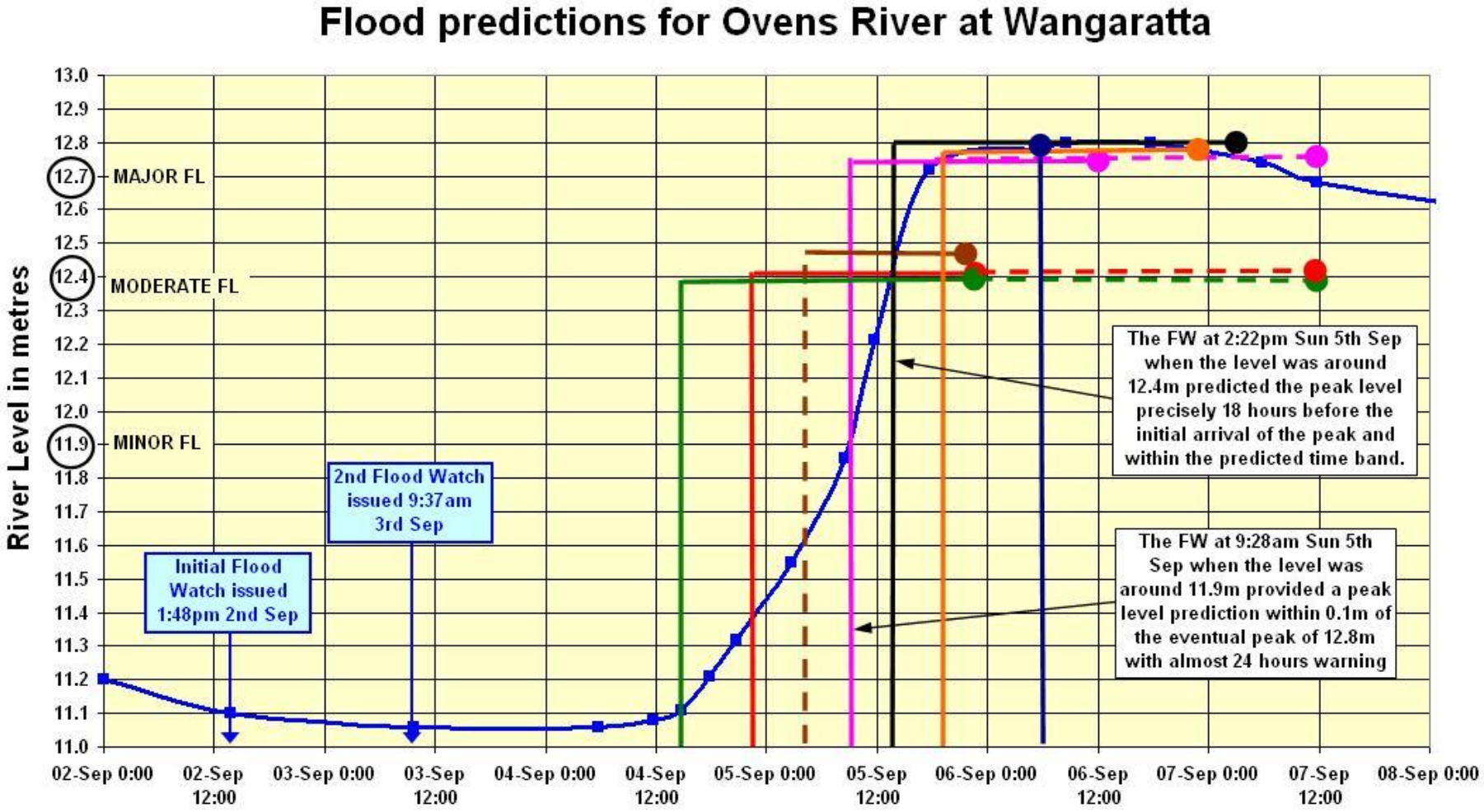

Figure 4: Flood Predictions for Wangaratta

i) Shepparton

The Manual suggests that model accuracy at Shepparton would be within 0.2m of actual levels and within 24 hours with regard to timing. It also notes that events with large peak timing errors have long flat peaks. Long flat peaks are possible at Shepparton as it is at the junction of three watercourses and the relative timing of their peaks will affect the size and duration of the peak at Shepparton.

The Manual also stipulates that major flood warnings should be issued every six hours at least, and minor and moderate warnings at least twice daily.

Figure 5 shows Shepparton forecasts against gauge readings for the September 2011 flood. The first flood watch was given more than three days before the minor flood level was reached.

The BoM's initial flood level prediction for the Goulburn River at Shepparton at 9:49am 5th September was *"Initial indications are that a peak around the major flood level (11m), is expected during Tuesday".* This proved to be an excellent estimate of the eventual peak level of 11.1 metres.

The prediction was subsequently revised to 11.1 metres the next day at 8:47am, still two days away from the eventual peak and virtually spot on the recorded peak. This is well within the suggested accuracy limits of the model.

Although the peak level was close to that predicted days in advance and this forecast level changed little, this was a major flood level and warnings were not issued every six hours as set out in the Manual.

As required by the Manual, forecasts for Kialla West and Orrvale were also provided (Figure 6 and Figure 7 respectively).

ii) Kialla West

The first flood watch was given nearly three days before minor flood levels were reached.

The initial peak level prediction for Seven Creeks at Kialla West was contained in the Goulburn River and tributaries flood warning issued at 9:49am Saturday 4th September which read, *"Seven Creeks at Kialla West is rising, and will exceed the minor flood level (4.5 metres), later Sunday. Initial indications are that a peak around the major flood level (6.0 metres), will occur during Monday."*

Three subsequent flood warnings maintained this same peak level prediction of 6.0 metres

By 8:47am Monday 6th September the Bureau's flood warning reported that *"Seven Creeks at Kialla West is currently above the Major Flood Level (6.0 metres) and rising. It is expected to peak at around 6.6 m during Monday".*

What the flood warning did not say was that the level had risen steadily overnight Sunday to be around 6.5 metres by 8:47am Monday morning, 0.5 metres higher than the Bureau's peak prediction 10 hours earlier.

This later flood prediction was fairly close to the eventual flood peak of 6.66 metres on Seven Creeks at Kialla West around midday Monday 6th September.

The timing of the peak level of Seven Creeks at Kialla West was excellent from the outset. The flood warning for the Goulburn River and tributaries at 11:26pm Saturday 4th September said, *"Forecasts for Seven Creeks at Kialla West will be provided when upstream gauges have peaked".*

However, both upstream gauges on Seven Creeks at Euroa and Stony Creek at Tamleugh had peaked by this time. This meant that 10-11 hours of advance flood warning time was lost for the rural community living around Kialla West.

It should also be noted that the Bureau's Flood Warnings repeatedly referred to the Major Flood Level for Seven Creeks at Kialla West being 6.0 metres, whereas it was in fact 6.6 metres.

iii) Orrvale

The first flood watch preceded minor flooding by more than three days.

The Bureau's flood warning at 11:36 am Sunday 5th September reported that *"The Broken River at Benalla peaked at 4.10 metres Sunday morning (major flood level 4.50 metres), and is now at 3.98 metres and falling."*

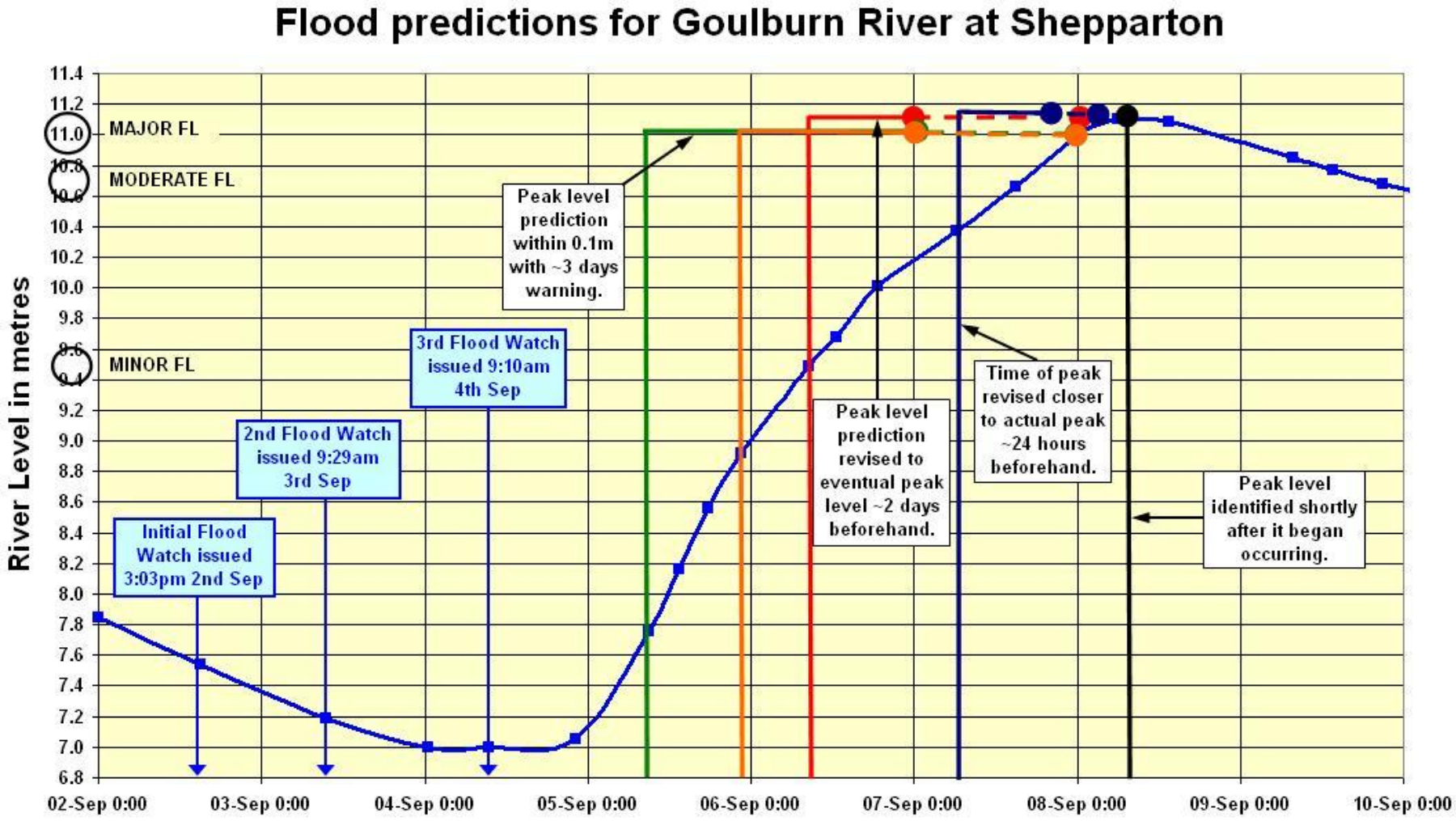

Figure 5: Flood predictions for Shepparton

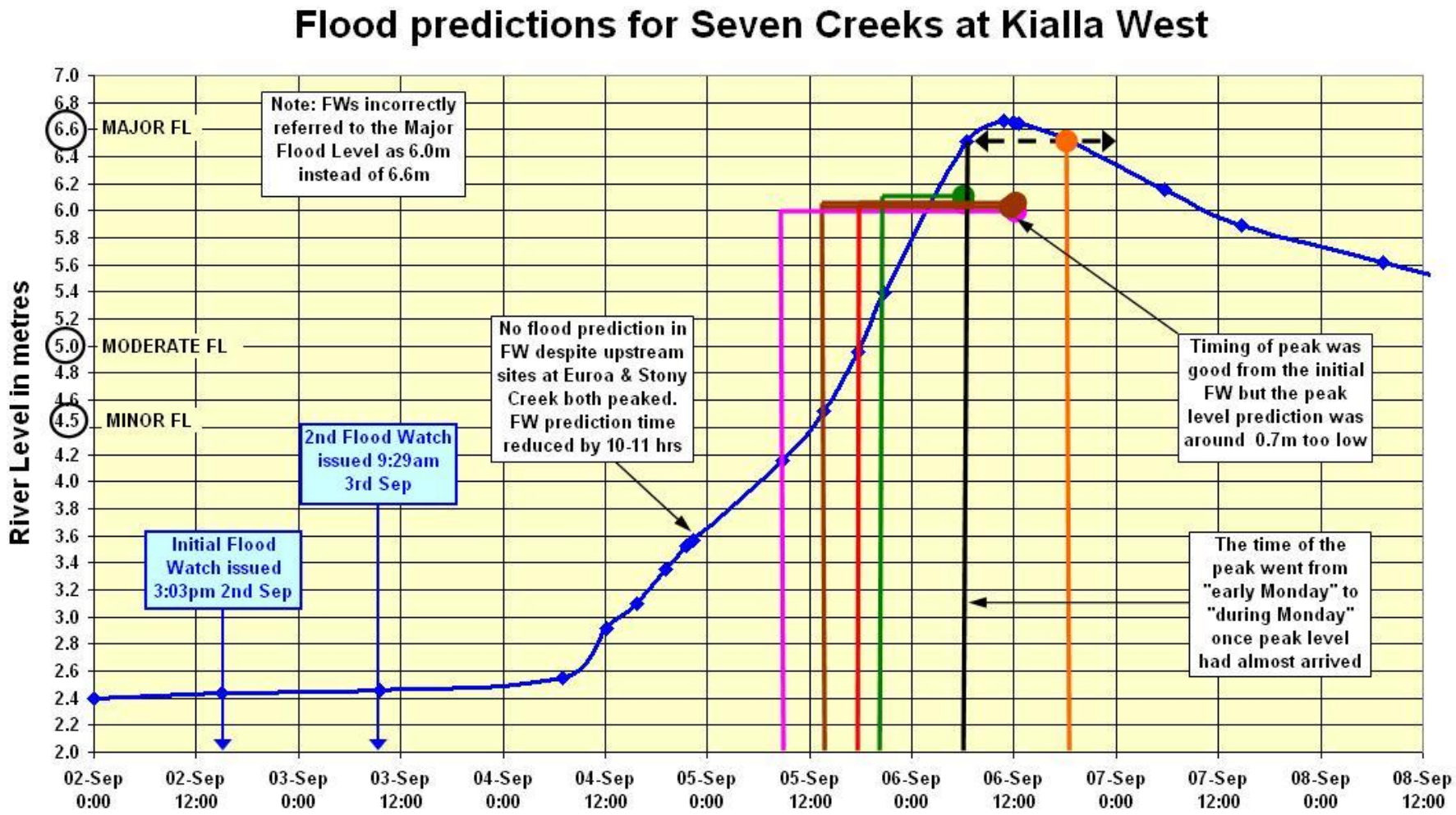

Figure 6: Flood Predictions for Kialla West

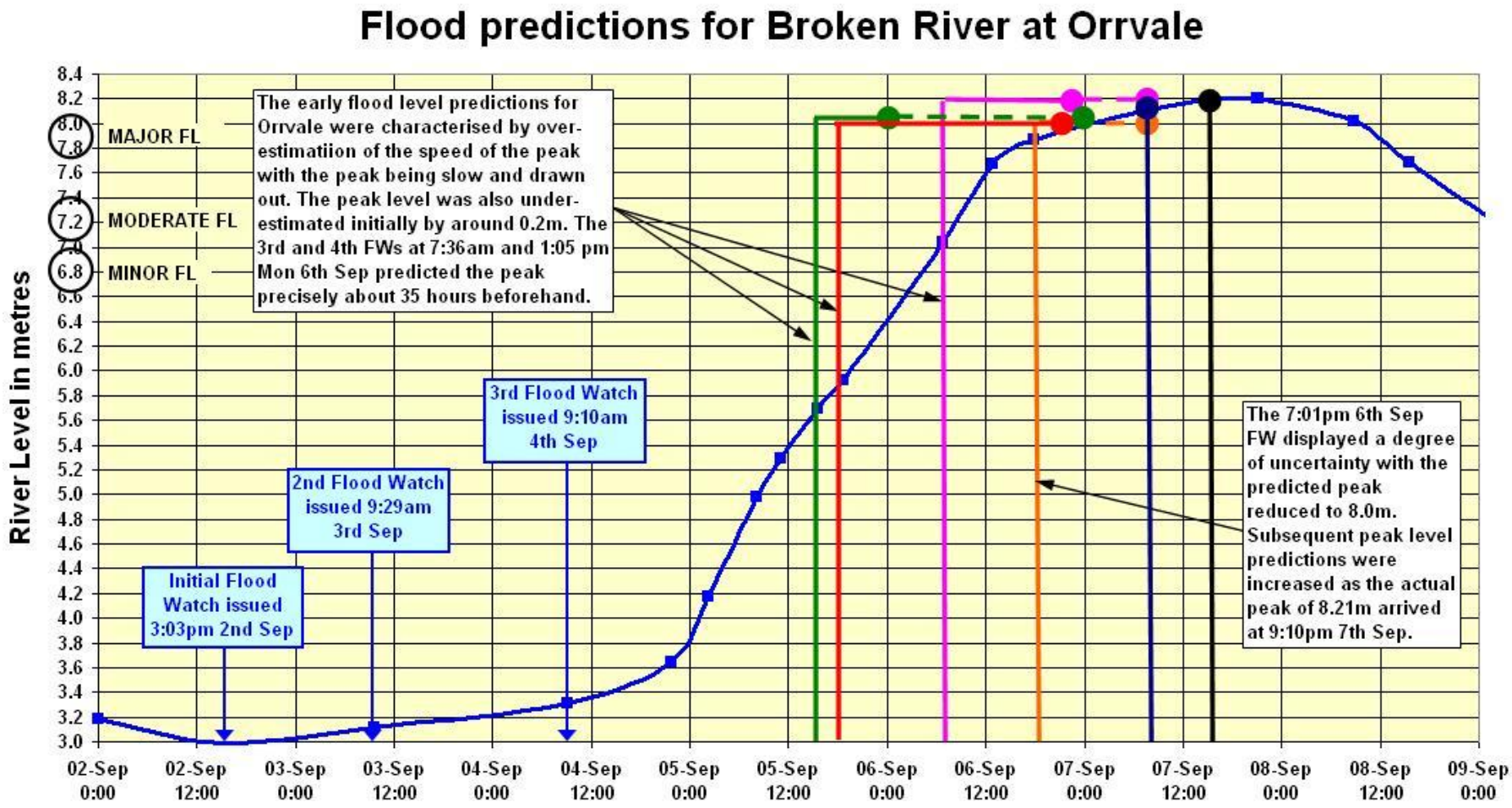

Figure 7: Flood Predictions for Orrvale

That flood warning also said that *"Broken River at Orrvale is currently at 4.98 metres and rising. The Broken River at Orrvale is expected to exceed the minor flood level (6.8 metres), Sunday afternoon. Forecast of a peak at Orrvale will be provided once upstream gauges have peaked".*

As there is no significant inflow along the Broken River from Benalla to Orrvale, a preliminary prediction could have been expected at this time for Orrvale as the river had peaked at Benalla.

Eight hours later the Bureau issued the next flood warning at 7:37 pm Sunday 5th September containing the first peak flood level prediction for the Broken River at Orrvale which said, *"Broken River at Orrvale is currently at 5.92 metres and rising. The river will exceed the minor flood level (6.8 metres) during early Monday morning. Initial indications are that a peak of around 8.0 metres (Major Flood Level 7.9 metres), will occur during Monday evening."*

The peak level at Orrvale was initially under-estimated by around 0.2m while the third and fourth flood predictions at 7:36am and 1:05 pm Monday 6th September predicted the peak precisely about 35 hours beforehand.

The subsequent peak level predictions were incrementally increased as the water neared the actual peak of 8.21m at 9:10pm Tuesday 7th September.

Overall, although there are no performance indicators for this gauge, a forecast within 0.2 metres 35 hours in advance would have to be considered to be a timely and accurate forecast. It is understood that this was done in the context of a serious gauge malfunction at Benalla upstream on the Broken River which as an important predictor of flooding at Orrvale.

iv) Benalla

Despite issues with the Benalla gauge in September 2010, the first quantified Flood Warning was able to be given 30 hours before the flood peak according to the BoM analyses (Figure 1). Similar advanced warning was able to be given in January 2011 but only half this time in February 2011. As stated elsewhere in this report, the BoM analysis does not compare the Flood Watch or the Flood Warning against the onset of flooding although it is noted that there are no performance targets agreed for this location.

v) Euroa

Less advanced warning was given in Euroa on Seven and Castle Creek where in September the flood warning preceded the peak by about 12 hours and in February only by about three. In January two days warning were available.

vi) Seymour

The BoM has reported that there is a service level agreement that Seymour upstream of Shepparton should get more than six hours warning of the flood peak.

With regards to that latter point, the BoM analyses suggest that the time from the first quantified Flood Warning to the peak in September 2010 was about 18 hours and in January 2011 about 27 hours. This does not mean that the peak forecast was more than six hours before the arrival of the peak. By contrast, in February 2011 (Figure 3) the first Flood Warning was less than six hours before the peak and therefore the peak forecast must have failed this agreed target timing.

vii) General

An Intelligence Officer who was working in the Shepparton ICC in September said:

'Timeliness improved as the flood went down the system because the BoM had a longer lead time to firm up predications. I felt what came from the BoM was pretty good which reflects the investment made by GBCMA in flood data collection and modeling.'

Accuracy also improved as the flood moved downstream because the upstream areas are more dynamic; relying more on rainfall than stream gauging."

c) Campaspe

The Campaspe Directive, which is dated 1993 and includes sections which date from 1985, sets out details of how to undertake flood forecasting for this river. Other than a requirement to issue minor and moderate flood warnings twice a day and major flood warnings

at least six-hourly, there are no other performance indicators for warnings on this river.

i) Barnadown

The BoM analyses at Barnadown show that Flood Watches were consistently issued one and a half days before the first flood warnings in each of the three events. However, the first flood warning was only 15 hours before the flood peak in September and February, compared to 45 hours in January.

ii) Rochester

Rochester, which is further downstream did not flood in September 2010 but experienced significant flooding in January 2011 and there were issues with the timeliness and accuracy of the flood warnings.

Figure 8 compares the forecasts with the gauge reading for Rochester. It shows the flood watch was issued three days before minor flooding occurred.

From Molino Stewart interviews with people involved in the warning process, review of the Campaspe Directive and analysis of the data it would appear that the problems around the warnings at Rochester stemmed mainly from the fact that there are two gauges which provide flood information for Rochester.

There is the Rochester Town gauge which is a manually read gauge within the township and there is the Rochester Syphon gauge which can be read remotely.

The Directive states that 'large floods at Rochester normally require an appreciable outflow from Eppalock Storage.' In September this storage was drawn down considerably and Rochester did not flood.

In November 2010, there was reportedly a moderate spill from Eppalock Storage which was enough to combine with other flows to cause flooding in Rochester just under a major flood. It was explained to Molino Stewart that in that flood the caravan park and some streets flooded. All warnings were given in relation to the Rochester Syphon gauge only but were exactly right.

Afterwards, the community had complained that it struggled with the BoM predictions because they were not given for the Rochester Town gauge and residents did not know how to relate the Syphon gauge forecasts to the Town gauge.

The Campaspe Directive has a diagram which shows a relationship between the Town gauge levels and Syphon gauge levels and directs forecasters to its use without actually stating that forecasts need to be given for both gauges.

In January 2011, the first three warnings were given for the Rochester Syphon gauge only but the subsequent two included additional forecasts for the Rochester Town gauge.

The first peak level prediction for the Campaspe River at Rochester Syphon was at 9:11am Friday 14th January when the Bureau advised *"The river is expected to reach the minor flood level during Saturday afternoon, with an expected peak between the Moderate [8.8m] and Major flood levels [9.1m] during Sunday".*

It is understood that at a public meeting in Rochester around 4pm Friday 14th January a NCCMA representative told the community assembled there that "*we're expecting this time for the flood level to peak at 114.8 metres"*, referring to the Rochester Township gauge.

Shortly afterwards, the BoM issued a warning that it was expecting the river to reach major flood levels and this was updated at 11:14pm with a warring which stated *"Further rises are expected with the River expected to reach the Major Flood Level (9.1 metres) during Saturday morning and peak during Sunday"* with no peak level forecast given in this warning.

It was reported in interviews that the CMA manager took a map to the Friday afternoon community meeting showing what the extent of the latest forecast meant and gave copies to attendees. A few local residents expressed views at the meeting and rang the ICC saying they thought the flood would be much higher than forecast and more like 1956.

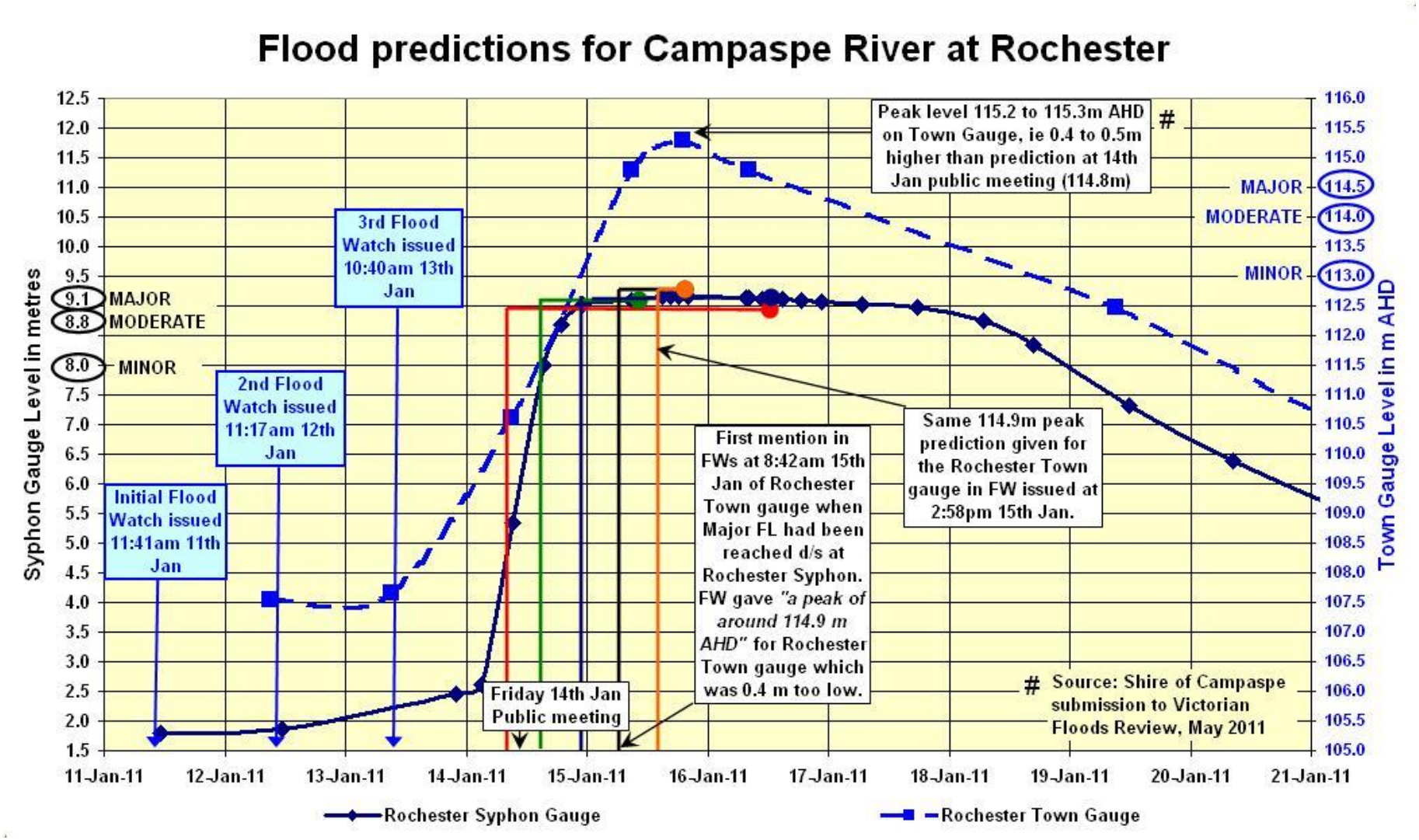

Figure 8: Flood Predictions for Rochester

The Intelligence Unit within the ICC looked at the Barnadown gauge readings and concurred that flooding in Rochester would be of a similar magnitude as 1956. This was communicated to the IC but Molino Stewart investigations have not been able to ascertain whether this information was communicated back to the BoM.

The next official flood warning was not issued by the BoM until 8:42am Saturday 15th January, around the time the Major Flood Level [9.1m] was reached downstream at the Rochester Syphon gauge. This was more than six hours since the previous warning, contrary to the requirements of the directive.

This was the first warning in which BoM included forecasts for the town gauge. In this warning the Bureau said the Rochester Township gauge *"had been exceeded by floodwaters where the level is estimated to be at around 114.8m AHD. Small additional stream rises are expected with a peak of around 114.9 m AHD during Saturday afternoon/evening."* Another later that afternoon predicted the same peak.

The river peaked later that evening when it was expected to peak and within 0.07m of the forecast level at the Syphon gauge.

iii) Evaluation

If the Syphon gauge levels and timings are considered in isolation it may seem that the Rochester forecasts were very good. However, these do not tell the full story.

At the Syphon Gauge the floodplain is quite wide and large changes in flow can result in small changes in level. For example the flow at 9.0 metres is around 33,000 ML/day while at 9.15 metres the flow doubles to around 66,000 ML/day (source: Victorian Water Data Warehouse). It follows then that a prediction could reasonably be made within ± 0.1 metres while the flow could be a sizeable ± 20,000 ML/day.

Furthermore, the floodplain through Rochester is much narrower than downstream and so a small rise in level at the Syphon gauge can result in a large rise at the Town gauge.

It would seem that the BoM used some sort of correlation between the forecast Syphon gauge level and the Town gauge level to create the Town gauge forecasts but there were problems with this approach.

Firstly, the correlation curve which is in the Directive only has calibration events up to about 114.7m on the Town gauge which is less than the 114.9m forecast and certainly much less than the peak which was eventually reached. The media reported that the river peaked at 115.3m which was higher than the top of the gauge. The BoM does not have any data on the eventual peak and requests to the CMA for an official value were unanswered at the time of writing.

Secondly, the BoM clearly did not use this curve for forecasting in January because if it did, its forecast of 9.1m at the Syphon gauge would have correlated to 114.5m at the Town gauge, 0.4m lower than forecast. This same curve suggests that 9.4m would need to be reached at the Syphon gauge before 115.3m, the reported peak, would be reached at the Town gauge.

Finally, even the highest correlation point on that curve is lower than the 2011 flood in Town but higher than the level reached at the Syphon which suggests that the correlation between these gauges may also be dependent on the shape of the flood hydrograph, its volume, not just the peak level.

The impacts of having a flood at the most meaningful gauge to the residents, that was at least 0.4m higher than expected, was exacerbated by the fact that there was no update to the forecast overnight. Then, when a new forecast was issued the forecast peak in Town was only revised upwards by 0.1m as was the forecast peak at the Syphon despite the significantly different stage hydrographs at each location.

Not only did the peak in Town exceed the forecast level, but it would have done so within a few hours of the warning being issued rather than at the forecast timing about eight hours after the revised peak warning.

By all of these measures the warning in relation to the town gauge was neither timely nor accurate.

d) Loddon

The Loddon Directive is a very basic type written document from 1985 which has information to assist the BoM to make forecasts but no performance targets, not even for the frequency of warnings.

i) Carisbrook

There are two rivers that converge just upstream of Carisbrook with one coming through Tullaroop Reservoir but neither having gauges with levels which can be read during a flood. The dam owner (Goulburn Murray Water) is able to forecast reservoir outflows but they are only one contributor to flows through Carisbrook. During the floods it was providing hourly updates of forecast outflows.

In addition to the two rivers upstream of town, there is a very large area to the south west which can direct overland flows towards the town with little warning. It was flash flooding from this area which flooded the town in September 2010 with early morning rain flooding the town within six hours.

Interviewees were less certain about what caused the flooding in January but they also suspected that overland flows were a major contributor.

In February 2011, the town was evacuated by Goldfields Council (without reference to the SES) because there were fears that Talbot reservoir would fail and flood the town. When the all clear was given and people returned, the rivers flooded the town.

As one of the people from the ICC stated, 'If happened tomorrow they would not know how to warn of flooding from the river or overland flow.'

ii) Laanecoorie

The BoM analyses suggest that in September and February a Flood Watch was given about a day in advance of the first flood warning for Laanecoorie on the Loddon but in January 2011 the Flood Watch preceded the warning by only about three hours. However, the first flood warning in January was issued about three days before the flood peak compared to about 12 hours before in September and 36 hours in February. As stated elsewhere, these comparisons do not indicate how soon before actual flooding occurred these warning products were issued.

iii) Kerang

Figure 9 provides a comparison of predictions with the flood hydrograph for the Murray Valley Highway at Kerang. The first flood watch preceded the minor flood level by five days.

The first indicative level prediction for the Loddon River at the Murray Valley Highway (MVH) gauge at Kerang was made at 8:19am Friday 14th January. This prediction stated,

"The Loddon River at the Murray Valley Highway at Kerang is currently at 76.7 metres AHD and rising (Minor Flood Level 77.0 metres). Early indications are that the river will approach the Major Flood Level (77.8 metres AHD) during the weekend."

At the time this implied that the Loddon River at MVH would have to start rising at a rate of 0.7 metres per day when the current rise was nowhere near that fast.

This prediction was repeated in three later flood warnings before it was finally acknowledged that the passage of the floodwaters upstream was going to take longer to reach MVH.

At 10:22am Monday 17th January the level was only 77.09 metres but the Bureau's progressive flood prediction was for the river to approach the Major Flood Level (77.8 metres AHD) during Monday which meant it would have to start rising at the rate of 1.2 metres per day.

Eventually at 7:08pm Monday 17th January, just prior to the river peaking upstream at Appin South, the level at the MVH began rising steadily at 0.7 metres per day. This was the same rate of rise the Bureau had expected it to start rising at 3 ½ days earlier

At 10:22am Mon 17th January the flood warning first mentioned *"This event is expected to exceed the 1933 flood which was the second highest on record after the 1909 event"* however no peak flood level was given for the 1933 flood peak.

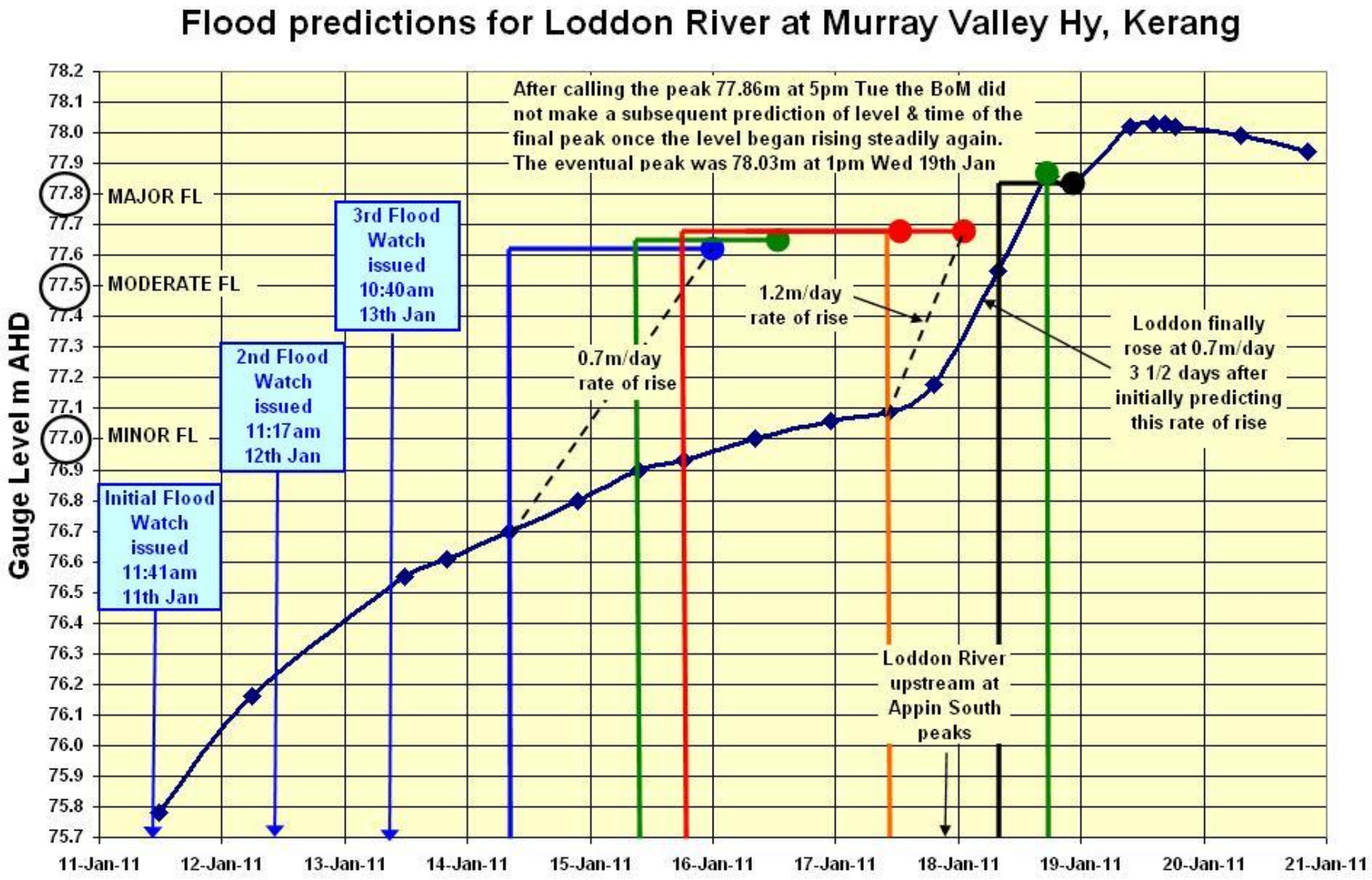

Figure 9: Flood Predictions for Kerang

No definitive peak level prediction was ever given for the Loddon River at the MVH and at 10:09pm Tuesday 18th January the Bureau advised *"The Loddon River at the Murray Valley Highway at Kerang peaked at 77.86 metres (Major Flood Level 77.8 m AHD) 5 PM Tuesday. The river at the Murray Valley Highway is currently 77.83 metres and falling very slowly."*

This was in fact incorrect as a secondary surge occurred almost as soon as that 10:09pm flood warning was issued with the river rising further overnight to a peak of 78.03m on Wednesday 19th January.

In terms of the Bureau's flood level predictions, while it made a good early call that the Loddon at MVHy was going to exceed the Major Flood Level [77.8m] the fact no definitive peak level prediction was given after the Loddon River at Appin South upstream peaked late on Monday 17th January could be seen as an issue.

Furthermore, forecasting that the peak would arrive days before it actually did does not necessarily provide additional warning time for appropriate response but rather can create doubts about the veracity of the warnings.

e) Avoca

The Avoca Directive which dates from 1999 stipulates that for Yawong weir and Charlton flood warnings should be given twice daily. At Yawong Weir these are to be given at least six hours before flooding commences while at Charlton a 12 hour warning of the peak is required.

At Quambatook only one warning each morning need be issued.

The Directive recommends comparisons with historic flood levels be included in the warnings.

The BoM analyses suggest that the warning time targets for Charlton were well and truly met with the first warnings being given nearly three days before the peaks in September and January and nearly four days before the February peak. However, these do not tell the full story.

The first flood warning was issued on the morning of 13th January and forecast flooding greater than the moderate flood level some time the following day. shows the first flood warning which predicted a peak close to major flood level which it did nearly two days in advance of the expected peak. It was not until 12 hours later that this was revised upwards slightly with no indication of the likely timing of the new peak other than to say it would occur the following day. This level was exceeded within a couple of hours

Within five hours of the previous forecast the predicted peak was increased by 0.5m but the river had already exceeded the previous peak forecast by 0.2m. Nevertheless, despite the steep rate of rise in the River, the peak was not expected to occur for nearly 24 hours.

The new forecast peak of 8.0m was exceeded 3.5 hours later at around 1:00 am and the River continued to rise another 0.05m within the next hour to be at near its final peak level.

The accuracy and timeliness of the latter warnings failed to meet the targets in the Directive.

Speaking to those involved in the ICC it would appear that the forecasts had been affected by technical problems at the Yawong weir gauge upstream. This gauge had been overwhelmed and was not showing any increase in flood levels. Those in the ICC realised that to be the case but in hindsight they believe that because the reading were not changing but were being reported on the BoM website, the general public may have thought that the river had peaked.

The first flood watch for Charlton was issued nearly two days before the minor flood level was reached.

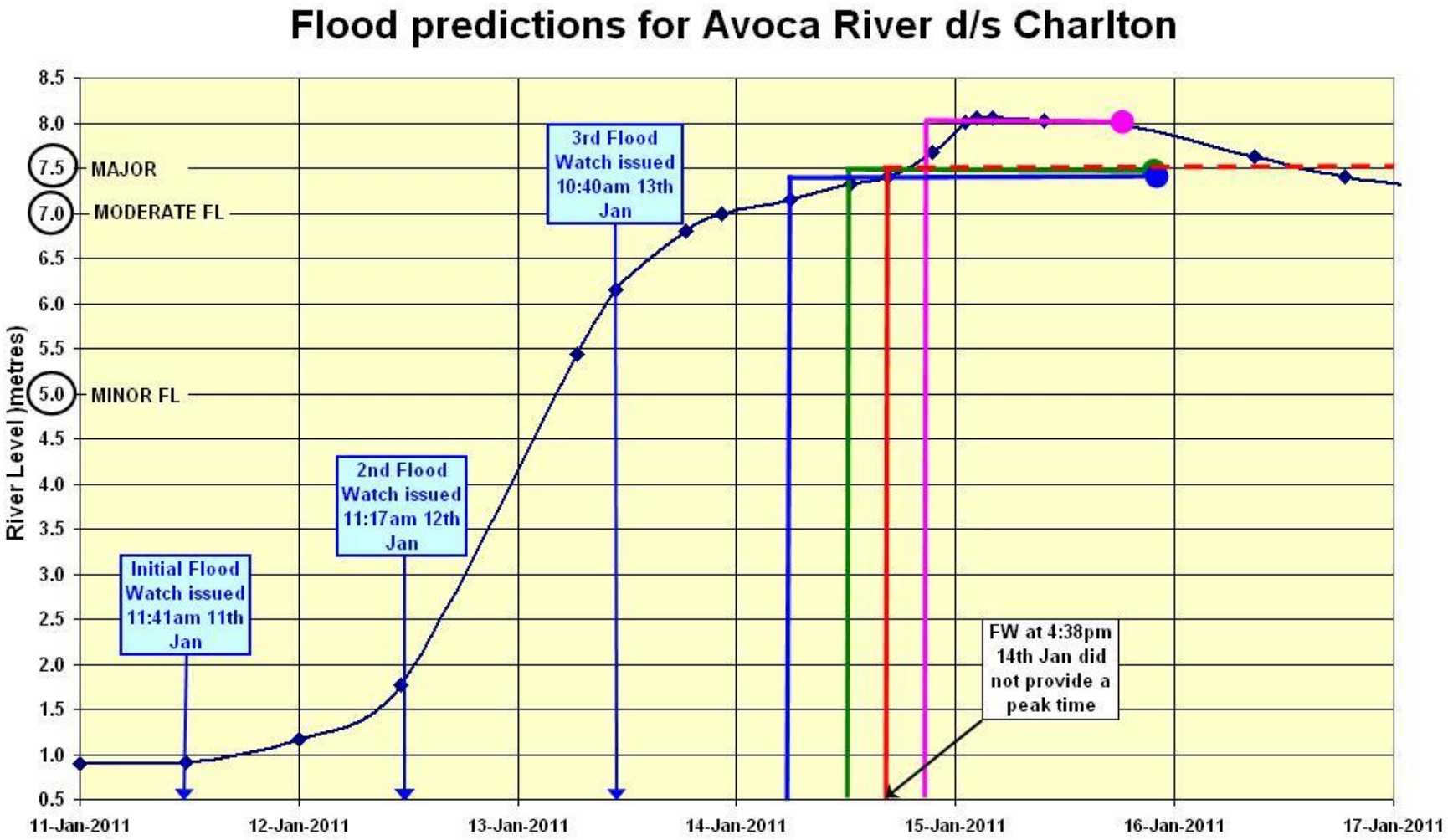

Figure 10: Flood Predictions for Charlton

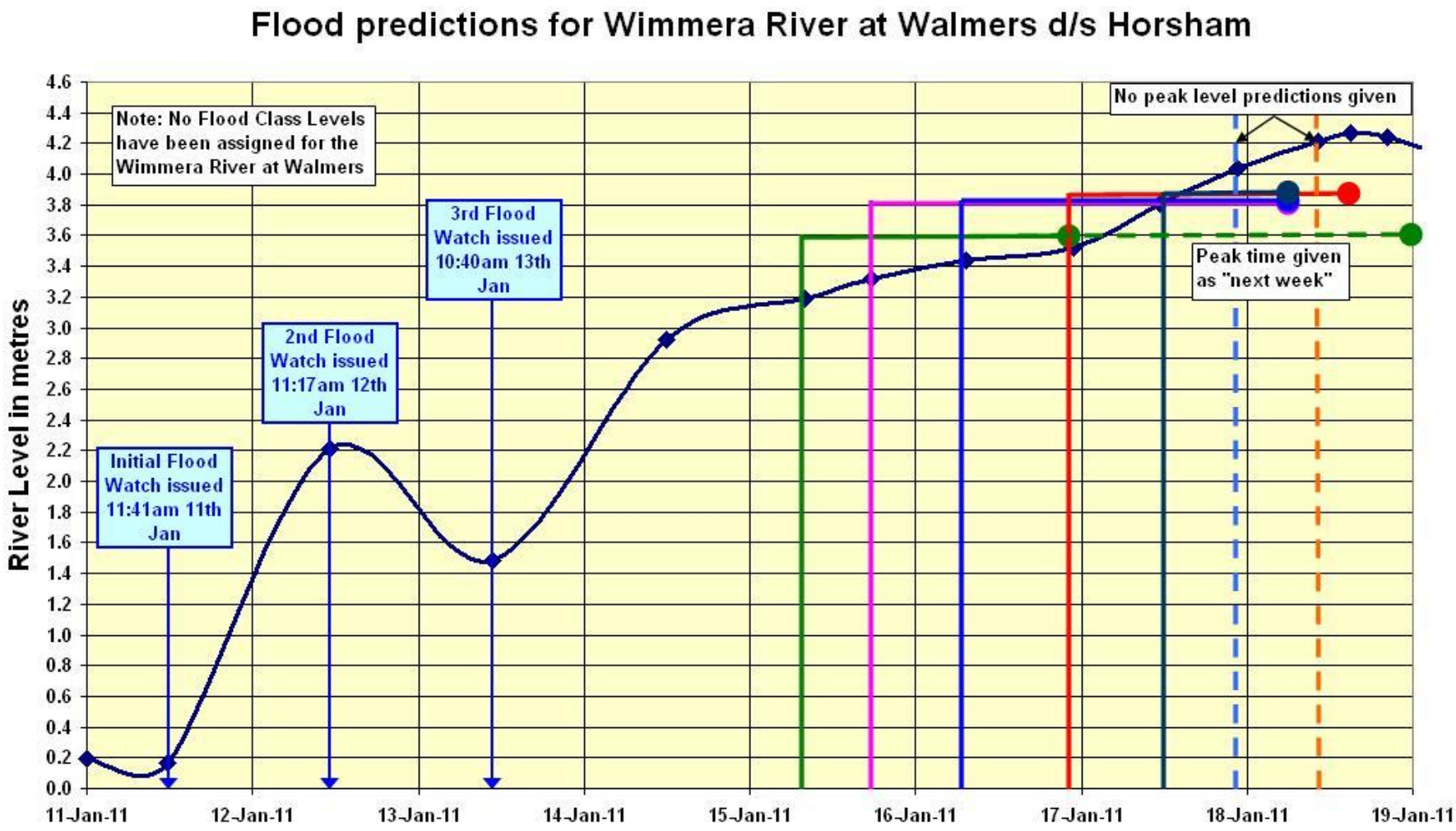

Figure 11: Flood Predictions for Horsham

f) Wimmera

The Wimmera Directive is a brief, typed document from 1985 which contains no performance targets. It includes the statement "At a meeting in Horsham in 1979 the Bureau said that it would not issue warnings for this River. Consequently RWC made their own arrangements to collect rain and river readings and disseminate flood warnings in the basin. During floods RWC contact the Bureau for weather forecasts and usually offers their data – if not, ask for it!" The tone of the rest of the document suggests that the BoM will provide warnings for the River generally and Horsham specifically however the official response from the BoM to this study is that it only issues official warnings for Glenorchy as agreed through a service level agreement.

The BoM analyses suggest that at Glenorchy flood watches were issued at least a day before the first flood warning which was issued a day before the September flood peak and three days before the January flood peak. It would appear that there was not flood in February despite the forecasts.

Despite the official line regarding forecasts, the BoM did provide forecasts for the Walmer gauge which is 6 km downstream of Horsham and is used for predicting impacts in Horsham. A comparison of the flood hydrograph and the forecasts for the January flood in Horsham are given in Figure 11.

The first flood level prediction for the Wimmera River downstream of Horsham at Walmer was made at 7:56 am Saturday 15 January 2011 when the gauge was reported as "not operating" but despite this the advice was that "levels are likely to be similar to the August 1981 event."

Research was necessary for recipients of the message to be able to determine that the August 1981 peak level was 3.6 metres as this was not stated in the warning.

The peak level prediction was increased steadily from around 3.8 metres later on 15th January to a peak of up to 3.85 metres expected overnight Monday 17th January into Tuesday 18th January when the level was already 3.8 metres around noon on 17th January.

By late Monday 17th January the Bureau discontinued flood level predictions for Walmer saying *"the Wimmera River at the Walmer gauge (downstream of Horsham township) is currently at 4.04 metres and rising. Flows from the McKenzie River and Burnt Creek systems may be contributing to elevated river levels at the Walmer gauge."*

The Wimmera River at Walmer peaked at 4.28 metres at 11:30am Tuesday 18th January.

As stated by the Bureau, inflows downstream of Horsham from McKenzie River and Burnt Creek were impacting on the level at Walmer seemingly impacting on their ability to make a peak level prediction for the Wimmera River at Walmer.

Discussions with those who were in the ICC suggest that this was well understood there and that as far as they were concerned the forecasts given to the Walmer gauge were correlating well with the corresponding observed levels in Horsham itself. This would not have been apparent to members of the public who were looking only at the gauge data of the BoM website.

Similarly, it was reported that in the earlier floods the gauge reading would jump by 2 metres because the settings on the level recording had been set for low flows. This was understood by those in the ICC but would have given members of the public looking at the website the impression that the river had risen very suddenly.

g) Hopkins

There is no directive or manual for the Hopkins catchment and Mt Emu Creek, which was investigated for this study, has no formal flood warning system in place.

The BoM analyses indicate that in September a flood watch was issued which covered this catchment but confirm that no flood warning was given and that there were no records of the gauged flood peak. The IC said that although people in Skipton knew the town could flood, they did not realise they were going to flood in September until the Creek began to rise and affect parts of town.

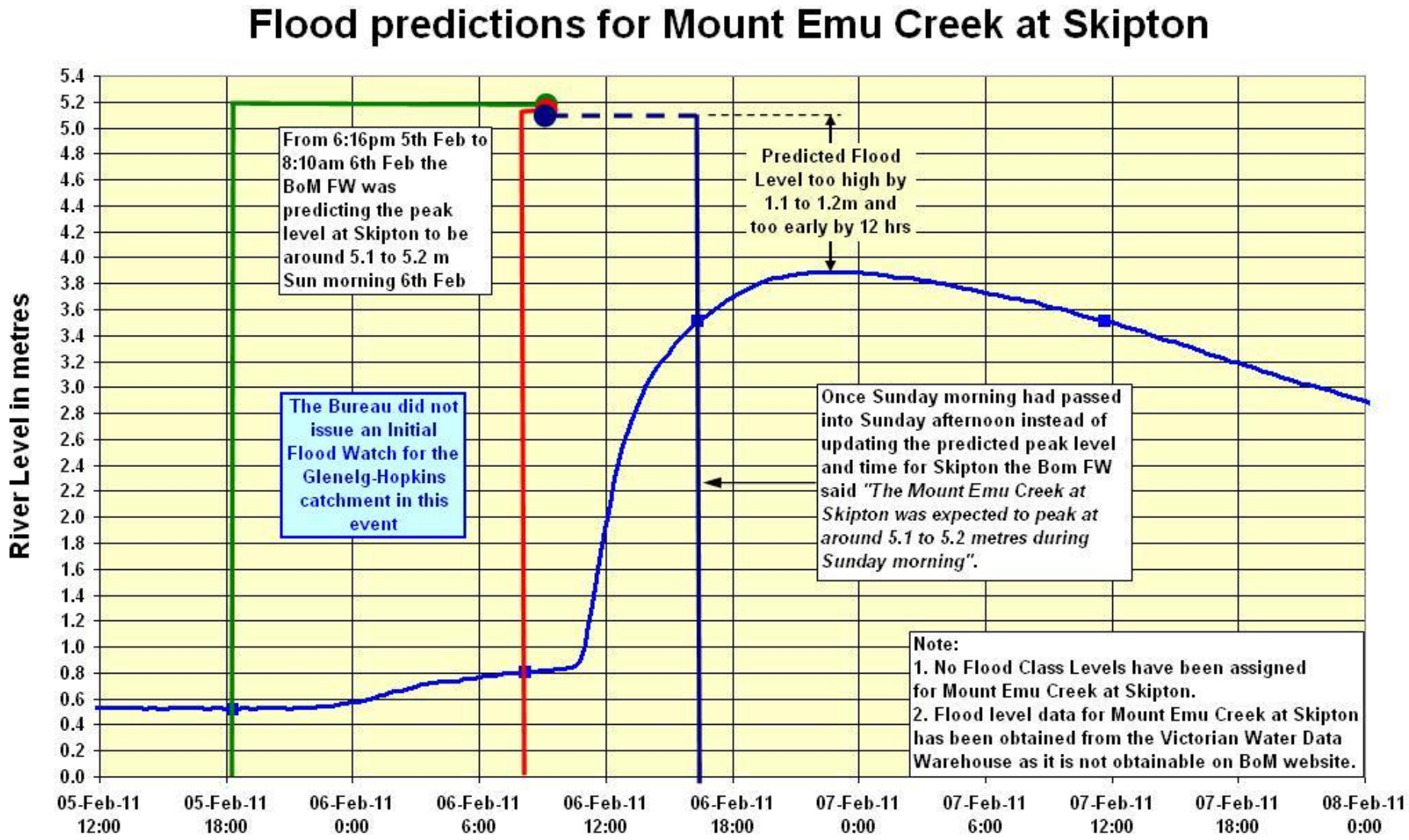

Figure 12: Flood Predictions for Skipton

By January some interim measures had been put in place and the CMA was able to dial into some upstream gauges and provide data to the BoM. A flood watch was issued nearly two days before the first flood warning and the first flood warning was issued about 18 hours before the flood peak.

However, because there was no formal flood warning system in this catchment, it was not possible to forecast downstream levels and timings with any sort of accuracy. As a consequence, the river rose much higher than anticipated and the sandbags which were put up to defend the town were overwhelmed.

Things had not improved by February and although no flood watch was issued, the flood warning was issued at least a day before the flood peaked. On this particular occasion the peak was much lower and later than anticipated as is shown in Figure 12.

h) Bunyip Creek

Bunyip Creek is within the Melbourne Metropolitan area and as such flood forecasting is done by Melbourne Water and issued through the BoM.

The town of Koo Wee Rup is close to where Bunyip Creek discharges into Western Port and is downstream of gauges at Cora Lynn Ford and Iona.

The BoM has done an analysis for Cora Lynn Ford which is the gauge closest to Koo Wee Rup. In September a flood watch was issued two and half days before the first flood warning which was about 18 hours before the flood peak. A flood watch was issued in January but no flooding eventuated.

For the February flood the BoM did the analysis for the Iona gauge. In this event the flood Watch was issued a day and a half ahead of minor flooding.

Melbourne Water has advised that the BoM issued any forecasts that Melbourne Water produced almost immediately so this step did not create any issues with timeliness of warnings.

The graph in Figure 13 shows the evolution of the February flood and accompanying warnings at the Iona gauge. It shows that initially a minor flood warning was given at 8:30pm on 5th February. It stated that the Creek was approaching minor flood levels at Iona and Cora Lynn and will exceed minor flood levels later this morning or early afternoon. It advised that the next warning would be issued at 4pm or earlier if required.

The minor flood level was exceeded within 30 minutes and according to the Iona gauge, the river was rising rapidly. The second flood warning was not issued until 3:40pm by which time the Iona gauge had already exceeded the major flood level (5.5m) and was already at 6.0m. This forecast was that a peak level of 6.2m would be reached at 2am on 6th Feb. The level actually reached 6.2m about 15 minutes after this forecast was issued. This meant that the local community at Iona living on either side of the main drain levees had no official warning of the major flooding before the water began overtopping the levees and inundating their community including the Catholic Church and school.

At the same time, the Cora Lynn gauge, which is about 7.5km downstream, was only at 3.7m which was well below the moderate flood level of 5m.

The Melbourne Water duty forecaster explained that at the time he had no reason to believe that there was any problem with the gauge reading and that a “wall of water” was coming down the Valley and would hit Cora Lynn sometime after it had arrived at Iona. He was aware that there was an ungauged tributary between Iona and the next gauge upstream and assumed that significant flows were being contributed by this catchment. Furthermore, the upstream gauge was fairly new with little calibration data so it was also possible that more water was coming from upstream than this gauge was suggesting.

An intelligence officer at the SCC said that they too had noticed this rapidly rising hydrograph at Iona which was significantly different to what was happening at Cora Lynn.

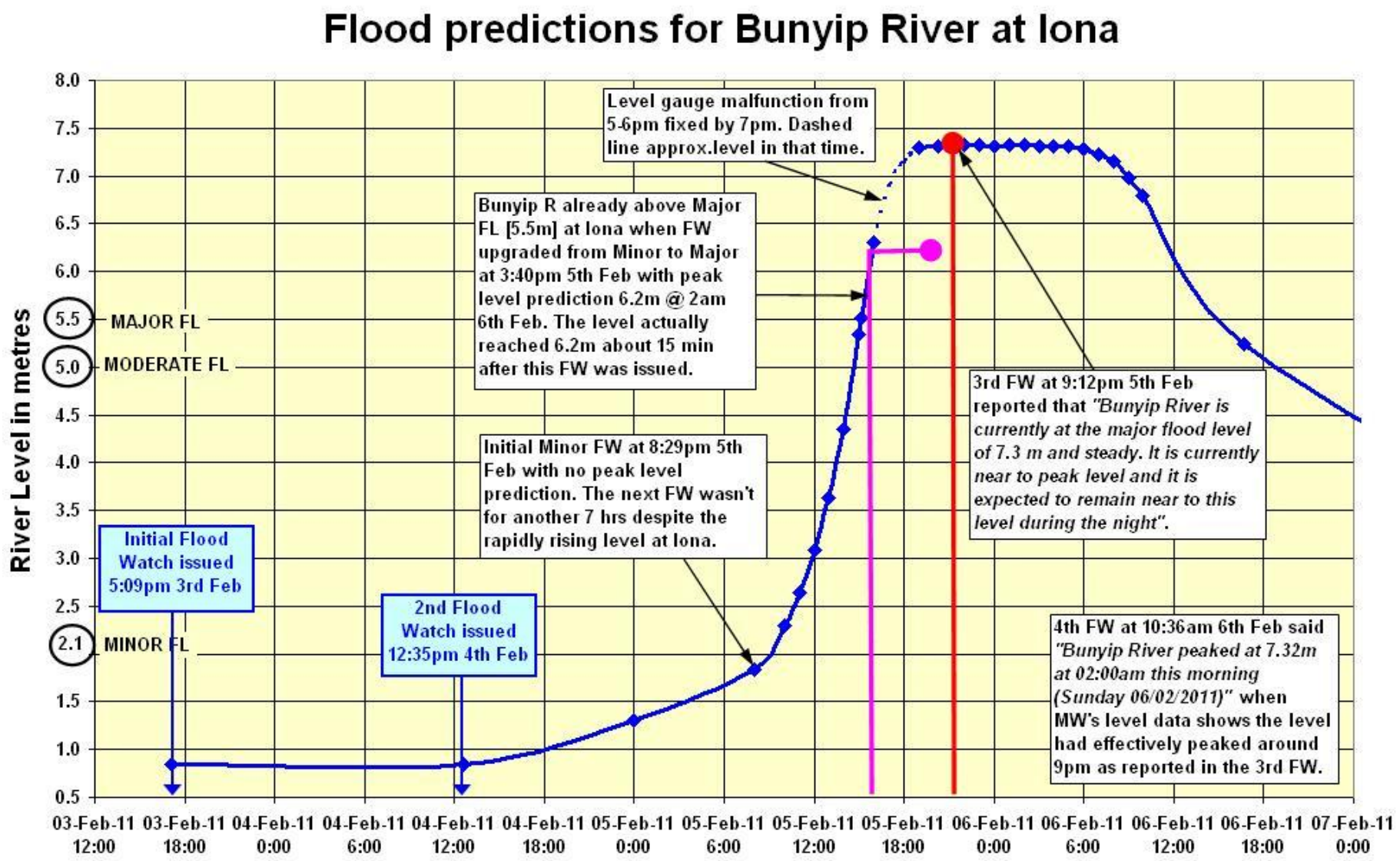

Figure 13: Flood Predictions for Iona

Soon after this warning was issued the gauge reading rose even more rapidly from 6.2m to 9m in a very short time. A technician was sent the gauge and a mechanical problem was identified and rectified by 7pm. By this stage the Iona gauge had almost reached its eventual peak of 7.32m and at 9pm a warning was issued that the river had reached 7.3m and was steady at or near its peak.

Once the gauge was fixed, the SCC were confident that the Iona gauge reading must be right and therefore looked for other explanations for why there was a discrepancy between this reading and those at Cora Lynn which had not risen so rapidly. Their explanation was that because the Creek had overtopped the levees at Iona, which they knew from field intelligence, the flows must have been bypassing the channel at Cora Lynn and making their way towards Koo Wee Rup by an overland path.

Subsequent investigations after the flood revealed that the rating curve for the Iona gauge was in error. The peak gauge readings were suggesting a flow of 260 cumecs when in fact the flow was only about 180 cumecs.

It has been observed that there is significant vegetation growing in the Creek at the Iona gauge and if this was not there when the gauge was first calibrated this could account for the large discrepancy between historical and current rating curves. It was also noted that this was the first time the URBS model had been used in the catchment (previously a RORB hydrological model was used) since it was implemented 12 months before.

2.2 COVERAGE OF FLOOD PREDICTION SYSTEMS

The Flood Warning Service Development Plan (VFWCC, 2005) provided catchment report cards which set out detailed information about the flood warning systems in every catchment in Victoria.

This very comprehensive document provided an excellent reference point for this project. In particular, the BoM was requested to provide an update on relevant aspects of the catchment report cards.

2.2.1 Data Collection

a) Coverage

The ideal data collection network is one which has a sufficiently dense network of rainfall and stream gauges which are continually recording and automatically transmitting data to forecasters. What is a sufficient density will be influenced by the complexity of the catchment and the time taken for floodwaters to reach downstream communities.

The FWSDP used a scoring system to rate the data collection networks within each catchment and compared them to a benchmark score below which systems could be considered to be in need of an upgrade. This assessment is reproduced in Figure 14. It clearly shows that the Broken and the Melbourne Metropolitan catchments were the best performing with Bunyip Creek being the poorest performing of the Metropolitan catchments. The Goulburn and the Ovens and King were the only other catchments of those considered in this study which scored higher than the benchmark.

The BoM provided an update of the current gauging and telemetry in each of the catchments of interest, except for the Bunyip,and this is summarised in Table 1.

This shows that in terms of additional gauging stations, the Goulburn has benefited most with a total of 23 new gauges installed. They have mostly been Event Reporting Real Time Telemetry (ERTS) enabled gauges which provide real time data. A further 29 have been upgraded, mostly to ERTS or at least to CR800 loggers which provide hourly updates and allow the download of the complete record. Redundant telemetry has also been added to this catchment with 18 editions.

The Wimmera is the next most upgraded system with eight new stations, 19 upgrades and 13 redundant telemetry added. The others have not been as substantially upgraded and the Avoca and Campaspe have received little more than a few station upgrades and the Hopkins nothing but access to one new gauge.

Were the 2005 network assessment to be redone it would be expected that the Goulburn and Wimmera exceed the benchmark

performance with the Loddon, Avoca and Campaspe around the benchmark level and the Hopkins still well short.

The FWSDP did a coarse cost benefit analysis which suggested that the Goulburn and Loddon would be the two catchments which would have the best benefit cost ratio with regard to network upgrades. It would appear that appropriate priority has been given to the Goulburn catchment but perhaps more attention could have been given to the Loddon.

In interviews it was noted by several people that catchments such as the Wimmera, Avoca, Loddon and Campaspe have vast distances between gauges, particularly in their lower reaches. This was considered to be a problem both in terms of collecting timely and meaningful data on the progress of the floods downs these rivers but also for providing a meaningful local reference level for occupants of the floodplain.

b) Reliability and Robustness

While gauge and communication coverage is important, so is reliability. There is little benefit in having a vast network of gauges if they do not deliver data when required.

The BoM was asked to provide data on gauge failure during the floods. Their response is summarised in Table 2 and shows that in September and February the Wimmera was the worst-performing catchment with only 66 and 59 per cent availability respectively. The Loddon and the Ovens both performed poorly in both events with availabilities in the 70s which the Avoca did better in September with 86 per cent compared to 73 per cent availability in February. Some catchments had greater than 95 per cent, up to even 100 per cent, availability during the floods.

However, this data needs some qualification. According to the BoM, any site that did not report at least once during a day was considered to have malfunctioned. In non-flood times automatic gauges are expected to report at least daily. During times of flooding automatic gauges are expected to report many times per day and data from manual gauges is expected to be received at least daily. There would be many more faults not identified in this summary either because the missing data would have been retrieved once the gauge was repaired or because the outage was less than one full day. Note gauges that were not reporting prior to/and during the events have not been included.

In other words, this data set is probably under reporting gauge failures. Furthermore, it appears to have also excluded as a failure a gauge which continued to report but which was transmitting erroneous data.

From all reports the reasons for gauge failure included one or more of the following:

- Faults in the telemetry
- Failure of power and communications systems
- Electrical or mechanical fault in the gauge
- Damage to the gauge by falling trees, flood debris or erosion
- Absence of the manual gauge reader
- Flood level exceeding maximum gauge recording level

Reliability can be improved by:

- better gauge and communications technologies
- better surveillance and maintenance
- redundancies in gauging and communications networks
- backup power supplies
- more flood resilient gauge designs

Even if all of the above were practical and affordable, some gauges will still fail in floods and methods need to be available for providing forecasts, even if less accurate and timely, in the absence of some gauge data.

It is noted that Melbourne Water reported that only two of its gauges failed during the February floods. The one at Iona and another which had a tree fall on it but it was in a catchment which did not flood.

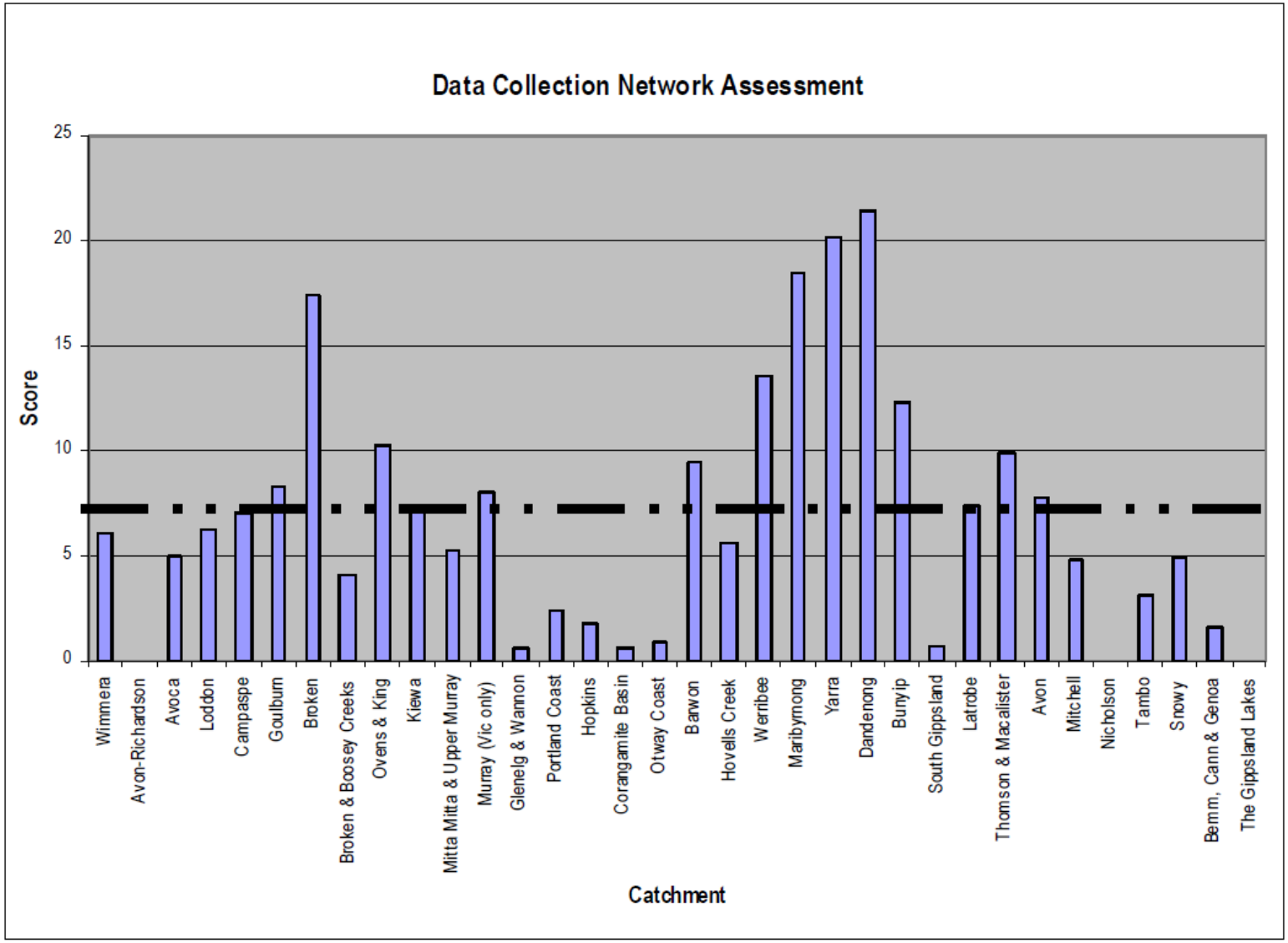

Figure 14: 2005 Data Collection Network Assessment (VFWCC 2005)

Table 1: Network Upgrades since 2005 (Source: BoM)

	Access to new stations				Redundant telemetry added			Station upgrades			
Catchment	ERTS	CR800	Other	Total	CR800	Other	Total	ERTS	CR800	Other	Total
Avoca	0	0	0	0	1	0	1	0	5	0	5
Campaspe	0	0	0	0	0	0	0	0	9	0	9
Goulburn	15	3	5	23	16	2	18	13	16	0	29
Loddon	0	3	1	4	0	2	2	0	11	0	11
Ovens	2	1	1	4	7	1	8	6	9	0	15
Wimmera	4	0	4	8	9	4	13	15	0	4	19
Hopkins	0	0	1	1	0	0	0	0	0	0	0

Table 2: Non Reporting Gauges 2010-2011
(Source: BoM)

	Catchment	Station daily reports	Max number of station daily reports	Station daily reports (%)
Sept	Avoca	239	279	86
	Barwon	91	93	98
	Broken	969	1116	87
	Campaspe	394	465	85
	Euroa	569	620	92
	Glenelg	31	31	100
	Goulburn	1788	2139	84
	Hopkins	30	31	97
	Kiewa	165	186	89
	Loddon	605	775	78
	Maribyrnong	31	31	100
	Ovens	1306	1767	74
	Thomson	148	186	80
	Wimmera	822	1240	66
	All catchments	**16385**	**18990**	**86**
Feb	Avoca	275	378	73
	Barwon	126	126	100
	Broken	1334	1512	88
	Campaspe	565	630	90
	Curoa	790	840	94
	Glenelg	42	42	100
	Goulburn	2411	2898	83
	Hopkins	42	42	100
	Kiewa	227	252	90
	Loddon	821	1050	78
	Maribyrnong	41	42	98
	Ovens	1866	2394	78
	Thomson	178	252	71
	Wimmera	991	1680	59
	All catchments	**28853**	**34914**	**83**

2.2.2 Flood Forecasting

The FWSDP made a similar assessment of forecasting capabilities across each of Victoria's catchments. It is summarised in Figure 15 and it shows that the Melbourne metropolitan catchments had the best forecasting services although most of the catchments subject to this study had similarly high performance scores which were well above the benchmark level. The exception was the Hopkins which had no forecast service. However it should be noted that forecast performance was based on analysis of data from a period when there was a paucity of major floods.

Again the 2005 catchment report cards were referred to the BoM for an update on their forecasting methods for each catchment. The comparison is provided in Table 3 which shows that forecasting was generally done using the hydrological model URBS, dam outflow forecasts from water corporations and height/flow correlations or a combination of these methods. These techniques and their appropriateness are discussed further in Section 2.3. In some locations rainfall and stream levels were used to create forecasts with the use of a hydrological or hydraulic model.

What the table shows is that since 2005 there have been upgrades to the forecasting methods in parts of the Ovens/King, Goulburn Broken and the Wimmera. In each case an URBS model, and in some cases dam outflows, replace the former more primitive methods of correlations to rainfall or upstream gauges, or in some locations no forecast at all. These have been significant improvements.

In Bunyip Creek the former RORB hydrological model has been replaced with URBS.

2.3 CURRENT TECHNOLOGIES

It is beyond the scope of this study to fully evaluate the best available technologies for flood forecasting but some general observations can be made to benchmark Victorian flood forecasting against practices elsewhere in Australia and internationally

2.3.1 Gauges and Communications

The best rainfall and stream flow gauges are those which continuously record and telemeter the data to the flood forecasters. In decreasing order of sophistications are those that telemeter data hourly, those that do it three hourly, those which have to be dialled up for data and those which are read manually.

Table 4 summarises the different gauge types within each of the catchments that are the subject of this study. A distinction has not been made between rainfall, stream gauge or combined gauges as the focus is on the technology

One reason that continuous or periodic reporting is preferable to a dial up gauge is because it is possible to know whether the gauge is encountering a technical problem before the flood rather than discovering the problem when the gauge is needed during a flood. Even so, someone needs to be checking the data which is being sent to see if it is making sense during non-flood periods and it is still possible for the gauge only to experience problems, or for problems only to be noticeable, when large events occur.

The manually read stream gauges not only suffer from the disadvantage of needing someone to be available to take the readings but the readings need to be manually sent back to the forecasters who then manually enter the data into the forecasting system. These all add time delays which do not occur with the automatic reading and telemetry. Furthermore, the manual readings can generally only be taken during daylight hours and when access is available and safe. The advantage that the manual readings have over automatic readings is that the reader can provide visual observations about the conditions of the gauge and the river which may be having an impact on the reading.

Having said that, manual readings or observations may be the only available data when automatic gauges fail.

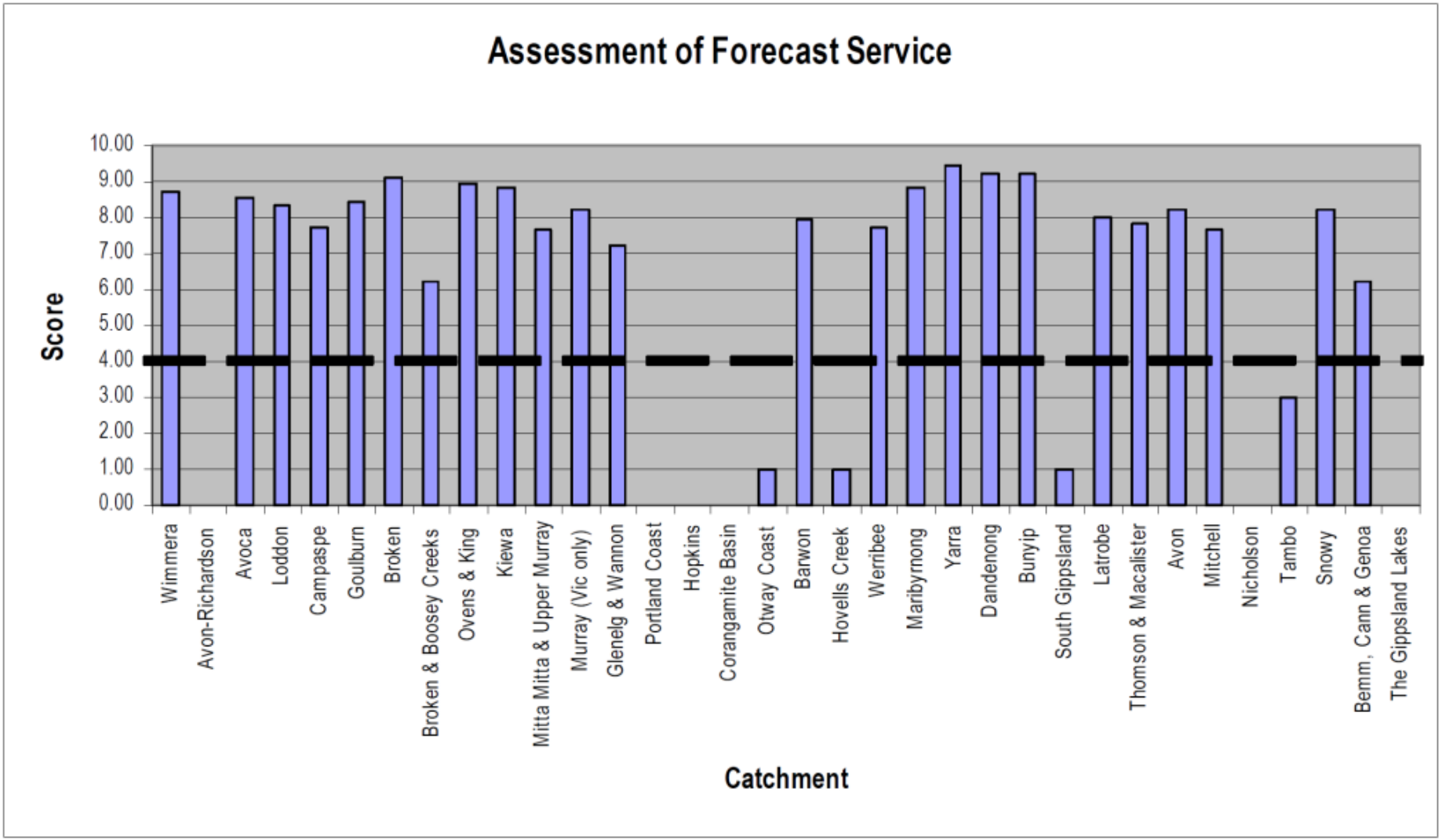

Figure 15: 2005 Assessment of Forecast Service (VFWCC 2005)

Table 3: Forecasting Method Upgrades since 2005 (Source: BoM)

	Baseline (Ref. Flood Warning Service Development Plan For Victoria, OCTOBER 2005)				**Variations to 2005 Baseline (Ref. Victorian Flood Warning and Forecasting Section, SEPTEMBER 2011**				
Basin	*River*	*Site*	*Forecast Type*	*Forecast Model/Technique*	*River*	*Site*	*Forecast Type*	*Forecast Model/Technique*	*Comment*
Ovens & King	Fifteen Mile Creek	Greta South	Quantitative	URBS					No Change
	King River	L William Hovell	Quantitative	URBS				URBS/GMW Information	Forecast provided through combination of URBS and forecast information received from GMW
		Cheshunt	Quantitative	URBS					No Change
		Docker Road	Quantitative	URBS					No Change
				Correlation from Cheshunt					No Change
				Correlation - Angleside + Cheshunt					No Change
	Ovens River	Bright	Quantitative	URBS					No Change
				Correlation from Harrietville					No Change
		Eurobin	Quantitative	URBS					No Change
	Buffalo River	Lake Buffalo d/s	Quantitative	Provided by G-MW				URBS/GMW Information	Forecast provided through combination of URBS and forecast information received from GMW
	Buckland River	Harris Lane	Quantitative	URBS plus Lake Buffalo outflows from G-MW					No Change
	Ovens River	Rocky Point	Quantitative	URBS					No Change
				Correlation - Bright+Harris Lane+Lake Buffalo d/s					No Change
		Wangaratta	Quantitative	URBS					No Change
				Correlation - Rocky Point + Docker Road					No Change
Goulburn/Broken	Hollands Creek	Kelfeera	Quantitative	URBS					No Change
	Broken River	Benalla	Quantitative	URBS					No Change
				Correlation from Moorngag					No Change
				Correlation from Kelfeera					No Change
				Correlation - Moorngag + Kelfeera					No Change
				Flow addition algorithm					No Change
		Caseys Weir	Quantitative	URBS					No Change
		Orrvale	Quantitative	URBS					No Change
	Goulburn River	Dohertys	Qualitative	Rainfall plus stream levels				URBS	Sites incorporated in URBS model covering the area upstream of Lake Eildon
	Delatite River	Tonga Bridge	Qualitative	Rainfall plus stream levels				URBS	

	Baseline (Ref. Flood Warning Service Development Plan For Victoria, OCTOBER 2005)				Variations to 2005 Baseline (Ref. Victorian Flood Warning and Forecasting Section, SEPTEMBER 2011				
Basin	*River*	*Site*	*Forecast Type*	*Forecast Model/Technique*	*River*	*Site*	*Forecast Type*	*Forecast Model/Technique*	*Comment*
	Goulburn River	Eildon d/s	Quantitative	Based on information from G-MW				URBS/GMW Information	Forecast provided through combination of URBS and forecast information received from GMW
	Acheron River	Taggerty	Quantitative	URBS					No Change
	Yea River	Devlins Bridge	Quantitative	URBS					No Change
					Yea River	Yea	Quantitative	URBS	Reference??
	King Parrot Ck	Flowerdale	Quantitative	URBS					No Change
	Goulburn River	Trawool	Quantitative	URBS					No Change
	Sunday Creek	Tallarook	Quantitative	URBS					No Change
	Goulburn River	Seymour	Quantitative	URBS					No Change
	Hughes Creek	Tarcombe Road	Quantitative	URBS					No Change
	Goulburn River	Goulburn Weir d/s	Quantitative	URBS with input from G-MW					No Change
		Murchison	Quantitative	URBS					No Change
					Goulburn River	Arcadia Downs	Quantitative	URBS	Site added following development of Flood Warning Service Charter for Shepparton (2006)
		Shepparton	Quantitative	URBS with liaison with G-MW because of their need to forecast for Loch Garry operation. G-MW use a simple spreadsheet					No Change
				Flow addition algorithm					No Change
		McCoys Bridge	Quantitative	URBS					No Change
				Correlation from Shepparton					No Change
	Seven Creeks				Seven Creeks	Strathbogie	Quantitative	URBS	Reference??
		Galls Gap	Quantitative	URBS					No Change
		Euroa	Quantitative	URBS					No Change
				Correlation from Polly McQuinns					No Change
		Kialla West	Quantitative	URBS					No Change
	Castle Creek	Telfords Bridge	Quantitative	URBS					No Change
Campaspe	Campaspe River	Redesdale	Quantitative	URBS					No Change
		Lake Eppalock d/s	Quantitative	Based on information from G-MW					No Change
		Barnadown	Quantitative	URBS					No Change
		Campaspe Weir d/s	Quantitative	URBS					No Change
		Rochester	Quantitative	URBS					No Change

	Baseline (Ref. Flood Warning Service Development Plan For Victoria, OCTOBER 2005)				Variations to 2005 Baseline (Ref. Victorian Flood Warning and Forecasting Section, SEPTEMBER 2011				
Basin	*River*	*Site*	*Forecast Type*	*Forecast Model/Technique*	*River*	*Site*	*Forecast Type*	*Forecast Model/Technique*	*Comment*
				Correlation from Barnadown + Runnymede					No Change
	Loddon River	Newstead	Quantitative	URBS					No Change
		Cairn Curran d/s	Quantitative	Based on information from G-MW					No Change
		Laanecoorie d/s	Quantitative	Based on information from G-MW					No Change
		Loddon Weir d/s	Quantitative	URBS					No Change
				Correlation from Laanecoorie d/s					No Change
				Correlation from Serpentine					No Change
		Appin South	Quantitative	URBS					No Change
				Correlation from Loddon Weir					No Change
		Kerang	Quantitative	URBS					No Change
				Correlation from Appin South					No Change
Avaco	Avoca River	Yawong Weir	Quantitative	URBS					No Change
				Correlation from Archdale					No Change
		Charlton	Quantitative	URBS					No Change
				Correlation from Yawong Weir					No Change
		Quambatook	Quantitative	Correlations from Charlton					No Change
Wimmera	Wimmera River	Glenorchy	Quantitative	Correlation from Glynwylln + Stawell				URBS + Correlations	URBS model developed as part of the new Flood Warning system/service development
		Horsham	Qualitative	Based on advice from GWMW staff	No official forecast provided				No official forecast provided from Bureau's persective. Initiatives for a new system/service to incorporate these sites is taking place, however this has not been agreed between stakeholders.
		Quantong Bridge	Qualitative	Based on advice from GWMW staff	No official forecast provided				
		Dimboola	Qualitative	Based on advice from GWMW staff	No official forecast provided				
Hopkins	Mt Emu Creek	N/A							No Change
Bunyip	Bunyip Creek	Iona	Quantitative	RT RORB				URBS	Forecast models migrated to URBS
	Bunyip River	Cora Lynn Ford	Quantitative	RT RORB				URBS	

One emerging technology which may be worth investigating for providing supplementary river observations are “crowd sourcing” platforms on the internet. These enable the uploading of data directly from smart phones and portable devices to a site dedicated to storing this data. An example of such a site in Australia is www.bushfireconnect.org which is a community developed site set up to allow community observations of bushfires to be added along with official notifications. It has been developed using the open source platform Ushahidi.

Such a technology may be useful in catchments where gauges don’t exist, along river reaches where gauges are far apart and at locations where automatic gauges have failed. Such a system would need to be designed in such a way that the location and time of the observation was accurately recorded, the observation was verifiable and there was a means of relating the observation to a flow estimate. These are not insurmountable technical challenges.

2.3.2 Forecasting Techniques

It is noted that there are generally three methods used in flood forecasting in Victoria:

- **Hydrological modelling** (generally using the model URBS) where rainfall observations from automatic rain gauges are extrapolated over a catchment and the volume of runoff calculated and the time that it would reach a location downstream estimated. This flow is converted to a gauge level at that location based on stage flow relationships developed from historical observations.
- **Flow additions** are used where streams merge and the flow estimates from hydrological modelling for each catchment are combined, taking into account the relative timing of flow arrival.A variation on this is where water corporations provide estimates of dam outflows based on inflows and dam operating rules.
- **Peak height/flow and travel time correlations** are used where historical observations suggest that if a flood reaches x metres at an upstream gauge now it will reach y metres at the next gauge downstream in a specified number of hours.

In some locations a combinations of these techniques are used to derive the forecast or correlation are used as a method of checking forecasts from the other methods. These methods are all used throughout Australian and around the world for flood forecasting. In the case of hydrological modelling and flow additions, this is more sophisticated than forecasting methods used by the BoM is some parts of the country, for example in NSW.

As far as hydrological models go, URBS is quite appropriate for the purpose to which it is being put as it has been specifically developed for use in flood forecasting and has the capability to estimate design flood flows. Melbourne Water used a real-time RORB rainfall-runoff flood forecasting model from 1992 to 2003 but has since decided to standardise with the URBS model used by the Bureau. There are other hydrologic models such as WBNM which are used extensively throughout the country for design flood flow estimation and which have also been used in flood forecasting and warning systems. This is the basis of flood warning systems at Moreton Bay Regional Council and Gold Coast City Council in Queensland at on the Camden Haven River, Dora Creek, Berowra Creek, Manly Lagoon and Narrabeen Lagoon in NSW.

Peak height/flow calibration is simple and therefore has the advantage that it does not require real-time calibration of model parameters, as required with URBS and other hydrologic models, and is independent of the actual flows required at either gauge location. It’s disadvantage is that waiting for the upstream gauge to peak will result in the loss of some warning time.

Where technological improvements could be made with regard to flood forecasting would be in the use of hydrodynamic modelling. This is done widely throughout the world and is used in some flash flood warning systems in Australia. A hydrodynamic model takes the runoff calculations from a hydrological model and routes them through a model which takes into account information about the river channel and floodplain such as length, size, shape, slope, roughness and storage capacity.

An advantage of this type of modelling has over the other techniques is that it takes better account of:

- storage which there may be in the floodplain;
- the shape and volume of the flood hydrograph for the particular flood in question
- inflows from tributaries

These can all vary from event to event and some river reaches are more sensitive to these factors than others, particularly as one moves down the catchment.

The examples in NSW cited above use WBNM as the hydrologic model and then whatever hydraulic model has been developed for design flood modelling in the catchment. On the Gold Coast Mike 11 is used for the hydraulic modelling. This model has a 20 minute run time (D McConnell, Worley Parsons, pers com).

Table 4: Gauge Types in Selected Catchments

	Data Collection Technique												
Catchment	Manual		Data Transfer from External Agency		Three Hourly		Hourly		Continuous		Automatic Weather Station		Total
	Count	% catchment total	Count	% catchment total	Count	% catchment total	Count	% catchment total	Count	% catchment total	Count	% catchment total	
Avoca	1	13%	1	13%	0	0%	5	63%	0	0%	1	13%	8
Campaspe	3	20%	0	0%	1	7%	9	60%	0	0%	2	13%	15
Goulburn	6	6%	5	5%	0	0%	19	20%	58	61%	7	7%	95
Loddon	2	9%	0	0%	6	26%	14	61%	0	0%	1	4%	23
Ovens	4	11%	0	0%	2	5%	10	26%	20	53%	2	5%	38
Wimmera	3	10%	0	0%	2	7%	0	0%	15	50%	10	33%	30

For example, the arrival of the flood peaks on the lower Avoca, Loddon and Murray days later than forecast and at much lower levels than expected could have been due in part to much of the runoff being absorbed by storage within these extensive floodplains.

Also it is possible that historical floods upon which gauge correlations were based had larger volumes that the 2011 floods even though they reached similar peak levels upstream. In other words they may have had longer, flatter hydrographs.

While it is only speculation that these were reasons for the discrepancies between forecast and actual peaks in these rivers, hydrodynamic models provide greater scope for using real time data for fine tune the model and account for these differences.

Another important advantage of a hydrodynamic model is that it can produce maps of flood extents which are important for real time flood impact forecasting. This was a serious deficiency in some of the Victorian flood warnings as explained in Section 3. It can do this at the same time as the flood level forecasts are made.

There are sophisticated hydrodynamic proprietary flood forecasting models which could be used in Victoria to integrate the existing gauging network data, hydrological modelling, historical height/flow correlations and reservoir outflows as well as the hydraulic models which have already been developed for some river reaches, to provide automatic flood forecasts in real time. "What if" scenarios can also be tested off line by considering the potential impacts of rainfall forecasts.

Companies such as DHI, Delft and Halcrow, amongst others, market such products and these are used extensively through Europe and some parts of the United States for flood forecasting. It is understood that the UK Environment Agency has such a system which covers the entire country.

In Australia hydrodynamic models have been developed by local firms on a smaller scale for flash flood catchments and for the Gold Coast.

There would be no real technological barriers to implementing such a system in Victoria but a benefit cost analysis may show that it is not worthwhile implementing it throughout the entire state or that the funds used to develop such a system are better spent on more extensive gauging.

While such a system extends across the UK, it is worth noting that the UK covers an area of 244,000 km^2 and has a population of 62 million. This compares to Victoria which has a population of 5.6 million spread over 227,000 km^2. In other words, less than one-tenth the population density. Victoria's population is much less evenly spread than that in the UK with 4 million people living within Melbourne Water's 13,000 km^2 service area compared to the 200,000 who live in the North East CMA area which covers 30,000km^2 and which experienced the most widespread flooding in 2011.

No matter how simple or sophisticated the flood forecasting method, if physical changes occur within the catchment between the gauge locations, local changes occur around the gauges or the stage-flow relationship at one or both gauges may change. For example, the vegetation growth in Bunyip Creek near the Iona gauge appears to have affected flood predictions for the February 2011 flood. It has also been suggested that cropping of a channel near Quambatook was enough to push floodwaters into the town unexpectedly.

One intelligence officer suggested that the long held demarcation of the BoM not providing quantitative flood forecasts in catchments with less than six hours warning, as these were flash flood catchments, is antiquated. It was suggested that the technology now exists to be able to provide warnings in these catchments and that systems are being installed in NSW, often with BoM involvement.

It was also asked whether there can be some sort of grading placed on flash flood warnings. "In January the BoM was accurate in telling us we were going to get intense rainfall but the community was not prepared for the type of flooding which eventuated."

2.4 COMMUNICATION BETWEEN STAKEHOLDERS

From the interviews and agency debriefs it was reported that there was generally good communication between the key stakeholders in regards to forecasting and particularly between BoM and the SCC and ICCs. The BoM scenario products were seen as very useful by the SCC in providing an update on current status across the state and where things might head although some said "it took us a while to get our heads around them.".

Not everyone saw it this way and one intelligence officer in the SCC stated that, "The biggest issue was BoM not operating 24/7. There was no overnight shift for eight hours and it is still happening now."

The BoM has advised that its flood desk was staffed 24/7 although overnight the duty officer sometimes worked from home.

More than one intelligence officer noted that you were not always able to get the information you needed from BoM when you wanted it because they were working on forecasts for another location. "They would give you what they had but too often you got nothing until the official forecast was posted on the web." They also reported that they could see data on the web which appeared that gauges were reporting incorrectly but it was not possible to get confirmation of that from the BoM. Some expressed concern that the public was seeing this erroneous information and everyone in the BoM, SCC and ICC knew it was wrong but the public were not being told.

It was suggested that the SCC should be able to direct BoM where to prioritise forecasts or better still to have BoM flood forecasters operating in the SCC as part of the team. There was a BoM weather forecaster in the SCC but not a flood forecaster.

Another intelligence officer from the SCC reported that during the flooding on Bunyip Creek it and the ICC were trying to contact the duty officer at Melbourne Water to get clarification of the apparent gauge issues and the rapidly rising readings but calls kept going to the message bank. They did not know that there was an incident control centre set up by Melbourne Water as the flooding had escalated beyond management by a duty officer. Melbourne Water's ICC did not take the initiative to contact the SES ICC of the SCC to provide explanations or status updates regarding the faulty gauge.

Melbourne Water ICC was unaware that a decision had been made to evacuate Koo Wee Rup until he heard the news on his car radio while driving home after the flood had peaked. He had intelligence that even with the overestimated flow forecast that Koo Wee Rup would not flood but that was not communicated to the SES ICC or SCC.

In the Mt Emu Creek catchment the CMA provided the BoM with the phone number of gauges upstream of Skipton following the September flood so that the BoM could provide some warning in January and February.

It was noted that in the agency debriefs and in some interviews that officers from CFA and DSE who joined ICC were unfamiliar with flood terminology.

One IC noted that there was no provision for disseminating flood forecasts from SCC and ICCs to those in the field who had to rely on the BoM website for updates.

More than one IC mentioned that there was no mechanism to pass field observations back to the BoM to incorporate in their flood forecasts and in community debriefs some community members stated that forecasts from friends further up the catchment provided a better indication of likely flooding that the official forecasts. Capturing such observations would supplement the information which forecasters have available and might help them verify or improve their forecasts.

Another intelligence officer said that he was able to pass information back to the BoM which helped the BoM with its forecasts. This however may reflect an already established personal relationship between that particular intelligence officer and BoM forecasters.

More than one interview said that it would be good to have forecasts for critical levels, not just peaks. E.g. when the levee will overtop and when the road will be cut. It was suggested that these levels need to be

communicated to BoM before flooding occurs so that BoM knows to forecast to that level. "They were more focussed on turning the handle every few hours and getting a prediction and focussing on the accuracy of peak level predictions rather than asking how useful the information is."

Another said, "The BoM don't see themselves as providing a service. Get what you get and be happy with it and be grateful. They are not customer focussed. Perhaps they could make more effort to understand what the needs of recipients are." But another stated, "They are doing the best they can with limited data and it is better than having no idea what's coming."

Some community members said that they did not understand flow rates which were given in some forecasts and that all forecasts should relate to levels.

It was also observed by some in the ICCs that because there continued to be a focus on the forecast of the flood peak and it arrived much later than expected in the lower Campaspe, Loddon, Avoca and Murray, people were caught unawares when their house flooded either because:

- They thought the flood had peaked because the expected time of the peak arrived but then the water kept rising and they weren't prepared; or
- They did not appreciate that their property was well below the peak flood level and therefore they would flood well in advance of the peak arriving.

Another observation made by several people was that there was data from malfunctioning gauges posting on the BoM Website but no communication that the data was erroneous. In the ICCs the intelligence officers were sometimes able to advise that the data was clearly in error but not always. There was nothing on the website to communicate to SES field personnel or the community that data was suspect. It was suggested that contributed to the Charlton community being caught unawares by the eventual height of the flooding.

The BoM has advised that its website does include warnings about the reliability of data, including with regard to rainfall bulletins, "*The data in this bulletin have not been subjected to full quality checking and may contain errors*" and with regard to river level bulletins and plots, "*The river height data is the latest available operational data provided for flood warning purposes and has not been quality controlled*."

The BoM also advised that when it became aware that all the Wimmera gauging station were affected by their cycle count problem, causing readings to jump by 2m, they were removed from the website.

2.5 LIAISON WITH DAM OWNERS

We spoke with the BoM and Goulburn Murray Water in this regard and both agencies said that the communication between them was excellent and done in accordance with MOUs. One intelligence officer noted that "Coliban Water were good", "Grampians Wimmera Mallee Water did what they could" and "Goulburn Murray Water were absolutely brilliant in sending information out, absolutely brilliant."

There was nothing in other interviews or agency debriefs to suggest these communications were otherwise for other agencies and other dam owners.

The one exception to this was in Goldfields LGA where council reportedly evacuated the town of Carisbrook because it was concerned one of its dams might fail but it did not inform the SES.

One suggested improvement from the SCC was that dam owners should know what the outflows of their dams would be were a failure to occur and also know what afflux is caused upstream when their structures are overtopped. As it was, the SCC had to bring in a dam safety expert from DSE to get this information from its library of dam break studies.

2.6 STRENGTHS AND WEAKNESSES

There are two core strengths of the data collection and forecasting components of the Victorian flood warning system:

- The dedicated team at the BoM which is committed to provide accurate and timely flood warnings 24 hours per day, seven days per week across a state which covers 227,000km^2.
- Those in local government, state government and water corporations who are as equally dedicated to provide the BoM with the support it needs to deliver its service

The weaknesses of the system are:

- The fragmented responsibility for the different components of the flood warning system
- The funding models for system upgrade and maintenance

Almost all of the problems discussed in the preceding sections can be traced back to these two fundamental weaknesses.

These weaknesses are not unique to Victoria and stem from Australia's three tiered system of government and the way in which flood warning responsibilities have been shared between them. They have been exacerbated in recent decades by the corporatisation of water supply utilities, making them essentially a player with a fourth agenda. One interviewee suggested that there are potentially 90 organisations involved in the installation and maintenance of the flood gauging network.

2.6.1 Responsibilities

A fundamental problem is that the BoM is responsible for flood forecasting but does not own any stream gauges and owns only some of the rain gauges. Responsibility for the maintenance and replacement of gauges varies depending on historical factors which are well documented elsewhere. The result is that BoM has to often "make do" with the gauging which is available. Some gauges are in less than an ideal location for flood forecasting purposes but there is no funding available to move them.

Rochester is a good example of this type of problem where the town gauge which is the most meaningful to residents is only manually read while the telemetered gauge which forecasts are made to is downstream of the township and very insensitive to large changes in flow once the flood is very large. Furthermore, the January flood exceeded the maximum reading on the town gauge for which no stage flow relationship has been established.

While MOUs have been established between the various organisations to ensure that all of the tasks required for the installation, operation and maintenance of a data collection network are allocated to someone, many of these are more than 10 years old and there is variability between them as to how responsibilities are shared.

If what has been provided by the BoM is the entire collection of MOUs for the catchments of interest in this study then it would appear that only the Ovens-King and Goulburn Broken catchments are covered in MOUs which include local government, CMAs and SES. There are also MOUs between BoM and Goulburn Murray Water and between BoM and Melbourne Water.

2.6.2 Funding

The installation of new gauges generally requires a co-operative funding arrangement between the BoM, a CMA, one or more councils and often a Water Corporation and is usually supported by State and Commonwealth grant money. Both this review and one which Molino Stewart completed in 2007 (Molino Stewart 2007a) revealed that there are parts of the state where improvements have not been made to the flood gauging network because local government has been unwilling or unable to contribute to the costs of maintaining the gauges as part of a co-operative agreement.

In 2007 some local government representatives said that they would not become involved on principle because they did not consider the maintenance of flood warning

systems to be a local government responsibility. In one instance two councils in a catchment said they were willing to contribute but the third was not and so nothing was done.

During this review a CMA officer noted that only once in the past five years has both the CMA and a particular council both had funds at the same time to contribute to a proposed flood warning network improvement. On that occasion they sought a Federal funding grant to provide the additional funds needed to do the work but were unsuccessful in their application.

This dependency on grant funding was highlighted as a weakness of the flood warning systems by many of interviewees. The grants pay for the installation of the networks but do not provide funds for the ongoing maintenance.

It was also noted that not all councils are taking advantage of the state-wide gauge maintenance contract and some are making their own arrangements which means that maintenance is not being done to a consistent standard across the state.

Many compared the quality, density and reliability of the Melbourne Water gauge network with that in the regions and noted that this arose because:

- Melbourne Water is committed to provide a flood warning service
- It owns and maintains the entire network within its area of operations
- It has a large and consistent revenue stream from which it can fund upgrades and maintenance
- Many of the gauges are needed for its water supply or waste water treatment operations and therefore would be installed in any case
- Its SCADA system which is used for communication with its gauges is used for operation of its entire water and waste water system so the incremental cost of using it for flood warning is very small

What no one pointed out is that Melbourne Water provides flood warning coverage for about 70% of Victoria's population in an area which is smaller than each of the other 9 CMA areas where the shared network arrangements exist. This makes benefit cost ratios better and therefore easier to justify the expenditure.

It was universally acknowledged that North Eastern CMA and Goulburn Broken CMA have the best of the regional networks because of the commitment of local government in those areas to food warning.

One interviewee asked the question, "What would happen to flood warning in Melbourne if Melbourne Water suddenly decided that it no longer wished to be involved because it was not core business and it was not under a legal obligation to provide it?"

2.6.3 Service Level Agreements

What is also lacking from the Victorian flood warning arrangements is some sort of service level agreement between the BoM and the other agencies. In NSW there is a State Flood Plan which lists for each river system a desirable and realistic advanced warning target which the BoM is meant to achieve.

Such targets need to be worked out in consultation between the key stakeholders and take into account the time needed for operational response and realistic time frames for the BoM to provide forecasts. This will be an iterative process and where the current system cannot provide forecasts within the necessary time frame then that provides an insight into where more investment may need to be made in data collection or forecasting.

It is noted that a draft state-wide agreement was in preparation in Victoria before September 2010.

2.6.4 Intelligence and Planning

It is difficult to develop a service level agreement for flood warning products if there is a poor understanding of what the impacts of different types of flooding are and what time is required to make appropriate responses. Flood intelligence is discussed in Section 3 and emergency response planning is outside of the scope of this investigation. As explained in the 2007 Molino Stewart report (Molino Stewart, 2007a), unless both of these are

improved it will be difficult to prioritise where improvements are needed in regards flood forecasting.

The other aspect of flood intelligence which has a bearing on flood forecasting is the line of demarcation drawn between BoM forecasts of flows and heights and the next step of taking that information and mapping it as a flood extent. As mentioned in Section 2.3.2, hydrodynamic modelling would be the logical next technological step to improve flood forecasts. The BoM representatives who were the interviewed for this project said that they had "Not considered using hydrodynamic models. We expect CMAs to use the height forecasts to put into hydrodynamic models. This is not a BOM responsibility. Starting to explore to whether hydrodynamic modelling would help. Also there is a lot of work setting them up. You need all the topographic information and it takes more time to run in real time. It depends on the size of area which you are modelling. They are costly to set up and would need to consider the cost benefit of it. The question might be better putting into better data collection systems rather than modelling."

2.6.5 Leadership

While ever the development, maintenance and operation of the data collection and forecasting components of the total flood warning system are shared between multiple agencies, flood forecasting will be less than ideal.

When separate agencies are responsible for flood intelligence gathering, emergency planning and emergency response it makes it difficult for flood forecasters to know what level of service they need to provide.

If data networks and forecasting systems continue to be funded by grants on an opportunistic basis then expenditure will not necessarily go to where it will deliver the greatest benefit.

A strategic plan is needed for the state's total flood warning system and the 2005 Flood Warning Service Development Plan appeared to provide that. Chapter 6 provides a review of progress against that plan and it shows that minimal progress has been made.

All of the above perhaps highlights another weakness in the system in that many people are involved but no single organisation is ultimately responsible for providing leadership.

Whichever organisation takes leadership, it needs to be supported by appropriate institutional arrangements and resources.

3 FINDINGS – INTERPRETATION

3.1 CURRENT REQUIREMENTS AND RESPONSIBILITIES

3.1.1 Flood Response Plan

Appendix 1 of V1-4 of the State Flood Response Plan for Victoria, which was applicable during the floods, summarises the activities which agencies undertake in support of flood response.

The only reference in the appendix which may be relevant to the collection and interpretation of flood intelligence is that:

DSE:

- Contribute to the collection of real event flood data for major floods of State significance

CMAs and Melbourne Water:

- Monitor significant flood events and collect flood data in conjunction with local government
- Advise the Minister for Water on flood events and damages

CFA and MFB

- Support for real time intelligence gathering

The main body of the Plan states:

"The State Emergency Response Coordinator will be responsible for… information collection, analysis of, and dissemination of intelligence to emergency response agencies"

Elsewhere it states, "VICSES will ensure that consistent information is provided to the Co-ordinator in Chief of Emergency Management and to the OESC…"

3.1.2 MOUs

There would appear to be MOUs for only some of the catchments throughout Victoria. Allocation of responsibilities varies between the different MOUs throughout the state. Those relevant to this study are:

a) Broken

This dates from 1997 and is principally focussed on the data collection network. However, it does give Council the following responsibility:

"In conjunction with the flood warnings issued by the Bureau, prepare and provide flood information to meet local flood response requirements."

b) Ovens King

This MOU from 1999 is also focussed on the data collection network but does give local government the role of "monitoring flood event and collecting data such as flood extent, flood levels and flood damages."

c) Shepparton Mooroopna

This is titled a Flood Warning Service Charter and was created in 2006. It has an entire section on interpreting flood predictions with data to assist in the task and clearly stated responsibility lying with Greater Shepparton City Council with support from Goulburn Broken CMA.

d) Goulburn – Eildon to Seymour

Dating from 2000 this is also focussed on the data collection network with local government's role being to monitor and collect data from floods as per the Ovens-King MOU.

e) Euroa

This also dates from 2000 but makes no mention of data collection or interpretation.

3.1.3 Implementation

Interviews with those who were in the ICCs and SCC suggest that roles and responsibilities with regard to flood intelligence and interpretation are not well understood.

It seemed to be generally understood that the CMAs had the most information which could be used in interpretation but there does not

seem to be a formal role for them in flood warning.

During the flood the CMAs were reportedly focussed on gathering data as required by the State Flood Response Plan. Some observed however that the CMAs tended to focus on maximum flood extents which is not the full suite of data which is needed for interpretation of flood forecasts.

It appears that the SES took the initiative to embed hydrologists as intelligence officers within the SCC and ICCs to provide flood intelligence. These intelligence officers were either CMA officers or consultants who had undertaken studies in one or more of the catchments. There is no formal arrangement in place for this to occur but everyone applauded this initiative and said that as time went on it worked much better. It was suggested that there is a "need to tighten up the formality of that arrangement to ensure it works and is always available."

3.2 ADEQUACY OF AVAILABLE FLOOD INTELLIGENCE

As with data collection and forecasting, the availability of flood intelligence varies widely across the state. Again, the north east of the state reportedly had the best flood intelligence because of the detailed flood studies which have been undertaken in these areas. There was also reportedly some good intelligence for the Wimmera. In other catchments there was little flood intelligence and in others there were none.

Even where flood studies had been completed, the type of flood intelligence in these varied.

Shepparton was cited as an example of a town where there are details of flood extents for a range of floods as well as information about which houses would flood in various events.

Wangaratta was also considered to have good flood intelligence but when the levee came under threat no one was able to advise what the consequences would be should it fail.

While Horsham also reportedly had good intelligence available, some in the ICC reported that not all of it was inaccurate. For example a main road was expected to be cut by a 1 in 60 flood event but it experienced a 1 in 200 event and it was still trafficable.

A common complaint was that even in these catchments where there was good flood intelligence it was generally confined to the main population centres. Outside of these the intelligence is poor and often there are long stretches of river between gauges where there is little or no information about how floods would behave.

Other catchments such as the Campaspe, Avoca and Loddon have little or no flood intelligence other than the local knowledge of CMA officers who have been in the area for decades.

Everyone agreed that there was absolutely no flood intelligence for Mt Emu Creek. Even when the CMA was able to get the BoM the phone numbers of gauges to poll, the BoM had no historical data to make accurate forecasts and no one had any idea what those levels would mean in terms of flooding the town.

It was reported that Melbourne Water rang a retired administrator of Koo Wee Rup hospital to determine whether the 1971 flood entered the town. It had a similar level on the Iona gauge as the 2011 event and when that individual reported that the town did not flood in 1971, Melbourne Water was confident it would not flood in 2011. At the same time the intelligence officer in the SCC used a recently completed draft flood study for Koo Wee Rup which suggested that the flows corresponding to the peak gauge level at Iona would flood the town. It was the latter which led to its evacuation.

Several other problems were cited with regard to flood intelligence including:

CMAs gather the wrong type of intelligence – the CMAs are mainly focussed on producing flood maps which can be used for town planning purposes or they map maximum extents of historical floods. While this information is useful it is not sufficient for flood warning and response. Intelligence is required around rates of rise, break out points, levels at which critical infrastructure is damaged, when evacuation routes and other roads are cut, when critical infrastructure is impacted, the

increments in the number of buildings which are flooded for rising flood levels and what happens if levees fail. Most of this information is not available except in some of the most recent flood studies. It was reported that when Charlton was told to evacuate its evacuation route had already been cut. Good flood intelligence would have informed the ICC of this before it happened.

Static Flood Maps for specific events are not sufficient – having a series of maps which shows the extent of the 1 in 20, 50 and 100 AEP events is not very helpful if the forecast event is in between those flood levels or worse still exceeds those levels. All reported that if they were faced with a 1 in 70 event for example, they would have no choice but to work with the extent of the 1 in 100 event which often meant the impacts were overstated and people were evacuated unnecessarily.

More than one person wanted access to hydraulic or hydrodynamic models which allowed mapping of flood extents for a continuum of levels. It was noted that any modelling will always be better for towns than rural properties because the towns have the greatest risk to life and economic damage and so the expenditure on more detailed models can be more easily justified.

Flood levels without topographic and property data is of limited use – It was reported that in some of the North Central catchments the only topographic data is available on paper maps with 20m contour intervals. Given that the slopes in some of these lower catchments is reportedly around 1 in 10,000, such contour information provides little indication of flood depths and hence hazard. Furthermore, without any idea of floor levels of buildings it is difficult to advise occupants whether they are likely to be flooded or to know whether evacuation is necessary. There are some locations where this information is available but for most it is not.

Likelihood of a range of impacts is needed – it was noted by all incident controllers that they erred on the side of caution when told of the range of flood levels and timings and possible impacts and worked on the basis of the worst case scenario. Some felt that if they were given information about most likely scenarios as well as worst case they might have made different decisions. Most ICs said they would still work on the basis of the worst case.

There are no arrangements for gathering information from the field and feeding that back into interpretation – Intelligence officers said that with the exception of the tail ends of the very long floods in the north of the state, they were getting very few field observations which would have confirmed or corrected their interpretations. Such feedback would have helped them with their work and would have aided the ICs in decision making.

CFA personnel noted that far less use was made of field intelligence in the ICCs in the floods compared to the reliance on field intelligence during bushfires. For example the CFA brigade in Carisbrook reportedly advised the local SES unit that the town had flooded but this was not passed up the chain of command to the ICC. Similarly no one in the ICC knew that Charlton was flooding and was without power or that the evacuation route had been cut before the evacuation order was issued.

When advice is issued from the SES which demonstrates a lack of awareness of the local circumstances, the credibility of the organisation is undermined.

It was suggested that flood wardens be instigated to collect and relay flood intelligence from the field and another suggestion that unmanned drones be flown to gather flood intelligence.

Changes to the landscape present challenges for forecasting and interpretation – there were several instances where people breached or built levees without authorisation before or during the floods and this changes flood behaviour. These changes are not usually able to be accommodated by the available flood modelling during an event.

Determining where floodwater will go is extremely difficult in some locations - It was also observed that in the lower reaches of the Wimmera, Avoca, Loddon and Campaspe the floodplains are so flat and braided that slight changes in the landscape can make a significant difference to where the water flows. Simply laser levelling of properties can change

the direction in which water flows by either changing the slope of the land or throwing up a windrow which is enough to divert the water.

It was said on more than one occasion that it would appear that there is lack of clarity as to what sort of flood intelligence is required for adding value to flood warnings and informing flood response. It was also acknowledged that the SES needs to advise what sort of intelligence they need and often they did not seem to be entirely sure themselves.

3.3 SPEED OF INTERPRETATION

The speed of interpretation was hampered by:

- Intelligence officers not fully comprehending their role
- Not having access to real time flood data
- Not knowing if published gauge data was correct
- Flood mapping and topographic data not being available
- Where data was available it was not always in a useful format
- There was a lack of hydraulic models which could be run to interpret flood forecasts
- Resources were not always available to create the required outputs

The following elaborates on these points

Generally, it was noted that the slower moving floods were easier to stay ahead of but in upper catchments the systems and data needed more time for interpretation than was available. This meant that rather than no intelligence being issued, inaccurate but conservative information was provided.

According to interviewees, the speed at which intelligence units operated and turned information around improved as the flooding continued and they worked much more efficiently in February than in September. It should be noted that the September 2010 floods was the first time that VICSES has used intelligence officers in an operational role.

Not understanding role

Most of the intelligence officers said that they did not understand their role when they were first part of an ICC although they understood it better as time went on. Similarly ICs by their own admission did not all understand the role of the intelligence units at first and some did not initially listen adequately to the intelligence which was being passed on.

It was suggested that the flood intelligence role and reporting lines need to be better defined.

One suggested that intelligence officers do an AIIMS course.

Not having access to gauge data

The intelligence units did not have real time access to gauges but only the same access which the general public had via the BoM website. One office said, “This was updated every three hours at best and there were times when it was not updated overnight because BoM officers had gone home. This was a problem in September to January but by February you could ring up some of the gauges because we got the numbers from a third party, not the BoM.”

The BoM advised that the website is updated hourly but not all gauges update that frequently so the frequency of updates on the website reflect the frequency with which the older gauges transmit data. The BoM also expressed concern about people getting numbers to dial into gauges as it could compromise data collection systems. The BoM suggested that there needs to be better communication between the BoM and emergency management agencies related to technical limitations and data availability.

Not knowing if published data was correct

In November the gauges at Avon South stopped working but there was no indication to the intelligence unit that this was the case.

When the Iona gauge malfunctioned the ICC and SCC were unable to make contact with Melbourne Water to confirm it was in error and could only assume it had been fixed when it was corrected by 2 metres.

At Horsham it was only the familiarity of the intelligence officers with the system there which allowed them to ignore the actual web-

posted gauge readings and work with the BoM forecast levels.

No flood maps or topographic data

There was no flood mapping available for most localities or, if there was, it was only for a few selected events so considerable time was spent creating maps or interpolating between available ones. In some locations these inundation maps were labelled according to the probability of the flood but were not tied back to a particular gauges height.

It was suggested that there is the need to have a series of "pre-cooked" inundation maps for different levels of flooding. This is available in Shepparton for different combinations of flooding on the three water courses which run into town.

Even when some form of mapping was available there was no topographic data to allow estimations of flood depths and no building level data to determine the impacts of inundation. Considerable time was spent trying to estimate which people needed to be told to evacuate.

Data was not in useful format

Much of the data was buried in reports, some of which were only available in hard copy as were many of the maps. Several intelligence officers cited instances of having to go back to their office to pick up a report or map which would provide useful intelligence because no such documents were available at the ICC or SCC for the area of interest.

Lack of Hydraulic models

The lack of a dynamic hydraulic model for most catchments was seen as a serious impediment to accurate and timely interpretation by most of the intelligence officers interviewed. They expressed frustration at having to make do with antiquated maps and manual techniques which were slow and inaccurate.

Resources not always available

Intelligence officers complained that they had to do their jobs with inadequate resources which slowed things down. The Bendigo ICC in January had no GIS person available and virtually not access to IT systems when the intelligence unit was first established which hampered their work considerably. The GIS person arrived the following day and it was stated that, "It is critical that there is a GIS person there from the start to get the maps going. This created a backlog of work which took a long time to get on top of."

The intermittent availability of GIS resources was an issue. When it was agreed at the ICC that the Rochester flood was likely to be higher than forecast by the BoM based advice from locals and analysis by the intelligence unit, updated flood maps needed to be produced to determine if evacuation was necessary. As there was no GIS person available at the ICC at that time, the SCC provided support to produce the required mapping but it took from 8pm to 5am the next morning for them to be ready. These were used to send an Emergency Alert to affected residents but by then a lot of available warning time had been lost in the production of the maps.

Some said that the intelligence officers were not always deployed to the ICC with the greatest need.

3.4 ROLE AND EFFECTIVENESS OF INTELLIGENCE UNITS

One IC said in relation to the use of intelligence units, "(it is) Absolutely essential to have that sort of intelligence. In any emergency management context you cannot make effective decisions re tactics, strategies or warnings without good intelligence. The better the intelligence the better all of those things can be done."

Another said, "They were good. A new concept and tended to put only one or two people in there. Without the hydrologists and CMA working in them we would have been flying blind. They are essential in operations."

Some suggested that they were not always deployed to the location of greatest need and that there are too few people supporting too many ICCs.

While the intelligence was being used in the ICCs and SCC some intelligence officers did not feel that the information was being delivered to the field units and the community

enough. "Flood maps were being produced but, with the exception of Echuca in January, the SES refused to put them on its website." The questions were posed, "Which website should they be posted on and what liability is there if they are wrong?"

"They can be taken to community meetings but they are only right at that point in time and we could not get an update to them." This happened at Rochester where the community was given a flood map corresponding to the BoM forecast peak on the Friday which was exceeded by 0.5m on the Saturday.

One Intelligence officers stated that "A lot relies on the good relationships between CMA, SES, other CMAs and consultants. If did not have those relationships it would not be effective."

More than one IC said that having hydrologists available to ask questions of and to produce maps was invaluable.

3.5 ADEQUACY OF SYSTEMS

CMA officers reported that they thought the data collection systems for flood extents were good with pegging and aerial photography providing good data on flood extents. Others felt that this focus on peak flood extents was too narrow and there is not system in place to collect and store other useful flood intelligence as the river is rising.

It was noted that in Swan Hill there are comprehensive flood intelligence cards with details of flood behaviour at various levels which proved very useful in planning flood response. This is the exception in Victoria and those who had experience in NSW felt that the collection and storage of flood intelligence by the NSW SES is much better but not without its own shortcomings.

The review of the BoM directives for each catchment as part of this study revealed that some of these have some flood intelligence embedded in them but not one IC or intelligence officer made reference to these being a source of flood intelligence.

More than one person noted that a lot of the useful information about historical floods and the location of roads and levees and their impact on flood behaviour is stored in the heads of a small number of people. This needs to be captured before these people are no longer available.

Other than this, most of the flood intelligence was being provided from predictive mapping based on design flood events which did not necessarily correspond to the actual event being experienced.

Several intelligence officers and some ICs said that hydrodynamic models which could use actual rainfall and stream gauging data to produce real time inundation extents is what is needed. Some conceded that the lower parts of the Wimmera, Avoca, Loddon and Campaspe may be hard to model even with these tools because they are so flat, have so many distributaries and are so sensitive to minor changes made to the landscape.

There was a general consensus that there is a need for a centralised electronic repository of flood intelligence data which is accessible to the SCC and ICC. While it was acknowledged that the Victorian Flood Database (VFD) is a good starting point, it noted that the data is not in a format which is quickly accessible and readily usable as flood intelligence during operations. On the other hand, the fact that a lot of the older flood studies had been scanned and entered into the VFD 18 months previously put the intelligence officers in a better position than they would have been.

It was noted that in Wimmera CMA data had been extracted from flood studies into reference tables of impacts which was a very useful format for quickly accessing intelligence. It was suggested that this needs to be systematically done for all existing and future flood studies and that information for the whole state be provided to each intelligence officer to carry with them.

It was pointed out that not all ICCs have internet access and that intelligence officers needs a kit which not only includes the latest version of above mentioned flood intelligence but they also need their own computer, a contact list (including other intelligence officers), a mobile phone and a broad-coverage wireless internet card. This needs to be spelled out in a position description.

Others suggested having intelligence available on a centralised GIS would be more helpful than the current arrangement of using PDFs of maps.

Others noted that there needs to be clear systems with ICCs for the flow and posting of flood intelligence so that everyone knows where to look within the ICC for the latest information. Some stated that providing updates to SCC and politicians took them away from updating intelligence.

The use of existing facilities for an all hazards approach to emergencies was seen as a good thing but this brought with it some systems problems.

It was observed that there were differences between SES, CFA and DSE computer systems which created issues for flood intelligence officers tyring to log into the ICC IT system depending on which organisation's facility it was running out of. A common operating platform between agencies would have saved a lot of time.

It was also considered necessary for those from other agencies to be given some training in the intelligence products for flooding otherwise it is not realistic to expect someone from another agency to slot into an ICC and become fully functional.

4 FINDINGS – MESSAGE CONSTRUCTION AND COMMUNICATION

4.1 CONTEXT

According to the draft 'Community Flood Warning Arrangements' (a sub-plan of the State Flood Emergency Plan), "flood warnings containing flood predictions are distributed directly to the media by the BoM and are published on the BoM website. BoM Flood Warnings do not provide detailed descriptions of potential flood consequences and provide only generic public safety advice statements. It is the role of VICSES to add value to BoM Flood Warnings through VICSES Flood Bulletins by providing a description of possible flood consequences and specific localised public safety advice actions." It is these subsequent warnings that are discussed in this section in relation to the 2010-11 floods.

During the 2010-11 floods, VICSES used three types of flood warnings based on the State Flood Emergency Plan:

1. **Flood Bulletins**. VICSES distributes flood emergency information to the media and on its website through 'Flood Bulletins'. Flood Bulletins provide BoM Flood Warning information as well as information regarding possible flood consequences and safety advice, not contained in BoM Flood Warning products. VICSES uses the title Flood Bulletin to ensure emphasis is placed upon BoM Flood Warning product titles.

   The relevant VICSES Region Headquarters or the established ICC will normally be responsible for drafting, authorising and issuing issue Flood Bulletins.

   Flood Bulletins should be focused on specific gauge (or in the absence of gauges, catchment) reference areas, that is the area in which flood consequences specifically relate to the relevant flood gauge.

   Flood Bulletins should be prepared and issued after receipt of each Flood Watch and Flood Warning from the BoM. Flood Bulletins are prepared by Regional Duty Officers or Information Units when established. Flood Bulletins will be approved by Regional Managers or Incident Controllers prior to their communication.

2. **Evacuation Messages.** The role of VICSES as the Control Agency for flooding is to recommend evacuation and provide evacuation warnings; and to support VICPOL in undertaking the evacuation. When evacuating communities VICSES provides messages to residents advising them of the need to evacuate and what to do when evacuating. The title of evacuation messages is 'Evacuation Warning'.

   Evacuation warnings are prepared in consultation with VICPOL, DHS and Local Government. Evacuation warnings are to be referenced within Flood Bulletins. In many cases, it may be necessary to issue a Flood Bulletin as well as an evacuation warning to provide advice on the wider consequences of flooding and public safety advice messages.

3. **Emergency Alert.** The Emergency Alert may be used to communicate warnings to the public. The Emergency Alert has the capacity to deliver warnings either by SMS or by a voice message. Template messages are available within the Emergency Alert interface.

Warnings should be communicated in a variety of ways depending on the location. According to the draft 'Community Flood Warning Arrangements', "methods of warning should be selected to ensure they are appropriate for the flood problem and to capture the broadest possible demographic spectrum of the community at-risk".

Warning communication methods available include:

- Emergency Alert (mobile and landline phones)

- Local Council Telephone based warning systems
- Radio
- Television
- Two-way radio
- Mobile and fixed public address systems / sirens
- Doorknocking
- Internet
- VICSES Flood Storm Information Line
- Variable Message Signs
- Community meetings
- Newspapers
- Email
- Telephone trees
- Community Flood Wardens
- Fax Stream
- Newsletters
- Letter drops
- Social Media
- Community Radio

Arrangements for the dissemination of messages through the media are contained within the following Memorandum of Understanding:

- Memorandum of Understanding – ABC Victoria and Victoria Emergency Service Organisations
- Memorandum of Understanding – Victorian Government and Sky News
- Memorandum of Understanding – Broadcasting of Emergency Information by Commercial Broadcasters in Victoria
- Memorandum of Understanding – Community Broadcasters miscellaneous

4.2 ADEQUACY AND TIMELINESS

4.2.1 Benchmarks and Best Practice

There are several guiding documents that outline features of best practice emergency warning messages. The Australian Government's 'Emergency Warnings: Choosing your Words' document (Attorney-General's Department, 2008) states that there are two outcomes of emergency warnings:

1. To 'inform the community of an impending or current threat'
2. To 'promote appropriate responsive actions'.

The 'Choosing your Words' document lists the following attributes of adequate messages:

- Don't make assumptions – people live in different areas, have different levels of understanding of risk
- It is a dialogue, not a command
- Responding to warnings is a process, not a single step
- Recipients of the message will have a need to confirm the message before they are likely to take action
- Consistency is critical – within each message, between each message, between information from different sources
- Accuracy is important
- Be as specific as possible
- Don't leave gaps
- Relate to previous floods as 'benchmarks' if appropriate
- Understand that recipients may be receiving the messages under conditions of stress
- Consider messages for people who do not speak English as a first language.

The 'Choosing your Words' document also lists the following attributes of an adequate emergency warning message:

- The name/title of warning
- Who is issuing the warning
- The type of threat (and preferably a description)
- How likely it is to happen
- How bad it is expected to be
- Where the threat applies/who is affected
- When it is expected to happen

- What to do
- A point of contact for more information or to report events.

The draft 'Community Flood Warning Arrangements' echoes the guidelines in 'Choosing your Words' for adequate message construction. It provides the following advice for messaging:

- Attempt to be personally relevant
- Be kept brief
- Be ordered (logical sequence)
- Use clear language and avoid jargon – use non-technical, user friendly language
- Use positive language where possible – where appropriate say what to do rather than what not to do
- Suggest action rather than inaction
- Invite sociability/networking rather than isolation, for example 'advise your neighbours'
- Be vivid. The message should arouse emotional interest and be easy for those at-risk to relate to their own situations. For example – 'to stay in your house is likely to become difficult, uncomfortable and dangerous because the telephone, power and water supply could fail and snakes, spiders and insects may gain entry'.
- Connect flood consequences with suggested actions. For example 'Farmland near the river will be inundated and farmers should consider relocating pumps, other equipment and livestock'.
- Create word pictures
- Do not leave gaps, if some information is not available, this should be stated
- Be clear that VICSES is issuing the message (In some cases this will be in partnership with the BoM).

Under Standard Operating Procedure (SOP) 009 titled 'Notification Process for Flood Warnings' there are the following protocols for the timeliness of Flood Bulletins issued by VICSES:

- Within 10 minutes of receiving advice from the BoM or a dam owner, the Regional Duty Officer (RDO) shall acknowledge advice by calling the BoM or dam owner
- Within 60 minutes after this, the RDO or the Information Unit (IU) will prepare a Flood Bulletin for all Flood Watches, Flood Warnings and Severe Weather Warnings outlining a high risk of flash flooding or known dam release.
- Within 30 minutes of being notified by the RDO or IU, the State Media Duty Officer will publish the Bulletin to the VICSES Public Website.

The Victorian Warning Protocol provides the following advice regarding the use of Emergency Alert: "The requirement to utilise the telephony based warning system will be dependent on the emergency and the intrusive alerting/warning requirements. Consideration should be given to the implications of utilising this system as part of the broader community warning and dissemination mediums. Agencies should not solely rely on telephony based dissemination methods for community warnings. Agencies should not overuse the telephony system as this could lead to the community developing a level of complacency towards receiving a telephone warning". The Protocol recommends that Emergency Alert be 'most likely' be used to issue Emergency Warnings.

VICSES has specific guidelines for the use and timing of Emergency Alert in its SOP 057. SOP 057 states that "the use of Emergency Alert should be considered by VICSES to precede an emergency warning message(s) to the Victorian community where the impact of the emergency poses an imminent threat to life or a message needs to be disseminated urgently such as following an earthquake".

According to SOP 057, Emergency Alert messages should be sent after Flood Bulletins. "It is critical that prior to providing warning messages to the community VICSES should ensure that updated information is available through the Flood Storm Information Line, VICSES Website and any other relevant websites (including local government).

"Prior to using the Emergency Alert, VICSES should ensure that media outlets have the appropriate warning messages available, to ensure further information is available to the public through radio and TV broadcast channels.

"Prior to issuing Evacuation Warnings VICSES should ensure that appropriate evacuation management arrangements have been made in consultation with Victoria Police and that facilities such as Relief Centres are open and traffic control measures are in place".

In terms of authorising the use of Emergency Alert, SOP 057 states that "the decision to use Emergency Alert rests with the Incident Controller or Regional Duty Officer (RDO) or State Duty Officer (SDO). The State or Area of Operations Controller may direct the Incident Controller to use Emergency Alert for emergency warning messages".

4.2.2 Perception of Message Senders

Molino Stewart interviewed several stakeholders including Information Officers at ICCs and SCCs that were involved in the construction and communication of messages.

Most believed that there was an improvement in the adequacy and timeliness of community warnings between the September 2010 floods and those in January/February 2011. For example, there appeared to be issues in September 2010 relating to different software being used across the State that were largely resolved in January/ February 2011. Practices of better preparing the ICC for the flood and the use of staffing from DSE and CFA were seen as factors that helped the adequacy and timeliness of messages.

The quality of intelligence data provided was also viewed as a factor that particularly influenced the accuracy of the warning messages. One interviewee cited the example of an ICC using a 1968 flood map in the Shepparton district to make decisions and warn communities.

Some interviewees believed the need for "several authorisations" (ICC and SCC) for the issuing of warning messages to be "very frustrating" and affected the timeliness of warning communication. There also appeared to be some concerns about the 'clunkiness' of the system (especially in the September 2010 floods) to produce Flood Bulletins (e.g. the use of Word documents) which also influenced the timing of warnings.

Also the need to update the information line and the website before issuing an Emergency Alert was seen to add an hour or more to message dissemination: "by the time it went out it was no longer accurate or current, particularly in quickly rising events."

It was reported that because there was not enough time to put information on the web when the Wangaratta levee was at risk, Emergency Alert was used to send out an invitation to a community meeting to explain the situation.

One incident controller expressed frustration that the media wanted to focus on final peaks and timings and so the important messages about the times when flooding would start to impact and people would need to respond were getting lost.

It was also noted that the description of the flooding was not always consistent with expected levels, ARIs, flood classification (e.g. major) and historical comparisons being used at different times.

One intelligence officer observed, "there were more flood warnings, radio and test alerts, than ever before but still lots of people were complaining that her were never warned. It is not possible to give people warning tailored to their specific address."

From the records of emergency agency de-briefs, the following comments were made in relation to the adequacy and timeliness of warnings issued:

- Emergency Alert – some technology issues encountered (Ballarat)
- Introduction of Emergency Alert accepted well (Bendigo)
- The SES website needs enhancing as to be comparable to the CFA site. (Bendigo)
- An SES capability to use OSOM at the local level, like the fire agencies, would be useful. (Bendigo)
- SES should also develop a statewide pre-prepared emergency message issuing system rather than have to contend with this when emergencies arise. Available templates are not sufficient. (Bendigo)
- Good use of community briefings over the radio. (Horsham)

- Emergency Alert – need to strike the right balance for usage of this in flood environments as to not have it lose impact. Is a great tool. (Horsham)
- Warning systems - the system for Code Red day fire warnings should be considered for the flood environment. (Stawell)
- Community concern about the floods necessitated the early convening of a community meeting and this afforded opportunity to convey to all present all that was at that time known about the flood risks, and to also advise that this was early information which may be subject to change. It was sensed that we had a duty to keep the community informed with what was known at the present time, although it was believed that further information would become available which would necessitate further engagement. (Swan Hill)
- Some newsletters drafted for release to the public contained incorrect and confusing content. Need good QA processes to underpin the preparation of such releases as to ensure accuracy and appropriateness of content (Swan Hill)
- Emergency Alert – a great tool but are we advising, recommending or telling? - are there language issues here? Feel that further templates are required to support a broader range of messaging. Furthermore with the process for issue of EA being two tiered, changes were able to be made to the polygon decided upon at local level so that intended targets were altered. Should be remembered that EA is intended as a system of last resort messaging and should be used alongside radio / TV / newspapers and other forms of media (Swan Hill)
- Early warnings to community served to decrease stock losses and increase community preparedness. Sensed that there was greater community satisfaction with the provision of information. (Wangaratta)
- Need better links and processes for warning those at greatest risk. Interim arrangements do not go far enough and much more needs to be done, particularly when a short notice late stage evacuation may prove necessary. Have many in the Koori community living along the river in the Swan Hill area and have doubts about our ability to provide information and messaging to them. (Wangaratta)

There were also pertinent comments from debriefs with local councils:

- SES sent the message to landlines of people in supported accommodation (who all got the message at 10pm at night and had no need to evacuate). Nursing home then calling the MECC – caused undue stress for older community members.(Benalla)
- Council hadn't been informed officially of Emergency Alert warnings but anecdotally, used in Rochester to inform of public meeting (but SES started too late and weren't able to contact everyone in time). Also used in Rochester to advise people of evacuation points – only advised re west side of town, not east (and town cut in half), plus spelt street names wrong (these inaccuracies didn't give people confidence in messages). Some warnings said to be 'watered down' or amended as they made it up the chain (Div Comm → ICC → snr controller) and they weren't as useful. (Campaspe)
- Mass confusion caused by alerts – Council not informed and couldn't respond to queries from doctors re evacuating hospitals. (Campaspe)
- Couldn't get any flood warnings or information from Bendigo ICC on the Thursday night (key flooding occurred early Friday morning). ICC was still being set up. Best intelligence came from VicPol who had learnt from his briefing. (Central Goldfields)
- Warnings – lack of specificity, too Horsham centric (because flood studies and gauges related to Horsham, not the surrounding regions) (Horsham)
- Issues around timeliness of warnings and lack of understanding of the size of what was coming (both in volumes of water and how to describe what happened – was described many times as a 'major flood warning on the Loddon'. This didn't mean anything – that description kicks in at 70 and this flood was 190). Water went places it hadn't gone before. (Loddon)
- Emergency Alert proved helpful but hesitant to rely on it because unable to put out messages district by district. Loddon a diverse municipality made up of various communities. Couldn't put an

alert to only part of Pyramid Hill, causing angst. Would be useful to be able to put out warnings district by district (i.e. Serpentine, Bridgewater etc) (Loddon)

4.2.3 Perception of Message Recipients

Some social research data provides an idea of community perceptions of the timeliness of warnings received during the 2010-11 floods. From social research (Strahan Research, 2011a) involving surveys of impacted communities 'almost four-in-ten (39%) of all respondents had received an early warning of the potential of flooding in their area. In country areas, almost one-half (48%) of respondents had received an early warning while in metropolitan areas (including Bunyip River catchment) just over three-in-ten (31.8%) had received a warning'.

Almost one-quarter of these respondents (24.2%) said that the flood arrived within one to five hours after receiving the warning. A further one-in-five (21.5%) had the flood arrive six to 12 hours after receiving a warning. Over one-half of respondents had in excess of 12 hours warning of potential flooding with a quarter (27.0%) having between 13 and 24 hours, 15.2% having 24 to 48 hours, and almost one-in-eight (12.1%) having more than 48 hours warning.

Respondents in metropolitan Melbourne reported a much shorter time between receiving a warning and the floods arriving than those in country Victoria. Over three quarters (77.7%) of those in metropolitan areas had 12 hours or less warning while almost seven-in-ten (69.5%) of country respondents had more than 13 hours warning.

A sample of flood-affected businesses was also surveyed (Strahan Research, 2011b). Over four-in-ten (45.1%) respondents had received an early warning of the potential of flooding in the area where their business is located.

Almost one-in-six of these respondents (15.8%) said that the flood arrived within one to five hours of receiving the warning. Over one in five (22.5%) had the flood arrive six to 12 hours after receiving a warning. More than six-in-ten respondents (61.8%) had in excess of 12 hours warning of potential flooding, with a quarter (25.4%) having between 13 and 24 hours, one-in-five (20.1%) having 24 to 48 hours and almost one-in-six (16.3%) having more than 48 hours warning.

From reports on community meetings held after the 2011 floods, information was gathered on 'what worked well' and on 'what didn't work well'. Pertinent comments relating to adequacy and timeliness of warnings are listed below:

1. <u>What worked well.</u>

- Emergency Alert messages (although some people didn't get it) (Beaufort)
- Emergency Alert (Charlton)
- Good warnings (on the ABC and from the BOM) – plenty of time to move livestock. (Dederang)
- Local radio station (3WM) devoted themselves to flood warnings (although were focused on Horsham and towns) – broadcast the community meetings. ABC did run some warnings but not until later (for the first day, was focused on Rochester). (Horsham)
- ABC flood watch and warnings – accurate, in conjunction with BOM and watching the river.(Moyhu)
- Warnings from CFA communications officer (Myrtleford)
- Emergency Alert (Myrtleford)
- September warning through telephone worked well (compared with January)(Skipton)
- Local knowledge and communication system was valuable (flood warnings – via UHF radio, because telephones were out) (Stawell)
- Different communication methods for the warnings – SMS, phone, community meetings (where old and new residents could share info) (Stawell)

2. <u>What didn't work well</u>

- Warnings that the ABC put out caused people to make inappropriate decisions. Based on VicRoads advice, which was incorrect (that no road problems in SW Victoria) (Beaufort)

- Warnings for September flood didn't communicate the severity of the flood. (Benalla)
- Warning system alerted everyone in the nursing home that they were about to be flooded – caused incredible trauma. CEO of nursing home then tried to contact the phone number and spoke to a lady in Ballarat who simply told her that she had to evacuate the home. Eventually got through to the local SES and drove again and ascertained didn't need to evacuate. (Benalla)
- Information coming from the SES wasn't helpful – didn't specify height or which houses would be affected. This information is known – the SES hydrologists could tell which houses were going to be flooded, the SES should only call those houses which need to be evacuated. (Benalla)
- Warnings said this flood would be the same as 1993 but it wasn't (Benalla)
- Warning system – used to get phone calls before Goulburn Murray Water took over, this time got nothing (Bridgewater)
- BoM warnings were 12 hours out of date and/or didn't work (Bridgewater)
- People get warnings on volumes rather than heights, which some people don't understand. People couldn't comprehend the size or speed from this – need the heights. (Bridgewater)
- Old system of phone messaging, calling from top to bottom, worked well – this hasn't happened for a long time (Bridgewater)
- Lack of warnings for non-irrigators (Bridgewater)
- Most text messages not received because no power (Bridgewater)
- No warning (Carisbrook)
- Nobody knew where the water was coming from (Carisbrook)
- Government phone warning (Emergency Alert) came after evacuation (Carisbrook)
- Warning at the January meeting of the flood height was incorrect – this is responsible for lots of other problems. Everyone thought same height as the September flood. If we had correct warning from people up the river (friends just up the river were able to give the correct warning). With a proper warning, nearly every car in Charlton could have been saved. (Charlton)
- Where the gauge is placed for the Kiewa Valley (flooded in December) does not allow enough time to prepare (Dederang)
- Warnings need to be expanded – BoM not exact enough – just said "Kiewa Valley in minor flood" and the recording station at Mungers Bridge not referred to. (Dederang)
- People not in towns got no warning (e.g. at Longrenong).(Horsham)
- Flood heights communicated in different ways and in ways that didn't make sense to certain people – needs to be a single method of measurement (Horsham)
- Communication from where the three inches of rain occurred (Beechworth) – Tarrawingee had no idea that this much rain was falling up there. A phone call would have been sufficient. Downpour occurred between 3 and 4 and we had wet feet by 8.30. (Moyhu)
- In the September flood, was meant to be a phone call to everyone in the post code warning that the rain was coming. A lot of people in town got the call but not the rural people who needed it.(Moyhu)
- BoM was giving out too many flood warnings by Dec-Jan ('crying wolf') (Moyhu)
- Buridgee Creek – didn't get warnings in September (Myrtleford)
- SES sent out one warning in the middle of the night that contained incorrect information (Geoffrey St was to be evacuated, when there was no water in Geoffrey St). This is because street names in this Shire repeat themselves. (Myrtleford)
- Some black spots – not everyone received SMSs (Myrtleford)
- SES website was not updated late at night (Rochester)
- There should be an indication on the BoM website suggesting whether how a flood is going to compare to a previous flood Rochester)
- Gravity of January event not communicated in time or with sufficient strength (Skipton)

- Local knowledge about weather should be given a higher priority (Skipton)
- ABC Radio was late and incorrect. Its warnings were directing traffic along roads known by locals to by closed (Glenelg Highway) (Skipton)
- No emergency alert to Beaufort. (Skipton)
- Mobile phone alerts inadequate – too late or not received at all (from Sept to Jan). (Skipton)
- Radio stations not used, websites were slow to be updated – CMA website was at least 8 hours behind (Stawell).

Although some are partly relevant to other sections of the report, comments from the community meetings relevant to timeliness and adequacy of warnings show the following trends:

- Emergency Alert appeared to work well in several locations
- The use of a range of ways to issue Flood Bulletins appeared to be well received.
- Timeliness of warnings in a few locations such as Bridgewater appeared to be a concern
- Several of the concerns about warnings appear to be due to poor intelligence providing inaccurate messages
- It appears that there was a need for more specific local information in some locations e.g. Myrtleford.

4.2.4 Timeliness of Flood Bulletins

From an analysis of Flood Bulletins issued after Flood Warnings issued by the BoM for the centres there generally appears to be good compliance to the timing for the release of Flood Bulletins as outlined in SOP 009 (see Section 4.2.1).

Also analysis of Emergency Alert data (see Section 4.4.2) shows that there was generally timely use of Emergency Alert to support Flood Bulletins as outlined in SOP 057.

4.3 ADHERENCE TO BEST PRACTICE

Aspects of best practice in message construction and communication are discussed in Section 4.2.1. These best practices appear to be well-entrenched into procedures such as SOP 009 and SOP 057. In reviewing the Flood Bulletins and Emergency Alert messages issued during the 2010-11 floods there appears to be good compliance to these SOPs. There also appears to be improvement in adherence to best practice from September 2010 to the January 2011 floods (e.g. in consistency of messages, tailoring to local situations).

Most of the issues around message construction and communication do not relate to adherence to best practice; rather, they relate to other issues such as authorisation protocols impacting on timeliness and poor intelligence leading to inaccuracies in warnings.

4.4 ADEQUACY OF SYSTEMS

4.4.1 Coverage

As noted in Section 4.2, there appears to be some areas that received no warnings e.g. Carisbrook. Some other areas only received warnings in part of the area e.g. in the Horsham area.

There also appear to be some vulnerable sections of the community where warnings were not received. For example, one interviewee said that warning information for CALD communities had to be translated which took several hours causing a delay in these communities being warned in their first language. However, it should be noted that VICSES translated messages and placed these on its website. VICSES also worked closely with local councils to assist them in engaging with CALD groups such as at Shepparton and Swan Hill.

As noted in one agency debrief and by one interviewee, there appears to be some issues in specifically warning outlying Aboriginal

communities e.g. in the Bendigo and Swan Hill districts.

Agency interviewees believed there was generally good coverage of warning communication systems across Victoria using the range of methods on offer. They made the following comments:

- Emergency Alert – people don't understand that it is based on billing address (a gap could be that people live out of town but may not receive an Emergency Alert message because their billing address is in town)
- Emergency Alert – Has much better coverage than other means and get immediate feedback on how many people are receiving it
- Emergency Alert – Some people were warned because they would be isolated rather than flooded but they did not necessarily understand this
- Emergency Alert – there was pressure to use it because it was a new technology but perhaps it was overused in some instances. If it is not used to warn of an imminent danger its credibility may be diminished
- Emergency Alert – some people were expecting an Emergency Alert and because they weren't warned by that means they did not respond
- SEWS was not used as much as in previous events, unless you use every single one of the warning dissemination systems you will miss someone
- Warnings need to be in a format that people can access depending on their age, culture and technology access
- Community meetings are the most efficient and effective means of warning where time permits because it becomes a two way conversation which is true communication. You know what people are feeling and can address their issues and questions
- At the final community meeting regarding the Wangaratta levee a spokesperson from the community thanked everyone for keeping them informed and the attendees gave a standing ovation
- Virtual community meetings over the radio were a good initiative where it was difficult for communities to travel to a central location
- ABC radio covers most of regional Victoria and has MOUs with local FM stations to stream its radio announcements where there are gaps
- Need to go and talk with CALD communities in rural areas e.g. fruit pickers.

4.4.2 Usefulness

As noted in Section 4.2 from debriefs, Emergency Alert was identified several times as a useful addition to the suite of warning communications methods.

Table 5 shows the success rate of text and landline phone messages sent using Emergency Alert in the September 2010 and the January/February 2011 floods.

Table 5 Use of Emergency Alert

Type	# Sent	# Received	Success %
2010 Text	5,727	3,696	64.54
2010 Phone	3,635	2,666	73.34
2011 Text	80,685	49,487	63.34
2011 Phone	61,270	34,596	61.56

These success rates are comparable with those recorded in other recent emergencies e.g. February 2011 Tostaree Fire in Victoria.

From the social research related to flood-affected residents (Strahan Research, 2011a), over one-in-five respondents (21.7%) said that they received an emergency warning or advice message on landline or telephone from the emergency services. Almost two-thirds of respondents (65.3%) received one (30.9%) or two (34.4%) messages. Over one-in-six (17.6%) received three messages, and 8.6% received four messages.

The Emergency Alert warnings appear to have been useful in the response of residents who received them. More than eight-in-ten respondents (84.7%) who received an Emergency Alert warning message remembers how they responded immediately after receiving it, more than seven-in-ten respondents (71.9%) remember the content of the message, and just over one half (53.8%) felt that the message assisted them in implementing their emergency plan.

Some interviewees believed that Emergency Alert was overused in some flood-affected communities. They cautioned that some communities could become reliant solely on Emergency Alert for warning messages due to its extensive use and media promotion in January/February 2011.

Regarding receiving Flood Bulletins and other flood information, the residents surveyed were asked to identify the main sources that they tended to use. The most popular information sources were:

- Television (63.2%)
- Neighbours (53.3%)
- ABC local radio (46.7%)
- Family (45.9%)
- Websites on the Internet (33.2%)
- Newspapers (32.7%)
- Local emergency services, local police, CFA or SES (31.6%)

In terms of usefulness, over 80% of those that used ABC local radio and websites found them 'helpful' or 'very helpful'.

It should be noted that 14.4% of respondents said they used social media such as Facebook and Twitter to communicate or access information leading up to, during and after the floods (18.5% in metropolitan Melbourne compared with 12.6% in country areas).

The main information sources used by the business respondents (Strahan Research, 2011b) during and after the floods to assist in their recovery were:

- SES (30.8%)
- Local Council (30%)
- Radio (25%)
- Bureau of Meteorology (25%)
- Emergency services including CFA and the Police (23%)
- Vic Roads (23%)
- Their insurer (21.4%)
- Rural Finance Corporation (16.2%)

During the 2010-11 floods, approximately 120 community meetings were held (with a further 30 doorknock campaigns conducted). It is estimated that 15,000 people attended these meetings.

There was a general belief from those Information Officers interviewed that the community meetings worked well across the State, particularly in tailoring broader warnings to local situations and providing responses to community concerns. The use of 'virtual meetings', where community meetings were broadcast live on ABC radio, was apparently effective in enabling people that could not attend to hear the meeting discussion.

4.4.3 Efficiency

As noted in Section 4.2, there were issues relating to the 'clunkiness' of using the flood warning systems. According to interviewees this had improved from September 2010 to January 2011, with further improvement anticipated with the recent uptake of the One Source One Message (OSOM) system used previously in fire emergencies in Victoria.

The authorisation process through both the Incident Controller and SCC was also identified as a factor affecting the efficiency of issuing of Flood Bulletins and Emergency Alert warnings.

4.5 ROLE AND EFFECTIVENESS OF INFORMATION UNITS

The Information Unit reports directly to the Incident Controller in the ICC in changes to AIIMS as a result of the recommendations of the 2009 Victorian Bushfires Royal Commission. Some Information Officer interviewees believed that this chain-of-

command was taking time to embed and that further training of Incident Controllers and Information Officers was required for improvement in this 'new relationship'. They also felt that links between the Intelligence Unit and the Information Unit need to be improved, particularly to obtain and communicate accurate flood warning information.

There was a general consensus from both the VICSES and other agency Information Officers that the use of CFA, DSE and Parks Victoria Information Officers was effective, not only in adequately resourcing ICCs, but also in allowing for inter-agency 'cross-fertilisation' of ideas and experiences. Others noted this also made it easier to find people with local knowledge to be part of the information units. The downside was that they were not conversant with flooding, particularly in the beginning.

Several Information Officers interviewed believed that there was a need for better communication between ICCs and the SCC. They felt this could be achieved by having an ICC person dedicated to liaison with the SCC.

One non-SES Information Officer thought that the Information Unit staff lacked dedicated roles compared (e.g. Media Officer, Community Liaison Officer) with those used in the bushfire Information Units in Victoria. This interviewee felt that there "was too much focus on the media" in the Information Unit and that staff tended to be assigned roles in a reactive and non-specialised way.

5 FINDINGS – COMMUNITY AND EMERGENCY RESPONSE

5.1 COMMUNITY RESPONSE AND ATTITUDES

Molino Stewart was requested to provide learnings from its previous social research across Victoria in relation to community responses and attitudes to flood information and warnings.

Molino Stewart surveyed communities in Gippsland affected by the June/July 2007 floods (Molino Stewart, 2007b). It asked respondents if they searched for more information about the possibility of flooding or tried to check information once they were aware of the flood threat. The majority of the respondents (76%) did look for further information, with 45% of all people going to the radio for further information. About one-fifth of the total population sought further information from the television and about the same number sought it on the internet. Seventeen percent asked a friend, neighbour or relative, 12% contacted the SES and 8% rang the flood information line. Seventeen percent of people sought information from other sources with the Police being the most nominated source.

Respondents were asked to specify what information they believed and why. The information sources which were listed are provided below with the number of times they are mentioned by the 36 people who answered this question indicated within the brackets.

- Radio (6)
- Storms/weather/saw waters rising (6)
- Internet (4)
- Believed all information (4)
- Previous flood experience/s (4)
- Local fishermen / tide charts / full moon (4)
- Emergency services (3)
- Television (2)
- River height reports /meteorology reports (1)
- Neighbour (1)

The most common reasoning given for why respondents believed these sources was that it was a “trustworthy source”. Other responses included “doorknock by emergency services provided up-to-date information”, “the experience of those giving information” and that “the information (severe weather warning, water levels rising etc) could be confirmed in person”.

Molino Stewart also surveyed residents that experienced flooding in November 2007 in Gippsland (Molino Stewart 2008). Many of these residents (e.g. at Newry) had been flooded in June/July 2007 and thus were being re-surveyed.

The majority (82%) of Gippsland respondents in November 2007 attempted to check the information or get more information about the possibility of flooding during the November event. This is similar to the June/July flood where the majority (76%) searched for more information about the possibility of flooding. As in the June/July flood, radio was seen as the most trusted source of information for the November flood. Flood wardens and community bulletins were also cited as trusted flood information sources in the November flood.

5.2 INFLUENCE OF PRIOR COMMUNITY EDUCATION

5.2.1 Extent and Nature

Community flood education is acknowledged in the State Flood Plan as a way to “provide awareness and education for community members about flood risk and preparedness”. Preparedness not only includes carrying out flood preparations but also how to respond to an emergency including flood warnings.

A document titled ‘Summary of Community Education Programs for the Victorian Floods Review’ states that “based upon the recommendations of the (2005) Victoria Flood Warning Development Plan, VICSES took

responsibility for the delivery of flood and storm education" and first developed its community education programs for floods and storms in 2006. The document notes that "prior to the development of the programs, community education activities had largely been Council-based, with little consistency and no responsible agency identified to lead delivery statewide".

The development of VICSES community education has largely been dependent on external funding between 2007 and 2011 and has therefore been ad hoc according to the document. The document provides a chronology of VICSES activities since 2007 including:

- Original programs were piloted in Benalla (FloodSmart) and Wodonga (StormSmart) to develop a program logic model and to gain support by key stakeholders. Evaluation of these programs indicated a positive impact on community preparedness for floods and storms.
- The programs in 2007 were further expanded to include Gippsland and other parts of the North East. Priorities for the delivery of programs were based upon identified flood risks and the existence of recent Council lead community education programs. These programs have continued in full- or part-time capacity to date through the support received from the Natural Disaster Resilience Grants Scheme, with two community education coordinators employed to support the program.
- The 'FloodSmart' and 'StormSmart' programs were rebranded to 'FloodSafe and 'StormSafe' in 2009 to ensure nationally consistent branding could be leveraged.
- In 2008, VICSES received support from Melbourne Water to begin limited community education programs in the Melbourne area. This involved support to employ a community education coordinator to conduct a 'StormSmart' pilot (covering flood risks) in the council area of Maroondah. This was significantly boosted by the signing of a four year partnership agreement in 2009 which expanded support to employ a further two community education coordinators. The partnership with Melbourne Water over four years aims to develop floodplain risk management and flood emergency plans for 36 municipalities in the Greater Melbourne area, supported by 'FloodSafe' and 'StormSafe' programs. Recent 2010/11 funding through the Natural Disaster Resilience Grants program has allowed the employment of a further four Community education staff to support this program.
- VICSES in 2008/09 was involved in the development of community education resources for communities within the Wimmera River catchment.
- In 2009 with support from DSE, VICSES develop a program to engage with communities in fire-affected areas about the increased risks of flood following the Black Saturday bushfires.
- VICSES since early 2010 has also been working with the Glenelg Hopkins CMA and local councils to develop FloodSafe programs in the communities of Warrnambool and Port Fairy.
- Community engagement throughout programs has often occurred through community doorknocks, media campaigns, street meetings, public meetings and direct mailouts. This has often occurred in partnership with local councils, CMAs, business and community groups and other emergency services.
- Local units have undertaken activities in many other municipalities throughout the state to engage with communities, but these could be considered more opportunistic rather than detailed programs.
- VICSES has expanded the availability of community education engagement resources (brochures, flipcharts etc) to all regions and now provides detailed community education information through its website. This information is routinely made available through community activities and events which VICSES units are involved in.
- VICSES in 2009 first began its successful 'Stormsafe' week concept. This was further expanded in June of 2011 to include a 'FloodSafe' week. Both of these weeks have been successful in gaining state-wide media attention and have involved VICSES units from across the State.

- Table 6 below provides details on the number of public and community education events which have been conducted by VICSES over recent years:

Table 6: Community education activities

2010-11	**Events**	**Hours**
Community Education	173	3775
Public Relations	340	7785
2009-10		
Community Education	103	2332
Public Relations	418	9465

- VICSES has produced generic education resources for CALD communities: Multi-lingual FloodSafe messages (January 2011), Multi-lingual StormSafe messages (August 2011).
- VICSES has produced generic education resources for specific sectors of communities e.g. businesses, caravans, farmers
- VICSES has produced a Home Emergency Planner to assist households in developing home emergency plans (January 2011)
- ViCSES has developed a Community Education Training Course for Volunteers based upon the NSW SES course
- VICSES in February 2010 launched its presence of Facebook. The use of this site to engage with the community has evolved and has been used more often to support community education and emergency information processes.

It should be noted that some CMAs and local councils have developed their own education resources and information include website material. In 2009, a Victorian Web Portal website was developed through funding obtained by the Goulburn Broken CMA.

From the above, it appears that prior to the 2010-11 floods specific, ongoing community flood education and engagement activity had been conducted in the eastern part of the State and Metropolitan Melbourne. According to the VICSES document, concentration had been on the following LGAs:

- Benalla Rural City
- City of Wodonga
- Rural City of Wangaratta
- Alpine Shire
- East Gippsland Shire
- Wellington Shire
- Latrobe City
- City of Glen Eira
- Casey
- Manningham
- Darebin
- Maribyrnong
- Maroondah
- Cardinia

Outside of these areas, communities only received flood education mainly through generic websites and information such as pamphlets.

The staffing of community education and engagement also raises some issues relating to the extent of prior community education. Through the partnership with Melbourne Water three community educators were in place prior to the 2010-11 floods, compared with two across the North-East and Gippsland regions (and none in the rest of the State).

Further comments about the nature of prior community flood education are found in Section 5.2.3.

5.2.2 Effectiveness

From the views of the Information Officers interviewed for this report, there appeared to be a high correlation between the level of appropriate response to warnings and those communities that had received prior specific, ongoing community education. For example, North-East communities that had received prior community education and engagement (including in the three days leading up to the floods) were apparently “better prepared” and “more responsive” (e.g. to evacuation messages) than their counterparts in the North-West of the State that had received

none or little community education and engagement.

The social research relating to the 2010-11 floods was conducted across the State and thus it is impossible to discriminate between those communities that had received prior specific, ongoing community flood education and those that had not. However, it is possible to gauge the effectiveness of some of the expected outcomes of VICSES community education programs and resources e.g. preparation of emergency plans, having an emergency kit.

From the resident survey (Strahan Research, 2011a) over four-in-ten respondents (40.4%) said they had a flood or bushfire emergency plan prior to the floods. Country respondents (48.2%) more than respondents from Melbourne (36.2%) said that they had an emergency plan prior to the floods.

Over four-in-ten respondents (43.6%) said they had an emergency kit prior to the floods. Over one-in-six respondents (17.8%) were prompted to get an emergency kit through their involvement in community education activities and a further 7.5% had taken up family and friends suggestions. Country respondents (23.2%) more than those from Melbourne (10.3%) were prompted to get an emergency kit as a result of educational activities.

From the business survey (Strahan Research, 20011b) almost one-third of respondents (33.1%) said they had an emergency plan for their business prior to the floods. Close to one-half of the respondents (48.4%) said they had an emergency kit prior to the floods (62.5% for businesses with over 20 staff). What prompted having an emergency kit was not explored for businesses.

The above are relatively high levels for these preparedness indicators. Generally, around Australia the figures are around 20% for having emergency plans and slightly higher for having emergency kits, particularly where there has been little community flood education. Unfortunately, the link with prior community education was only explored explicitly once (for residents having an emergency kit) in the social research.

There were some comments made about the effectiveness of community flood education in post-event community meetings. These comments included:

- Better community education required, particular about previous floods and how to prepare and respond (Bridgewater)
- Lack of information before, during and after (Charlton)
- Education of evacuation procedures – people who refused to go (Charlton)
- Holistic community education program required including for elderly, people in isolated communities (Kerang)
- Most property owners are not aware of what they are responsible for – e.g. driveways, culverts and bridges – and they are consequently not included on insurance policies. A public education campaign about this is needed.(Myrtleford)
- Community education about flooding preparedness. A Flood Survival Kit, akin to that for Bushfires. Ditto with group plans (as some communities have for bushfires – so people in the street knows who is vulnerable etc.) (Rochester)

Comments about prior community flood education were also made in agency debriefs. These comments included:

- From a preparedness perspective, the pre-warning of communities was a positive. Those with history of recent floods reacted better. (Bendigo)
- Community Education (flood related) was lacking - Consequently, community was not as well prepared as may have been possible (Bendigo)
- Community flood education capabilities of SES need strengthening. SES need to enhance community flood awareness and engage with those living in flood prone areas – SES don't have the resources for this (Bendigo)
- The community educators from Melbourne gave a standardised presentation for each of the community presentations – sensed these would have been better received if they were more localised and tailored for each community. – Some key messages always appropriate ie move valuables to higher places within premises, however some recognition of local issues would have added value. (Swan Hill)

- How many community educators does the SES have? SES has a limited capability in this space whereas CFA has increased substantially. (Wangaratta)
- SES had campaigned for FloodSafe in NE Victoria. In general terms this gave rise to a good level of community awareness – Accordingly, most acted responsibly and calmly. (Wangaratta)

Comments made in council debriefs include:

- Communities need to be aware how these systems work (won't differentiate between high and low areas, will pick up more people rather than less). Need a degree of accuracy so people can determine if the warnings apply to them – this could be worked into the FloodSafe public education program. (Campaspe)
- CMA ran an education campaign about their specific functions four year ago. It was effective for a while but no longer. (Alpine)
- FloodSmart education program and signs generally effective in Benalla in assisting with response (Benalla)

5.2.3 Adherence to Best Practice

Although it appears that prior community education and engagement was effective in those areas where it was ongoing and locally-tailored, an assessment was made to examine if VICSES community education adhered to best practice at the time of the floods. It should be noted that since the floods, VICSES has developed a Community Education Strategic Plan.

In 2007, Molino Stewart conducted an extensive review of community flood education to position VICSES as a leader in this field. In this review, Molino Stewart (2007c) identified ten best practices at the time for VICSES to follow in its community flood education. These best practices were:

1. Flood education programs should be delivered through community groups where communities are empowered to research, plan, implement and evaluate their own activities
2. Community flood education plans should be developed to help communities maintain and improve their flood education activities
3. Emergency agencies such as VICSES should act as consultants to communities (e.g. facilitators, resource providers, change agents, coordinators) rather than directing the change process in a top down manner
4. Flood education programs should address the psychological aspects of preparedness, response and recovery, including their psychological barriers
5. The emphasis of flood education programs should be on developing preparedness plans (e.g. through personal or organisational preparedness plans) and building community resilience (e.g. capacity building) rather than just awareness raising
6. Opportunities for cross-hazard (and cross-agency) programs should be identified and implemented where possible
7. Flood education planning should be part of floodplain and emergency planning processes Flood education programs should be evaluated as they proceed to ensure continual improvement
8. Social research should be used in the planning, implementation and evaluation of flood education programs
9. Flood education programs should be strongly linked into the total warning systems e.g. warnings should trigger appropriate response behaviours and this relationship should be clearly communicated through education programs

Subsequent research such as that conducted by RMIT University (Elsworth et.al., 2009) has strongly supported these as best practices. The RMIT research particularly promoted a locally-tailored participative approach to the design of community hazard programs as opposed to the top-down provision of education through information.

Comparing the ten best practices with the status of VICSES community education

programs in 2010-11 the following observations are made:

1. The only areas that could have been involved in a participatory approach to community flood education were those staffed by VICSES community educators.
2. VICSES has developed and implemented local community flood education plans particularly in the north-east of the State and in metropolitan Melbourne in conjunction with Melbourne Water.. These are seen as a an important way of ensuring ongoing and locally-tailored programs and have been successful elsewhere in Australia (Webber and Dufty, 2008)
3. Evaluation is seen as critical to the improvement of these programs (Elsworth et.al., 2009, Dufty 2008. VICSES conducted an evaluation of the pilot FloodSmart and StormSmart programs. It also conducted an evaluation of flood education as part of social research into community behaviours related to the September 2010 floods (Colmar Brunton, 2011). This research found that only 6% of survey respondents had been involved in community education programs run by VICSES or other agencies. However, 74% said they had seen information about what to do before and in a flood with VICSES being the main source of information (33% of respondents).
4. There appears to be a large amount of scope to improve an all-hazards approach to community education in Victoria, particularly with the CFA having well-evaluated education and engagement programs and both VICSES and CFA having common goals in community behaviours e.g. development of emergency plans. However, there is evidence of the emergency agencies regularly collaborating locally regarding community education events, such as the successful SAFE programs run throughout the north-west of the State which involve most key agencies engaging with school students
4. Community education resources such as FloodSafe Guides did refer learners to warning triggers to elicit appropriate responses. However, these Guides had only been produced in a limited number (four) of locations.

Based on Section 5.2.1, some other observations are made below in relation to the nature of community flood education:

- There is only generic information for CALD communities As stated previously, VICSES translated flood messages and placed these on its website. VICSES also worked closely with Councils to assist in engaging with CALD groups prior to and during the floods e.g. at Shepparton and Swan Hill. There was no information or education program provided to specifically assist potentially vulnerable people e.g. aged, disabled.
- There appeared to be minimal education programs resources developed for school students. Dufty (2009) stresses the importance of flood education in school to build community resilience. This should be done through existing curriculums, and not as an extra-curricula activity.

5.3 COMMUNITY EXPECTATIONS

Those stakeholders interviewed generally felt that community expectations for accurate and timely flood information and warnings were high and, at times, “unrealistic” in relation to what was feasible. Some interviewees believed that community education should be used so that people in flood-prone areas could understand limitations of warning systems in their local area and, in this context, know the triggers to react to warnings or other prompts e.g. river gauge heights.

In the survey of residents (Strahan Research, 2011a) respondents were asked whether the flood had a greater, similar or less impact than what was communicated to them in warnings and flood information. Almost four-in-ten (37.9%) respondents said that the floods had a greater direct impact on them than they had expected based on warnings and information.

A similar proportion (37.8%) said that the impact was as they expected and just over one-in-five (21.1%) said the impact was less than expected.

The majority of businesses surveyed (Strahan Research, 2011b) thought the impact was greater than that outlined in flood warnings and information. Almost six-in-ten (57.3%) respondents said that the floods had a greater direct impact on their business than they had expected based on warnings and information. Over a quarter of respondents (26.6%) said that the impact was as they expected and over one-in-seven (14.9%) said the impact was less than expected.

5.4 COMMUNITY RESPONSES TO EVACUATION WARNINGS

As noted in Section 4.1, according to 'Community Flood Warning Arrangements' (a sub-plan to the State Flood Emergency Plan), "the role of VICSES as the Control Agency for flooding is to recommend evacuation and provide evacuation warnings; and to support VICPOL in undertaking the evacuation".

Evidence of how people behaved in relation to evacuation warnings can be gleaned from the social research. From the resident survey (Strahan Research, 2011a), over one-in-five respondents (22.8%) who had taken actions to lessen the impact of the floods evacuated their home as a result of the floods.

Almost four-in-ten respondents (39.7%) who had evacuated did so when they realised that the flooding would affect their property. Over one-third (36.2%) of these respondents evacuated as soon as they received the first warning. Almost one-in-five respondents (19.0%) did not evacuate until the flood hit their property.

A majority of respondents (55.2%) who evacuated did so because they were concerned about the safety of their family. Almost one-third (31.0%) evacuated because they were advised to do so by the emergency services.

Almost six-in-ten (57.9%) evacuees went to stay with friends or family in a safe location. Over one-in-five (21.1%) evacuated to their local township or village. Almost one-in-seven (14.0%) went to an evacuation or relief centre in their local area.

The two main reasons why three-quarters of respondents did not evacuate were because:

- There was no threat to them or the safety of their family (42.4%)
- Their property wasn't threatened (32.5%)

Country respondents (39.3%) more than metropolitan respondents (19.1%) did not evacuate because they felt that their property wasn't threatened.

Comments from emergency agency debriefs about community responses to evacuation warnings included:

- Evacuations – The community responses to Emergency Alert were generally good.(Bendigo)
- The process of doorknocking as to warn provided a source of intelligence as to if assistance may be required to relocate / evacuate. (Horsham)
- Some aged care facilities utilised relatives of residents to affect evacuation whilst the remainder were scooped up by council means. (Horsham)
- Lack of public reaction to warnings to evacuate was an issue. In Charlton there were those who ignored warnings which ultimately served to put not only themselves at later risk, but also those who then had to conduct rescues (Swan Hill)
- The speed of events necessitated some late-stage evacuations (caravan parks). (Wangaratta)

Comments were also made about responses to evacuation warnings in debriefs with councils:

- Three buses of people evacuated – not sure of exact number (Central Goldfields)
- Private evacuations were OK – some people evacuated who didn't need to.(Horsham)
- Evacuation went really smoothly, couldn't have gone better (Pyrenees)

- All authorities worked together, in the one ICC, around the clock – Council, SES and VicPol. Information out there quickly. Some people refused but most responded in a positive way.

5.5 ADEQUACY OF EVACUATION DECISION-MAKING AND WARNINGS

According to the State Flood Plan:

"The decision to recommend that people evacuate shall be made by the Incident Controller in consultation with VICPOL, DHS, AV, Local Government and other expert advice (eg CMAs, infrastructure providers or specialist flood consultants), unless time constraints prevent this consultation. If an evacuation decision is made, VICPOL shall manage the withdrawal, shelter and return phases of the evacuation process.

"VICSES shall be responsible for the dissemination of evacuation warnings to the community. Emergency Alert and SEWS should be considered to warn affected communities. VICPOL, CFA, MFB, DSE and Local Government will provide resources to support VICSES with doorknocking and use of mobile public address systems

"Generally under circumstances when life and safety are at risk, evacuation should be considered. Specific circumstances in which evacuation may be considered include:

- Evacuation of people when their homes or businesses are likely to flood
- Evacuation of people who are unsuited to living in isolated circumstances due to flood water closing access
- Evacuation of people where essential energy and utility services have failed (or are like to failed) and will result in impact to human health
- Evacuation of people from buildings that have been made uninhabitable

"The following factors should be considered in deciding to recommend the evacuation of a flood threatened community:

- Safety of emergency service personnel
- Anticipated flood consequences and their timing
- Size and location of the community to be evacuated
- Likely duration of evacuation
- Evacuation priorities
- Risks associated with an evacuation
- Access and egress routes available and their potential flood liability
- Current and likely future status of community infrastructure
- Resources required to conduct the evacuation
- Resources available to conduct the evacuation
- Relief service availability and resources (including emergency shelter and accommodation options)
- People with additional needs
- Time of the day
- Forecast weather
- Transportation of people without access to transport"

Agency interviewees commented that In hindsight the following places should not have been told to evacuate

- Koo Wee Rup – the forecasting overestimated the flood flows and the intelligence was poor
- Pental Island – the flood took much longer to arrive and only isolated the community which had ample time to stock up on supplies
- Shepparton – there was uncertainty whether the levee might overtop based on forecasts so a decision was made to err on the side of caution

In each case it was said that the decisions to evacuate were made using the best available information at the time and were appropriate in that context.

The towns which interviewees said should have been evacuated and were not, or were not evacuated in a timely manner were:

- Charlton – when the order to evacuate was given the evacuation route was

already long cut and parts of the town were flooding – this stemmed from an untimely flood warning and lack of intelligence about road levels available to the ICC and of impacts from the field

- Carisbrook – there was a lack of any flood warning and little intelligence on how the town would flood
- Rochester – it should have been evacuated earlier but there was an underestimate of the official warning and even when the ICC determined that it would assume a larger flood it took almost 12 hours to develop flood intelligence to inform an evacuation decision
- Skipton – there was inadequate gauging and forecasting available and no flood intelligence.

One interviewee noted that although the Police are meant to provide evacuation commanders, some of the designated commanders did not understand their role.

6 FLOOD WARNING SERVICE DEVELOPMENT PLAN

In 2005 the Victorian Flood Warning Consultative Committee (VFWCC) published the Flood Warning Service Development Plan for Victoria - Review of Flood Warning System Development Priorities within Victoria (VFWCC, 2005). The purpose of this document was to establish priority actions for the improvement of the total flood warning system in Victoria. It included 22 recommended actions which were grouped according to priority:

- Short Term – 6-18 months
- Medium Term – 12-24 months
- Long Term – longer than 24 months

This Chapter provides a brief overview of the status of the recommended actions as at February 2011. If focuses on those recommendations and catchments which are within the scope of this study. It is understood that the VFWCC is undertaking a more comprehensive review.

6.1 SHORT TERM

Recommendation 1

The VFWCC recommends that the ranked list of catchments and associated activities at Section 9.2 above should be used to guide TFWS development activity within Victoria over the next five to ten years but that this should not occur at the expense of other recommendations in this report or of other projects seeking an upgrade to TFWS elements where there is clear economic benefit.

Status

There were 10 priority catchments identified including the Loddon, Wimmera, Campaspe, Goulburn, Broken, Metropolitan Melbourne which were part of this investigation.

Substantial improvements have been made to the total flood warning systems in the Wimmera, Goulburn and Broken catchments. Bunyip Creek within Metropolitan Melbourne had some upgrades to its gauging network and forecast modelling. It is of note that it was recommended that each catchment have a service level agreement development but none has been developed although it is noted that a draft state-wide agreement was in preparation before September 2010.

No upgrades have been done in the Loddon or Campaspe catchments although it is understood a Natural Disaster Mitigation Program grant application for the Loddon was unsuccessful a few years ago.

Recommendation 2

The VFWCC recommends that as a matter of urgency and with due regard for the above, responsibilities for flood awareness raising and the interpretation of flood forecasts be raised with the State Flood Policy Committee and the Office of the Emergency Services Commissioner with a view to resolving the following key questions:

- Who is responsible for raising community flood awareness and how should such responsibilities be resourced, funded and discharged.
- Who is responsible for the interpretation of flood forecasts produced by the Bureau and Melbourne Water into areas/assets likely to be affected and in communicating this to the at-risk community and how should such responsibilities be resourced, funded and discharged.

Status

A report was commissioned in 2007 (Molino Stewart, 2007a) which investigated the ability of VICSES to take on this role and what resources would be required to discharge these responsibilities. VICSES subsequently adopted the responsibility for community education, has sourced some funding and has implemented its FloodSafe program where possible based on funding constraints. Although VICSES has taken the lead in community education, it still remains underfunded to implement appropriate programs across Victoria.

VICSES has taken responsibility for interpreting flood forecasts and has collated available flood studies, established intelligence units within ICCs and the SCC in the recent floods and developed key messages and a flood bulletin product to add value to BoM forecasts.

Recommendation 3

The VFWCC recommends that in the interim, it take the lead on auspicing a State-wide flood awareness raising project. This could involve lodgement of an NDMP (or EMA State Support Package/Local Grants Scheme) funding application for a comprehensive review and recommendations on community engagement and the development of an on-going program for raising flood awareness across the State.

Status

The SES has taken on this responsibility across the State as per status for recommendation 2. Note that the grant schemes available for such funding have changed names since this recommendation was formulated.

Recommendation 4

The VFWCC recommends that:

- Similar to fire related legislation, Municipalities with an identified flood risk be required to form a Municipal Emergency Flood Planning Committee (or similar) that embraces all local stakeholder entities (e.g. LG, CMAs, RWAs, VICSES, community, etc.) and has responsibility for input to development and maintenance of the MEMP Flood Sub-Plan.
- A comprehensive template be developed as a guide for Flood Sub-Plan preparation.

Status

Outside scope of this study

Recommendation 5

The VFWCC recommends that DSE routinely report to the VFWCC on:

- The status of all flood related studies being undertaken by CMAs and/or Municipalities;
- On those projects that are implementing structural flood mitigation works; and
- All flood related study deliverables and recommendations that have flood forecast and warning service implications.

Status

Outside scope of this study

Recommendation 6

The VFWCC further recommends that:

- DSE deliver a hard (or digital) copy of all flood related study final reports to the Bureau (or Melbourne Water as appropriate) for information.
- The VFWCC follow up any recommendations for improvements to flood warning service elements by encouraging the Bureau (or Melbourne Water as appropriate) and local Council to scope out such improvements with a view to establishing a funding source, identifying a project champion and other stakeholders and assigning a priority to the identified works.
- Following the implementation of structural flood mitigation works, the Bureau (or Melbourne Water as appropriate), in conjunction with the local Council and CMA, reassess the Service Level Agreement for that location and make any necessary changes to operational directives, operational protocols and priorities.

Status

Outside scope of this study

Recommendation 7

The VFWCC recommends that both the Bureau and Melbourne Water allocate resources to the update of existing operational manuals to include:

- Relevant information from recent flood study and related reports;

- Knowledge retained by individual staff;
- Details of recent changes to forecast techniques and data collection networks; and
- A dynamically updateable section on the cause, progress and effects of all significant (probably major) floods along with lessons learnt.

Status

URBS modelling has been extended across additional catchments but there was no evidence that operational manuals have been updated and some of the flood directives provided by the BoM to facilitate this study dated back to 1985, even where there have been significant upgrades to the warning system.

Recommendation 8

The VFWCC recommends that the Bureau and Melbourne Water work with the VFWCC to:

- Establish a priority or protocol for service delivery that recognises constraints on available resourcing within each organisation.
- Develop a staffing strategy that will allow delivery of flood forecast and warning services consistent with community expectations and Service Level Agreements (see Section 9.3.3.1) particularly under severe, prolonged and/or widespread flooding conditions.

Status

There are no service level agreements yet established. Although the BoM maintains that its help desk for flood forecasting was staffed 24/7 throughout the floods, several people who were interviewed from the SCC and ICCs stated that warnings were not being updated overnight and the help desk was not always contactable overnight. Furthermore, there was a perception from those same people that the BoM was not sufficiently resourced at the peak of the events to provide forecast updates in a timely manner for critical levels.

Recommendation 9

The VFWCC recommends that:

- The Bureau extend the establishment of formal Operating Principles and Guideline Agreements to all authorities including G-MW, SRW, GWMW, BW, SH, SHL, MDBC and GVW, who operate dams on rivers covered by formal flood warning systems.
- The Bureau and Melbourne Water maintain an active awareness of Water and other authority Flood Operations Manuals (or similar) and seek to routinely (say 2 yearly) join with such authorities to re-examine flood related matters so that arrangements and details remain up to date and effective.
- The Bureau continue to pursue data collection node sharing, access rights or interagency reciprocal data transfers with Regional Water and similar Authorities, either as an extension to the Water Monitoring Partnership Agreements or as stand alone arrangements.

Status

Based on the information provided by the BoM, it would appear that BoM has only been able to establish MOUs with Melbourne Water and Goulburn Murray Water although it is noted that other water authorities were party to MOUs which were established prior to 2005 for total warning systems in some catchments.

Recommendation 10

The VFWCC recommends that:

- A VFWCC Sub-Committee be formed to prepare a Position (or Briefing) Paper on TFWS upgrade project issues for consideration by the State Flood Policy Committee and the Office of the Emergency Services Commissioner.
- The Office of the Emergency Services Commissioner be requested to initiate a critical examination of existing emergency management roles and responsibilities in the context of TFWS concepts and interrelationships, with particular attention to the matter of raising and maintaining flood awareness and communicating risk (i.e. Recommendation 2).

- As a follow-on to the above, the Office of the Emergency Services Commissioner be requested to consider issues of resourcing and skill set assistance for those Municipalities involved in recent TFWS upgrade projects.
- As a further follow-on, the Office of the Emergency Services Commissioner be requested to review the TFWS upgrade project MoUs with a view to renegotiating the assignment of roles and responsibilities in accordance with recommendations flowing from the above and Recommendation 2.
- Considerable caution is exercised by TFWS stakeholders in initiating further TFWS upgrade projects without adequate attention to the capabilities and capacities of all stakeholders to fully and consistently deliver on all project expectations.

Status

This does not appear to have been done.

Recommendation 11

The VFWCC recommends that a regular (annually or perhaps every two years) flood warning system non real-time tabletop exercise is conducted that as a minimum involves key stakeholders and focuses on a selection of catchments that have not experienced recent flood activity and that extend across one or perhaps two VICSES regions.

Status

This does not appear to have been done.

Recommendation 12

The VFWCC recommends that DSE provides the Bureau with full access to the Victorian Flood Database (VFD) datasets and establishes procedures aimed at ensuring that DSE provides any updates to the Bureau in a timely manner.

Status

This does not appear to have been done.

6.2 MEDIUM TERM

Recommendation 13

The VFWCC recommends that the Bureau (in cooperation with Melbourne Water within the Port Phillip and Westernport CMA area) and with input from key stakeholders, initiates the establishment of formal Service Level Agreements for each flood forecast location across the State.

Status

This does not appear to have been done.

Recommendation 14

The VFWCC recommends that the Bureau and Melbourne Water in association with VICSES and other stakeholders:

- Jointly review the information provided in flood warning messages in the context of Flood Warning Service Level Agreements with a view to providing flood forecasts that contain more information on the developing (or receding) flood (e.g. full hydrograph, time to exceed critical levels, etc.) than the peak height and expected timing.
- Consider routinely adding action statements, attributed to VICSES, to all public issue flood warnings that encourage particular damage reducing and life preserving behaviours.

Status

It would appear that in some locations additional flood forecast information is being provided. The SES includes action statements in its flood bulletins.

Recommendation 15

The VFWCC recommends that the Bureau and Melbourne Water:

- Continue to examine and implement additional or alternative mechanisms and facilities for making raw real-time rain and river level data more accessible to at-risk communities and individuals with particular regard for timeliness and relevance.

- Routinely remind the Victorian community of data availability.

Status

The number of gauges which provide real time data on the BoM website have been increased but as noted in this report there is no mechanism to inform the public of the reliability of the displayed data.

Recommendation 16

The VFWCC recommends that the Bureau in consultation with Melbourne Water investigate the technical feasibility of and review capacity to provide a warning service for Victorian coastal areas and towns affected by storm surge and/or flooding. If deemed feasible, it is further recommended that the Bureau and/or Melbourne Water in close consultation with relevant bayside and coastal Councils, initiate development of appropriate models and technical tools to facilitate delivery of a service to the at-risk communities as an extension to existing flood forecast and warning services and engage in discussions with other stakeholders to establish the necessary supporting infrastructure (e.g. gauges) as well as delivery, awareness and feedback/service assessment mechanisms.

Status

Outside the scope of this study

Recommendation 17

The VFWCC recommends that a VFWCC Sub-Committee:

- Initiate discussion with the Office of the Emergency Services Commissioner on the coordination of post-flood information collection activities and the integration of flood damages and other post-flood data into a single database.
- With due regard for the data/information collection and collation activities of agencies and organisations involved post-flood, commission the preparation of a questionnaire aimed at collecting the base data necessary to complete a justification of past and future TFWS upgrades. Essential questions will revolve around issues dealing with how people responded in real and damage-saved terms, their level of flood awareness, how they received and verified flood related information and warnings, how they interpreted this information, and so on.
- Identify and document the analysis tools needed to use data collected through the questionnaire so that questions can be 'fine-tuned' before use and returned data analysed in a timely manner. Critical analyses will revolve around questions such as the degree to which the warnings resulted in intended changes in behaviour, the appropriateness of information provided, the effectiveness of warning delivery methods, and the cost benefit of the warning system.
- Consider initiating a review of the effectiveness of the TFWS following major flood.

Status

Outside the scope of this study

6.3 LONG TERM

Recommendation 18

The VFWCC recommends that a VFWCC Sub-Committee be formed to develop a code of practice that outlines those things that need to be done to keep flood warning systems alive across all stakeholders. One of these activities should be the routine testing and streamlining of all dissemination arrangements including verification of receipt and understanding between and within organisations and the removal of unnecessary duplications.

Status

This does not appear to have been done.

Recommendation 19

The VFWCC recommends that the Bureau and Melbourne Water further develop consistent flood forecast performance assessment criteria and routinely report to the VFWCC and others as necessary.

Status

This does not appear to have been done.

Recommendation 20

The VFWCC recommends that the Bureau:

- Give a high priority to improving flash flood warning and outlook services, with particular attention to problem areas identified in the Report Cards (see Appendix B) and responsibilities identified in VFWCC (2001) and the Emergency Management Manual Victoria.
- Make rainfall accumulations available to relevant authorities as and when they become available.
- Ensure that warnings of flash flooding are delivered to stakeholders and authorities in the shortest possible time.
- Work with the VFWCC (see Section 9.3.2.1) on a program to raise community awareness of flash flood warning services and related matters.

Status

BoM has improved its forecasting systems to better enable it to give generalised flash flood warnings within a severe weather warning.

More rainfall forecast and record data is available on the BoM website than previously.

Local government remains responsible for flash flood warning although it continues to be under resourced for this role.

The SES FloodSmart program applies to flash flood catchments but none have been particularly targeted to date.

Recommendation 21

The VFWCC recommends that a VFWCC Sub-Committee examine the issues listed in Appendix A7 (a collection of the issues raised during the study workshops during 2004) and give consideration to how best to address each in order to appropriately engage key stakeholders and thereby reduce negative impacts and/or maximise benefits to flood warning services. This Sub-Committee should report periodically to the full VFWCC through a standing agenda item in order to gain wider input on and consideration of progress with addressing matters raised.

Status

Outside the scope of this study

Recommendation 22

The VFWCC recommends that this Plan be reviewed and the underlying analyses reworked every eight to ten years, or more often if considered necessary, in order to reassess priorities.

Status

It is only six years since the plan was developed.

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APPENDIX A – REVIEW PLAN

Yellow highlight denotes work to be conducted by the Victorian Floods Review

Examination of the Total Flood Warning System in Victoria
Review Plan

No.	Objective To assess:	Scope	Methods	Data sources
1.	**Prediction**			
1a	Accuracy and timeliness of flood predictions	▪ **Assess** how accurate and timely flood predictions were for 2010-11 Victorian floods against performance measures or benchmarks	<u>Evaluation steps:</u> 1. Identify performance measures for accuracy and timeliness of flood predictions 2. Collect official flood warnings issued for Ovens, Goulburn - Broken, Loddon, Avoca, Wimmera, Campaspe, Mount Emu Creek, Pakenham (Bunyip Creek) catchments for floods from Sept 2010 to Feb 2011 3. Relate flood warning predictions e.g. warning level, times, heights for these catchments to actual flood data to analyse accuracy and timeliness and identify any issues 4. Review the BoM and VICSES	MOUs, BoM directives, Melbourne Water directives, draft table of performance indicators (BoM) Official flood warnings issued Flood data e.g. hydrographs URBS results Interviews with VICSES, DSE BoM, councils, CMA

No.	Objective To assess:	Scope	Methods	Data sources
			perceptions of timeliness and accuracy of flood predictions during the 2010-11 floods and ask them to identify any issues encountered 5. Review results of 3. and 4. to identify any issues for timeliness and accuracy and consider if these issues had an impact on response and at what point can you do something that has an effect.	
1b	The coverage of flood prediction systems in Victoria including systems for the prediction of flash flooding	▪ **Assess** the coverage of flood prediction systems across all riverine and flash flood-affected communities in Victoria	<u>Evaluation steps:</u> 1. Identify the current coverage of flood prediction systems across flood-affected communities in Victoria 2. Identify any gaps in the coverage 3. Review community expectations of gauge coverage 4. Review gaps and analyse viability of providing coverage in these areas	Documentation on coverage of flood prediction systems across Victoria Interviews with BoM, VICSES, previous reports e.g. Cawood Social research e.g. survey, focus groups
1c	Strengths and weaknesses of current	▪ **Identify** perceived strengths and weaknesses of current flood prediction systems in	<u>Evaluation steps:</u> 1. Identify perceived strengths and	Interviews with BoM, VICSES,

No.	Objective To assess:	Scope	Methods	Data sources
	flood prediction systems	Victoria	weaknesses of current flood prediction systems from key stakeholders based particularly on experiences from 2010-11 floods 2. Review responses for 1. In relation to findings from other evaluations of flood prediction systems.	DSE, CMAs, local councils
1d	Communication between key stakeholders in relation to flood prediction	▪ **Assess** the effectiveness of communication between key stakeholders (including agencies and flood-affected communities)in relation to flood prediction during the 2010-11 floods	<u>Evaluation steps:</u> 1. Locate baseline flood prediction communication protocols for key agencies and organisations 2. Assess compliance to protocols and perceived effectiveness of key stakeholder communication relating to flood predictions during the 2010-11 floods 3. Identify any flood prediction information originating from flood-affected communities and assess its perceived effectiveness relating to flood predictions during the 2010-11 floods	EMMV, State Flood Response Plan vers 1.4, BoM directives, SOPs State Emergency Response Plan Interviews with BoM, VICSES, DSE, CMAs, Melbourne Water Multi-agency de-briefs Interviews with BoM, CMAs Social research reports
1e	Current technologies	▪ **Compare** the strengths of current	<u>Evaluation steps:</u>	

No.	Objective To assess:	Scope	Methods	Data sources
	and modelling techniques used in flood prediction	technologies and modelling techniques used in flood prediction in Victoria with those used in other Australian States and Territories and those currently available or planned	1. Identify current technologies and modelling techniques used in flood prediction in Victoria 2. Compare perceived effectiveness of current technologies and modelling techniques used in flood prediction in Victoria with those in other States and Territories and those available and planned	Interview with BoM Interviews with BoM, expert consultants, Melbourne Water
1f	Liaison with dam owners in regards to the impacts of dam operations on flood predictions, specifically information flow between dam owners, SES and BoM	▪ **Assess** the effectiveness of liaison with dam owners in regards to the impacts of dam operations on flood predictions, specifically information flow between dam owners, SES and BoM **(Note review being conducted by SKM on dam releases, operations)**	<u>Evaluation steps:</u> 1. Identify MOUs or protocols outlining requirements for liaison between dam owners, SES and BoM regarding impacts of dam operations on flood predictions 2. Investigate the extent to which the communication protocols etc. were adhered to in the 2010-11 floods 3. Assess whether the liaison during the 2010-11 floods was effective and how it could be improved.	MOUs, protocols with dam operators Interviews with water authorities, VICSES, BoM Multi-agency debriefs Interviews with water authorities, VICSES, BoM Multi-agency debriefs

No.	Objective To assess:	Scope	Methods	Data sources
2. 2a	**Interpretation** Current requirements and responsibilities for flood intelligence and its use in Victoria	▪ **Assess** the effectiveness of current requirements and responsibilities for flood intelligence and its use in Victoria	<u>Evaluation steps:</u> 1. Identify current requirements and responsibilities for flood intelligence and its use in Victoria 2. Investigate and assess the perceived effectiveness of current requirements and responsibilities for flood intelligence (e.g. flood records, flood models, maps) in Victoria particularly in relation to the 2010-11 floods 3. Identify any improvements to the current requirements and responsibilities	EMMV, State Flood Response Plan Interviews with local councils, CMAs, VICSES, DSE, Vic-based consultants, Melbourne Water Multi-agency debriefs Interviews with local councils, CMAs, VICSES, DSE, Vic-based consultants, Melbourne Water
2b	Adequacy of available flood intelligence and its use	▪ **Assess** the adequacy of available flood intelligence and its use particularly in relation to the 2010-11 floods	<u>Evaluation steps:</u> 1. Assess available flood intelligence (e.g. flood records, flood models, maps) and its use against the recommendations for flood interpretation in the Molino	Interviews with local councils, CMAs, VICSES, DSE, Vic-based consultants, Melbourne Water Multi-agency debriefs

No.	Objective To assess:	Scope	Methods	Data sources
			Stewart 2007 report 2. Identify any gaps or improvements based on 1.	
2c	The speed at which interpretation occurred and impacts on the speed of community warnings and information	▪ **Gauge and assess** the speed at which interpretation occurred and impacts on the speed of community warnings and information in relation to the 2010-11 floods	<u>Evaluation steps:</u> 1. Estimate the speed at which interpretation occurred for sample catchments & flood scenarios during the 2010-11 floods 2. Compare the time at which the BoM issued initial warnings to when community warnings and information were issued by the SES for selected catchments to estimate overall time taken for interpretation and message construction/communication 3. Compare results from 1. with those from 2. to gauge the impact of interpretation on the speed of community warnings and information	Interviews with Incident Controllers, CMAs, Vic-based consultants Multi-agency debriefs BOM flood warnings issued Community warnings and flood information issued
2d	The role and effectiveness of	▪ **Assess** the appropriateness of the role and the effectiveness of intelligence units in	<u>Evaluation steps:</u> 1. Assess the perceived	Interview Intelligence Officers

No.	Objective To assess:	Scope	Methods	Data sources
	intelligence units within IMTs (including the SCC and ICCs)	IMTs in relation to interpretation	appropriateness of the role of intelligence units in ICCs for interpretation 2. Assess the perceived effectiveness of intelligence units within IMTs for interpretation particularly during the 2010-11 floods	in SCC, ICCs Incident Controllers, CMAs, Vic-based consultants Interview Intelligence Officers in SCC, ICCs Incident Controllers,
2e	Adequacy of systems for the collection, analysis and storage of flood intelligence	▪ **Assess** the current adequacy of systems for the collection, analysis and storage of flood intelligence	<u>Evaluation steps:</u> 1. Identify the current systems for the collection, analysis and storage of flood intelligence 2. Assess the current systems against the requirements for flood interpretation	Interviews with local councils, CMAs, VICSES, DSE, Melbourne Water Interviews with local councils, CMAs, VICSES, DSE, Melbourne Water
3 3a	**Message Construction and Communication** Adequacy and timeliness of flood information and warnings to the community	▪ **Assess** the adequacy (e.g. clarity, relevance, local tailoring) and timeliness of flood information and warnings to the community particularly in relation to the 2010-11 floods	<u>Evaluation steps:</u> 1. Review community responses and interview stakeholders regarding the adequacy and timeliness of flood information and warnings in relation to the	Social research reports e.g. focus groups, community surveys Interviews with Information

No.	Objective To assess:	Scope	Methods	Data sources
			2010-11 floods. 2. Compare the time at which the BoM issued initial warnings to when community warnings and information were issued by the SES for selected catchments to estimate overall time taken for interpretation and message construction/communication 3. Benchmark 1. and 2. against best practices to ascertain timeliness and adequacy of flood information and warnings to the community particularly in relation to the 2010-11 floods	Officers, Incident Controllers, OESC, ABC, VicRoads. BOM flood warnings issued Community warnings and flood information issued from media monitoring, ABC, OESC, VicRoads Flood Warning Manual, Victorian Warning Protocol and Choosing Your Words
3b	Adherence against best practice for message construction and communication including the Victoria Warning Protocol	▪ **Assess** how well message construction and communication used in the 2010-11 floods adhered to best practice including the Victoria Warning Protocol	<u>Evaluation steps:</u> 1. Identify best practice in message construction and communication including accessibility standards for CALD, disability and 'vulnerable' communities 2. Assess message construction and communication used in the	Victorian Warning Protocol, EMA Flood Warning Manual, Choosing Your Words Examples of media releases, other warning information Interviews with Information Officers, Incident Controllers

No.	Objective To assess:	Scope	Methods	Data sources
			2010-11 floods in relation to 1.	
3c	Adequacy of systems to construct and communicate messages	▪ **Assess** how adequate (coverage of flood-affected communities, efficiency) systems are to construct and communicated messages	<u>Evaluation steps:</u> 1. Assess the coverage of flood information and warning systems (e.g. Emergency Alert, Shepparton system) across flood-affected communities in Victoria and identify any gaps 2. Assess the efficiency (e.g. ease-of-use) of technical and non-technical systems used to construct and communicate messages in relation to the 2010-11 floods and identify any improvements	Interviews with Information Officers, DSE, OESC, VicRoads Social research re receipt of warnings Interviews with Information Officers, DSE, OESC, VICSES, other emergency agencies
3d	The role and effectiveness of information units within IMTs (including the SCC and ICCs)	▪ **Assess** the appropriateness of the role and the effectiveness of information units in IMTs in relation to message construction and communication	<u>Evaluation steps:</u> 1. Assess the perceived appropriateness of the role of information units in ICCs for message construction and communication 2. Assess the perceived effectiveness of information units	Interview Information Officers in SCC, ICCs Incident Controllers Interview Information Officers in SCC, ICCs

No.	Objective To assess:	Scope	Methods	Data sources
			within IMTs for message construction and communication particularly during the 2010-11 floods	Incident Controllers
3e	Influence of social media	▪ **Gauge** the influence of social media during the 2010-11 floods	Evaluation steps: 1. Collect data and views about social media usage (e.g. rates, types of use, types of social media) during the 2010-11 floods 2. Compare social media usage to 'traditional' forms of communication (e.g. media, websites) used in the 2010-11 floods in Victoria and also for the 2011 Queensland floods	Social research e.g. OESC survey Interviews with VICSES, OESC, DSE, VicPol, VicRoads, CFA Social research e.g. survey
3f	Communication with CALD and vulnerable groups	▪ **Assess** the effectiveness of communication with CALD and vulnerable groups	Evaluation steps: 1. Locate examples of CALD and vulnerable groups impacted by the 2010-11 floods 2. Assess effectiveness of communication with these groups during 2010-11 floods	Interviews with Department of Health, Department of Human Services Social research e.g. surveys Interviews with Department of Health, Department of Human Services

No.	Objective To assess:	Scope	Methods	Data sources
4. 4a	**Community and emergency response** Community response and attitudes to flood information and warnings	▪ **Assess** the community responses and attitudes to flood information and warnings issued during the 2010-11 floods	Evaluation steps: 1. Identify community responses and attitudes to flood information and warnings in a sample of communities affected by the 2010-11 floods 2. Compare responses and attitudes to those desired by emergency agencies and analyse reasons for any divergences	Social research e.g. surveys, focus groups Interviews with VICSES, OESC, other emergency agencies Molino Stewart to provide VFR with 'past learnings'
4b	The influence of prior community education	▪ **Assess** the influence of prior community flood education in flood preparedness, response and recovery in relation to the 2010-11 floods	Evaluation steps: 1. Identify the extent and nature of previous community flood education in flood-affected communities including CALD communities, remote areas and people with disabilities 2. Analyse the effectiveness of prior community flood education in preparedness, appropriate response and recovery including CALD communities, remote areas	Interviews with VICSES, local councils, CMAs Flood education programs and resources Number of emergency plans in communities Social research Interviews with VICSES, local councils, Department of Health, Department of Human

No.	Objective To assess:	Scope	Methods	Data sources
			and people with disabilities	Services Analysis for 4d
4c	Community expectations for flood information and warnings	▪ **Identify** and **analyse** the current level/s of community expectations for flood information and warnings	Evaluation steps: 1. Collect data on community expectations for flood information and warnings 2. Analyse data and identify level/s of community expectations for flood information and warnings 3. Compare 2. with what is able to be achieved (e.g. timeliness, accuracy, clarity) by the current TWS	Social research e.g. surveys, focus groups Interviews with BoM, VICSES, CMAs, local councils
4d	Effectiveness of warnings in reducing flood damage	▪ **Assess** the effectiveness of warnings in reducing flood damage related to the 2010-11 floods	Evaluation steps: 1. Obtain estimates of potential damages caused by floods in a sample of catchments/locations 2. Obtain estimates of damages caused by the 2010-11 floods in the same sample of catchments/locations 3. Compare 1. with 2. to obtain	DSE, CMA data, insurance data DSE data

No.	Objective To assess:	Scope	Methods	Data sources
			some quantitative view of the influence of warnings and education in reducing flood damage 4. Obtain anecdotal evidence of the impact of warnings in reducing damage during the 2010-11 floods 5. Compare results of 3. with 4 to obtain idea of the effectiveness of warnings in reducing flood damage	Social research e.g. focus groups, surveys
4e	Community behaviour in response to evacuation warnings	▪ **Identify** and **assess** the community behaviours in response to evacuation warnings during the 2010-11 floods	Evaluation steps: 1. Locate catchments/locations in which evacuation warnings were issued 2. Estimate evacuation rates in these communities 3. Analyse reasons why people did or did not evacuate after receiving	VICSES records, media monitoring Registrations at evacuation centres Emergency Alert data Social research e.g. surveys Interviews with VICSES, Department of Human Services, VicPol, Red Cross

No.	Objective To assess:	Scope	Methods	Data sources
			evacuation warnings	
4f	Adequacy of evacuation decision-making and warnings	▪ **Assess** the adequacy of evacuation decision-making and warnings	<u>Evaluation steps:</u> 1. Identify intelligence used by IMTs to inform evacuation decisions and analyse whether this was adequate 2. Assess whether the evacuation warning was warranted or whether there were communities in which evacuation warnings should have been issued 3. Assess the time taken for IMTs to make evacuation decisions and to issue evacuation warnings	Interviews with Incident Controllers Interviews with Incident Controllers, VICSES, DSE, OESC, other emergency agencies, CMAs, local councils Social research e.g. surveys, focus groups Interviews with Incident Controllers, VICSES, DSE, OESC, other emergency agencies, CMAs, local councils