Hydrology of the November 2005 Floods

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Introduction

The floods of November 2005 were significant in that the effects were both widespread, with many catchments being affected, and in some instances severe, with large damage costs and significant impacts on infrastructure and society.

This paper will examine the floods to put them in context of their likelihood, and provide information on their impact on the extent of knowledge of flood hydrology in South Australia.

Flood Hydrology – an Overview

Flood hydrology involves the prediction of peak flows and flood hydrographs (a flow versus time prediction) within catchments for a range of probabilities. It is based on available information on the response of the catchments over a long time and to large rainfall events. By a combination of examining the pattern of flooding over a long term, and individual storm events the picture can be built up of the likelihood of a flood event of a particular magnitude occurring.

This prediction can then be used in the production of floodplain mapping, where the extents of flooding of various probabilities occurring can be mapped, and in the design of flood mitigation works.

Flood hydrology is limited in the most part by the lack of information, mainly for large floods. Most reliable flood records in South Australia go back 30 years, when the State Government put a large investment in the collection of data. Unfortunately the level of confidence in the prediction of flood flow reduces with the magnitude of the flood. The more extreme the flood, the greater the uncertainty. With 30 years of data there is only reasonable certainty of the prediction of flows up to say the 50 year flood, above which the error band increases. This is only more an issue of course on catchments where there is no data available, as every catchment behaves in a different fashion, due to differences in soil and rock types, land use and vegetation.

Compounding this is the errors that are induced because of the measurement of large flows in rivers, and the fact that the period of record is only a minor part of a long term historical record, and there may be long term cycles in flooding that have not been recognised.

Measuring the Flood

We are fortunate in that in more recent times the technology and cost of the collection of data has come down, and this is particularly the case with the gathering of rainfall data, where electronic data loggers have replaced the charts that were used. However the collection of stream flow data is still an expensive exercise, with the hardware required being subject to failure when most needed, recording large flows.

In the most part gauging stations performed adequately during the November flood, but a flood of the magnitude of the November floods can significantly alter channel shape, or impact directly on the measuring equipment.

The gauging station on Sixth Creek is an example of the impact of channel shape. The weir that provides a stable section for monitoring has been outflanked, so the estimation of flow becomes difficult. The gauging station at the Stradbroke Primary School on Fourth Creek had the pressure transducer, used to measure flow depth, washed away. Figure 1 shows the measured hydrograph on Fourth Creek, which returns to zero flow at about 9:15pm, with a predicted hydrograph produced by a hydrological model at the station.

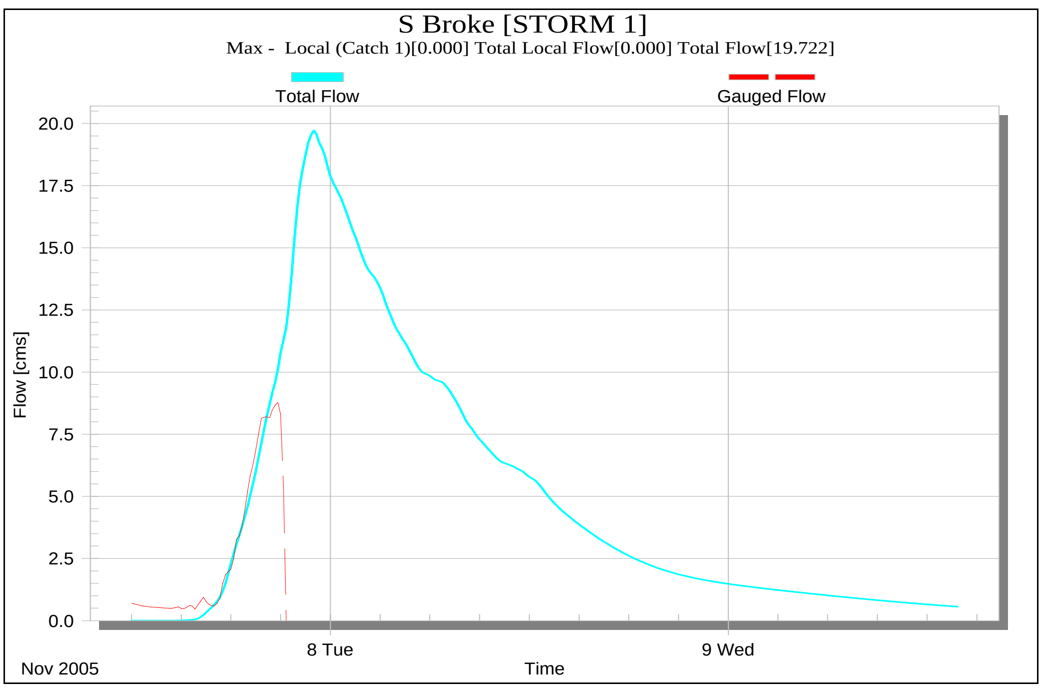

Figure 1 Measured and Predicted Hydrograph in Fourth Creek at Stradbroke Road

If the flow is higher than catered for by the station setup there is also a problem. Figure 2 shows the measured hydrograph in First Creek above the waterfall, where the flow appears to return to close to zero just before the peak. A visit to the station revealed that the instrumentation was completely submerged at around that time, leading to the false reading.

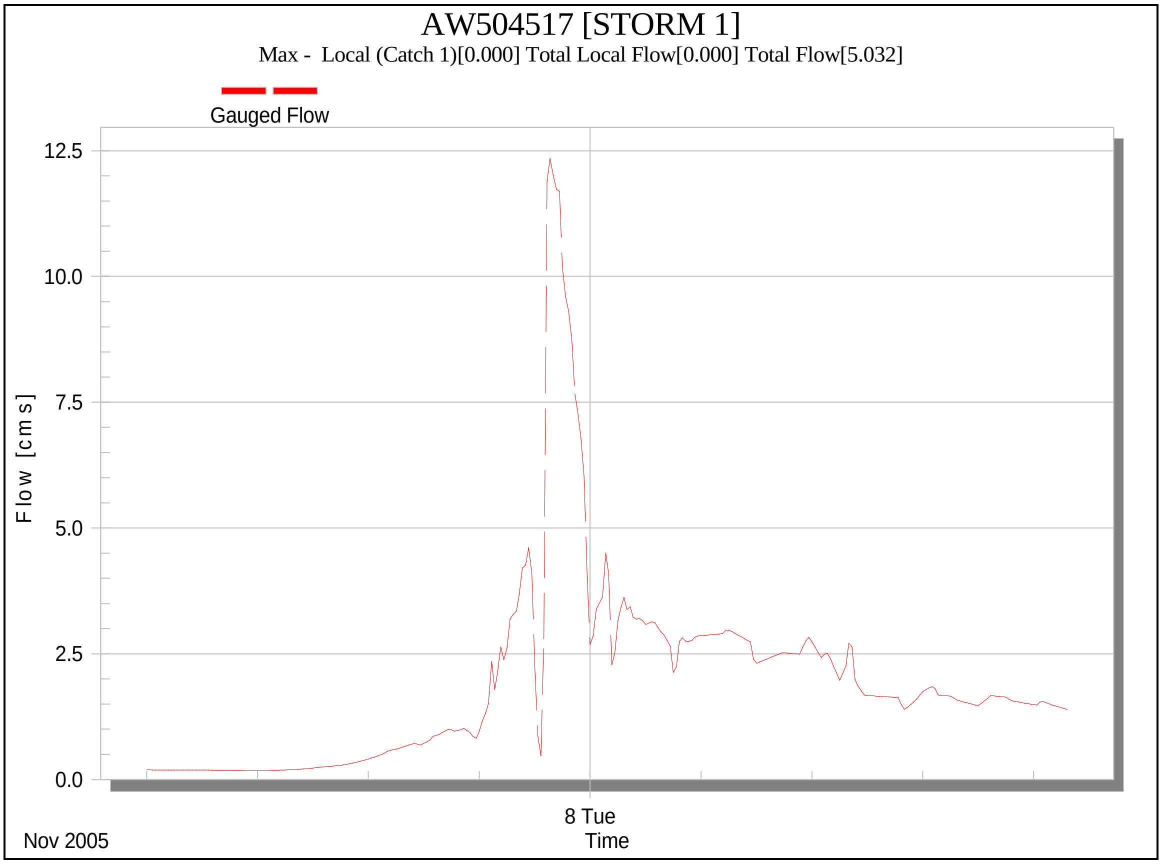

Figure 2 Measured Hydrograph in First Creek Above the Waterfall

There is a need to visit the gauging stations as soon as possible after a major flood, to confirm the peak level, and thus flow. A visit two days after the flood showed the cause of the problem with the First Creek hydrograph (Figure 3). Even if the hydrograph is apparently good, there can be a problem. This was the case on Fifth Creek, where the recorded peak level was different to the measured peak level.

Figure 3 First Creek Gauging Station Above the Waterfall - Author Showing Peak Water Level

Factors Affecting Flood Hydrology

In order to put the November Floods into context it is useful to consider the factors that affect catchment response, and thus the flood produced when rainfall occurs on the catchment.

The response of a catchment depends on the rainfall input, and the state of the catchment. In summer, floods occur because of storm events with large rainfall amounts, or very extreme rainfall intensities. There is generally a large initial loss before runoff occurs. In winter, smaller rainfalls can produce flooding as the losses are generally lower. This happens because the catchments are generally already wet, and do not require as much rainfall for runoff to occur.

Peak flows also depend on the storage levels in reservoirs, and to a lesser extent farm dams. This is because these storages must be filled for flows to be passed downstream. A reservoir that has gates controlling outflow can affect downstream flows. Figure 4 shows the influence of the Mount Bold reservoir on the flows in the Onkaparinga River during the flood. The Houlgraves weir is just upstream of the reservoir, and the Clarendon Weir below.

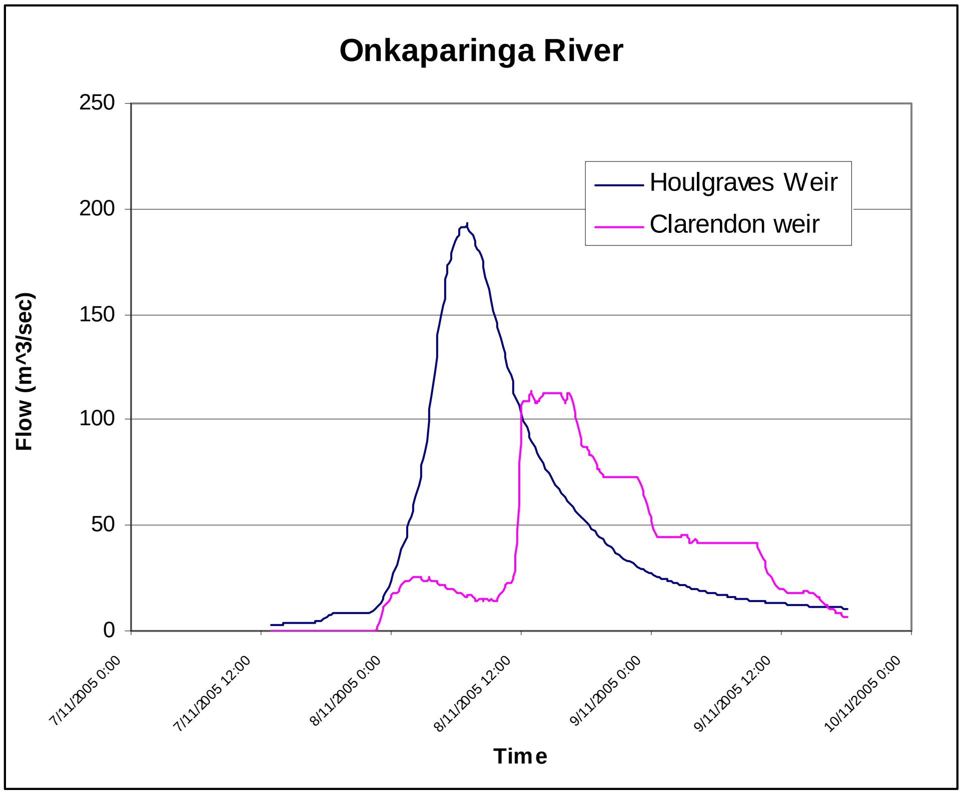

Figure 4 Onkaparinga River, Showing the Influence of the Mount Bold Dam

The probability of the rainfalls that occurred in November 2005 is greater than the probability of the floods, due to the condition of the catchments and dams when the rainfall event that caused the floods occurred.

The catchments were in a very wet state, and the dams were full or close to it. The highest rainfall intensities were confined to the higher parts of the ranges, centred on the Sixth Creek catchment, with a second cell in the upper catchment of the Gawler River. The peak 48 hour rainfall intensity was 50 year ARI (Average Recurrence Interval) on the Sixth Creek catchment, and 10 – 20 years on the upper Gawler River catchment.

The rainfall pattern resulted in a wide range of flow ARIs, even within a single catchment.

Flows

The peak flows for the floods have been assessed using stream gauge data, both from recorded information at the site, or from hydraulic analysis to match measured flood levels.

Where possible, and particularly in the eastern suburbs where a flood study and floodplain mapping is in progress, the total flow hydrograph was obtained and compared with the output from a hydrological model, which seeks to replicate the runoff process within the catchment. This showed up any gross errors.

In general the flooding pattern followed the rainfall pattern, with the largest floods occurring in the catchments closest to the area around Uraidla, as well as the Gawler River. The most extreme flows occurred in the catchments of Aldgate Creek, the rural part of Brown Hill Creek and First Creek, Cox Creek, Fourth Creek, Fifth Creek and Sixth Creek. Of these First Creek in Waterfall Gully and Cox Creek had flows in excess of 100 years ARI, according to hydrology previously carried out for flood studies. The other catchments had flows in the range of 50 to 100 years ARI.

Away from this centre the peak flows were less significant. Due to the larger catchment size the flow in the Gawler River was of the order of 10 years ARI.

One qualifier on the assessment above is that as the ARI of the event goes up, the uncertainty does also. Although it is reasonably certain that the Gawler River flow was of the order of 10 years, there is a greater degree of uncertainty on the actual ARI of flows near Mount Lofty.

First Creek

The First Creek in Waterfall Gully was the subject to a more detailed investigation than any other catchment, partly because it is the subject of a current flood study, but more importantly because the flow appeared to be several times larger than the predicted 100 year ARI flow from the study.

Because the instrumentation at the gauging station was overtopped, and the recorded hydrograph unreliable, the steering committee for the flood study arranged survey of creek sections and flood levels both upstream and downstream of the gauging station, and at the gauging station itself. From this estimates of the flow were obtained, which gave a better idea of the actual peak flow of the event.

It was found that the recorded hydrograph, adjusted to give a more reasonable peak flow could not be fitted with the hydrological model. To do this would have required more runoff than rainfall at times during the flood. Figure 5 shows that the model could predict most of the flood, but could not account for the peak.

Investigation within the catchment revealed that there had been a substantial amount of erosion, and indeed a mass failure in the sediments that made up Wilson’s Bog.

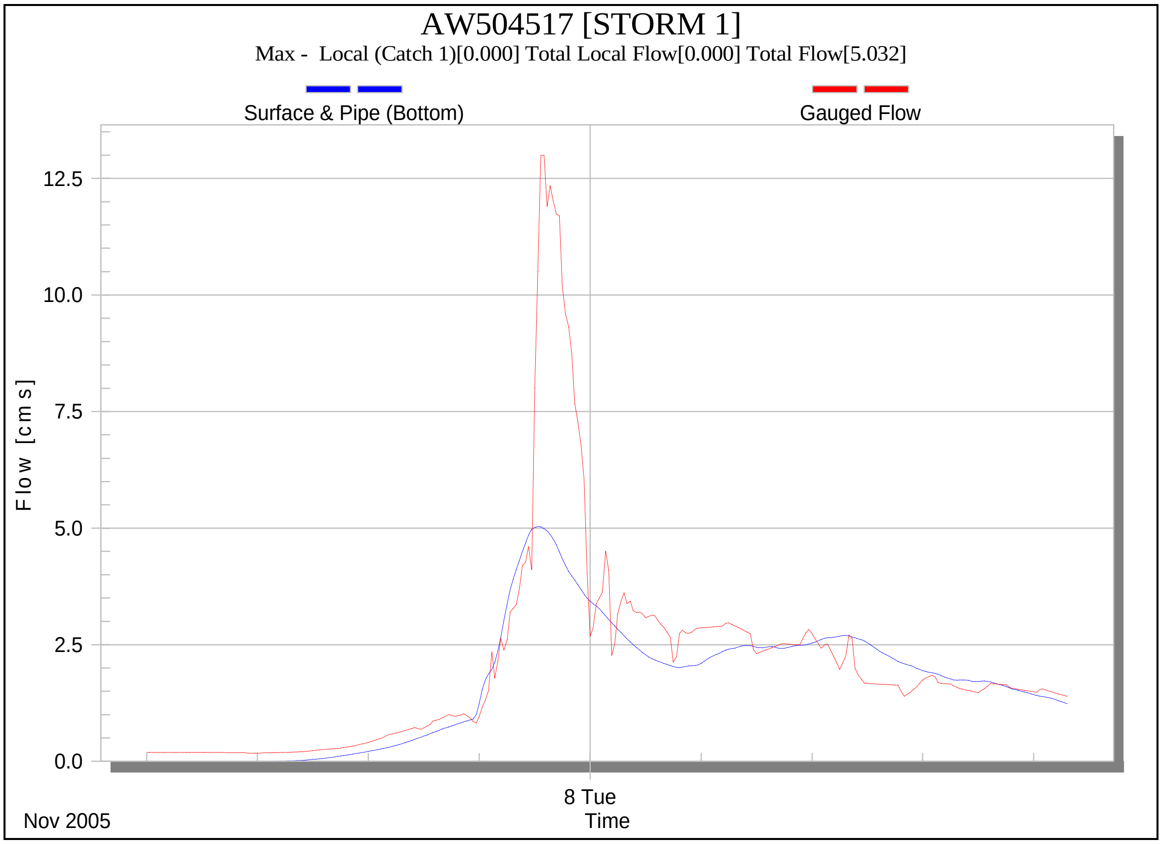

Figure 5 Adjusted Hydrograph and Predicted Flow in Waterfall Gully

The failure of Wilson's Bog represented mechanism by which floods much larger than expected with normal runoff processes could occur, and it was necessary to obtain more information on the causes and likelihood of the mechanism. A report by a geomorphologist was commissioned, that gave more information on which to base an assessment of the ARI of the November flood. It is now thought that the most likely ARI of the flood in Waterfall Gully was 100 years. However, since the catchment above the waterfall only contributes a minor amount to the creek within the urban area, and the rainfall was a lot lower on the plains, the ARI of the flow in Norwood to the Botanic Gardens was only of the order of 10 – 20 years ARI.

The November flood has revealed an unexpected result, which may have implications on flood prediction both in South Australia, and Australia in general.

Figure 6 Erosion in Wilson's Bog, First Creek Catchment

Figure 7 Wilson's Bog, First Creek Catchment

Conclusions

The floods of November 2005 were significant in both the magnitude on the floods that occurred and in the spread of catchments over which the flooding was spread. They gave a good opportunity to examine the flood hydrology of the catchments, and to review previous predictions.

To summarise:

- The rainfall fell onto catchments that were wet. Reservoirs were full or close to it. The resultant floods that had a lower probability than the rainfall that caused them.
- Floods of this magnitude tend to create problems at gauging sites, so on ground measurement of peak levels was required. This was best done within days of the flood, when the evidence was still fresh.
- The floods with the lowest probability occurred in the highest parts of the Mount Lofty Ranges.
- The floods lead to a review of flood frequency in First Creek. They revealed a flood producing mechanism that was not previously known.
- There will always be uncertainty in the estimation of the probability of floods like this.