A STORY OF BRISBANE FLOODS
WIVENHOE DAM OPERATIONS 8 – 13 JANUARY 2011
Compiled by Roger Brewster

The newspaper reports of mismanagement of the Wivenhoe Dam during the early phases of the January 2011 Brisbane floods have been compared to the chronology published in the Queensland Floods Commission of Inquiry (QFCI) Interim Report. These records indicate that while there may have been some errors of judgement, the dam engineers operated in a reasonable response to the developing situation.

Full water supply level (FSL) in the Wivenhoe Dam is a lake level of 67.0 metres. At 75% of FSL, the lake level is 64.0 metres. Flow modelling in February 2011 showed if the Wivenhoe manual had been amended so that gate operations would occur when the water level exceeded 75 per cent, that for the January 2011 event, the peak flow out of the dam would have been 4512 m^3/s, a 40 per cent reduction on the actual peak flow of the event (7528 m^3/s).

The published chronology from Chapter 2 of the QFCI Interim Report and the detailed strategies are reproduced below.

Flood releases are not made at Wivenhoe Dam until the lake level exceeds 67.25 metres. The first flood strategy to be used to operate the dam is W1; the primary consideration at this stage is minimising disruption to downstream rural life. The aim is to keep seven particular downstream bridges open for as long as possible:

Strategy	Bridge aimed to be kept open (maximum flow until bridge is submerged)[344]	Lake level trigger (m)	Trigger for commencement of strategy and status of gates[345]
W1A	Twin Bridges (50 m^3/s including the Lockyer Creek) Savages Crossing (110 m^3/s including the Lockyer Creek) Colleges Crossing (175 m^3/s including the Lockyer Creek)	67.25	7.42 am, 6 January. All gates closed.
W1B	Colleges Crossing (175 m^3/s including the Lockyer Creek) Burtons Bridge (430 m^3/s including the Lockyer Creek)	67.50	Lake level measured at 67.52m, at 2.00 am, 7 January. All gates closed.
W1C	Burtons Bridge (430 m^3/s including the Lockyer Creek) Kholo Bridge (550 m^3/s including the Lockyer Creek)	67.75	Lake level measured at 67.75m at 9.00 am, 7 January. All gates closed.
W1D	Kholo Bridge (550 m^3/s including the Lockyer Creek) Mt Crosby Weir Bridge (1900 m^3/s including the Lockyer Creek)	68.00	Lake level measured 68.03m at 3.00 pm, 7 January. First gate opened at 3.00 pm, 7 January.
W1E	Mt Crosby Weir Bridge (1900 m^3/s including the Lockyer Creek) Fernvale Bridge (2000 m^3/s including the Lockyer Creek)	68.25	Lake level measured at 68.26m at 10.00 pm, 7 January. Transition to W3 at 8.00 am, 8 January when the lake level measured 68.52m.

Strategy W2 requires the releases from Wivenhoe to be managed so that the flow in the Brisbane River does not exceed the naturally occurring peaks at Lowood and Moggill (in the tidal range area).

Strategy W3 requires the flow at Moggill to be limited to 4000 m^3/s, the threshold of non-damaging flows in urban Brisbane, according to the Wivenhoe manual. Outflows from Wivenhoe reach Moggill 16 hours after release, a large time lag for controlling dam releases and taking into account downstream flows from the Lockyer Creek and Bremer River catchments, as well as other local catchments affecting Brisbane.

Strategy W4 - The only consideration when operating Wivenhoe at a lake level above 74.0 metres in accordance with W4 is the safety of the dam. The strategy is to open the gates continuously, as far as is safely possible, until outflows match inflows and the lake level stabilises. In these circumstances, it means that a rapid rise in releases from the dam is inevitable. The first Dam wall fuse plug initiates at 75.5 metres.

Flood alert

Courtesy of La Nina, the summer rains came. December 2010 was the wettest on record for Queensland. South East Queensland was saturated. The dams were full.

In the 24 hours to 9.00 am on 6 January 2011, the Wivenhoe and Somerset dams' catchment experienced steady rainfall in the order of 20 to 50 millimetres (mm). At 7.00 am that day, the Wivenhoe lake level was 67.31 metres and the Somerset lake level was 99.34 metres. Flood releases are expected at those lake levels and the flood operations centre was mobilised at 7.42 am. The start of this flood event was similar to those that affected the dams in October and December 2010 – but that is where the similarity ends.

"The Wivenhoe manual requires a transition to strategy W2 or W3 when the Wivenhoe lake level exceeds 68.50 metres, as it did at 8.00 am on 8 January. At 8.00 am, the requirements of strategy *W2* were impossible to meet–the predicted natural peak was 530 m^3/s at Lowood and 770 m^3/s at Moggill–while releases from Wivenhoe were already in the order of 900 m^3/s."

"The flood engineers moved immediately to strategy W3 [at 8.00 am], which on their understanding required the flow at Moggill to be limited to 4000 m^3/s." [The Australian asserts the actual strategy was maintained at W1D early on 8 January.]

However the Interim report also records that "from 8.00 am to 5.00 pm on 8 January, the lake level at Wivenhoe rose extremely slowly, from 68.52 metres to 68.65 metres. The rate of rise averaged just 1.4 centimetres per hour. The lake stabilised at 68.65 metres until 11.00 pm and then *decreased slowly*, recording 68.54 metres at 12.00 pm on *9 January*. The flood engineers' strategy during this time was to minimise releases. Two bridges remained open (Fernvale Bridge and Mt Crosby Weir) and at this stage the flood engineers thought that they would be able to keep them open."

The Interim report records that "On 8 January, the falls in the catchments upstream of the dams were relatively small, generally less than 30 millimetres, with some instances over 40 millimetres. With the lake level under 69 metres, the flood engineers were comfortable maintaining releases of under 1250 m^3/s. They reasoned that if the forecast rain did fall, there was sufficient storage capacity in the lake to contain it."

A period of about 5 hours was problematic on 9 January:

> At 3.30 pm, all four flood engineers met to discuss the strategy to be adopted. Wivenhoe's lake level was 68.61 metres, and they were in strategy *W3*. The seven day forecast indicated three days of solid rain ahead, and a severe weather warning

was current for the dam catchments. The three day ACCESS forecasts predicted average falls of 140 mm in the Somerset catchment and 170 mm in the Wivenhoe catchment. The five day ACCESS forecasts predicted average falls of 141 mm in the Somerset catchment and 171 mm in the Wivenhoe catchment. A large volume of water was on the ground and expected to flow into the dam and cause the lake level to rise to 70.5 metres. The 'with forecast' model of the lake level showed a peak of 71.8 metres. The Bureau's ACCESS model and general synoptic forecast indicated the rainfall system currently drenching the dam catchments was expected to move south in 24 to 36 hours.

The four flood engineers decided to maintain releases at around 1400 m^3/s in an attempt to keep Fernvale Bridge and Mt Crosby Weir Bridge open [effectively strategy W1E], given rainfall was expected to increase the flows from the Lockyer Creek and the Bremer River. The flood engineers were concerned that if they increased releases and the rain system moved south, they might increase flooding downstream.

The predicted peak lake level from the 'without forecast' model which until midday on 9 January was consistently below 69.0 metres, was then predicted to reach 72.7 metres in the model run at 8.00 pm on 9 January. (The 'with forecast' model run at 8.00 pm was the first to return a peak lake level of over 74 metres, the trigger point for strategy W4.) On the basis of these developments, at 9.04 pm the flood engineers abandoned all plans of keeping Fernvale Bridge and Mt Crosby Weir Bridge open. The inflows were too high to maintain sufficiently low releases." [Strategy W3 was therefore invoked at about 9 pm on Sunday 9 January.

Holding Moggill flows to 4000m^3/s

Increasing the outflows from Wivenhoe caused a difference of opinion between the flood engineers on duty and Ken Morris of the Brisbane City Council. "Mr Morris took issue with a statement in the most recent situation report that the limit of non-damaging flows downstream of Moggill was 4000 m^3/s, stating that the council's information was that 3500 m^3/s was the correct figure."

Later in the morning of 10 January, the new shift engineers indicated that "they would attempt to limit the flow at Moggill to 3500 m^3/s; which reflected the council's view that that figure represented the lower limit of damaging flows in urban Brisbane and was consistent with the W3 aim of protecting urban areas from inundation." Releases were around 1800 m^3/s compared to inflows of 9312 m^3/s [obviously a very large differential]. At 5 am the lake level was 70.77 metres and rising sharply, having risen 40 centimetres in the previous two hours. However, with inflows from the upper catchment diminishing, the flood engineers expected the event could be contained within strategy W3.

However, the situation report issued earlier at 6.30 am on 10 January "warned that the threshold of damaging discharge in urban areas might be exceeded within 24 to 48 hours if predicted rainfall in the downstream tributary catchments eventuated." [The lesson here is that the dam manual flood strategies cannot be isolated from events occurring in downstream catchments. A different flood model is needed that can assess and direct appropriate catchment-wide strategies including the Bremer.]

"Around midday on 10 January, the flood engineers still intended to keep flows in the Brisbane River at Moggill to 3500 m^3/s, the figure mentioned in their discussions with the Brisbane City council. The 10.00 am quantitative precipitation forecast issued by the Bureau indicated 50 to 100 mm of rain was expected in the next 24 hours in the dam catchments. By 3.00 pm, the plan to keep flows at Moggill to 3500 m^3/s was overtaken by significant rain falling in the dams' catchment: the aim was changed to hold the flow at Moggill to 4000 m^3/s. [in fact the estimated Moggill flow rates from

6.00 pm on 9 January to 8.00 am on 10 January were less than 2000 m^3/s. This rate then rose slowly to 4000 m^3/s by about 11.00 am on Tuesday 11 January]

The dam levels at Wivenhoe and Somerset were both rising–at Wivenhoe, the lake level was 72.54 metres, having risen over a metre since 8.00 am." [The flood engineers did not know until an email at 5.32 pm from the Bureau of Meteorology, of a flash flood event in the Lockyer Creek catchment – later that night estimated by BOM to be as much as 600 mm in the Lockyer catchment.]

The flood engineers worked on options to hold back releases until after the Lockyer peak had entered the Brisbane River. Mr Ayre contacted the dam safety regulator, Mr Allen, to discuss a possible departure from the procedures of the Wivenhoe manual to exceed 74.0 metres for a short period without invoking strategy W4.

[During the period from 9 pm on Sunday 9 January to about 3.00 pm on Monday 10 January, the outflows from Wivenhoe could have been increased to hold the flow at Moggill (16 hours later) to 4000 m^3/s despite the BCC objections. This would have had only a marginal effect on continuing rising lake levels from about 71.0 to 73.0 m.]

11 January 2011- the deluge

The Interim Report records that in the early hours of Tuesday 11 January, "intense rainfall again fell over the dam catchments. The estimate was of over 700 mm, an enormous amount. As a result of that estimate, inflow estimates increased sharply, up to 6817 m^3/s by 6.00 am and 8060 m^3/s by 8.00 am. Discharge from the dam was fairly constant, around 2700 m^3/s. The lake level was moving steadily up toward 73.5 metres."

"The models indicated the lake level would peak at or above 74.0 metres, both with and without forecast rainfall. The flood engineers did not move to strategy W4 at this time, which they considered would require stabilising the lake level by opening the gates quickly to match outflows and inflows. Instead they strove to keep the dam operating in strategy W3. With unknown inflows from the Lockyer Creek, a rainfall system moving south to areas downstream of the dam and a dam level more than 0.5 metres below 74.0 metres, the flood engineers did not want to release large volumes until they considered it absolutely necessary." [The estimated flow at Moggill was still only 3480 m^3/s at 8.00 am, but could not be contained]

However the modelling showed the rapid rate of rise in Wivenhoe's lake level and inflows. "Confirmation of continuing heavy rain finally ended the hope that the flood could be contained in strategy W3. Strategy W4 was invoked, for the first time in Wivenhoe's history, at 8.00 am on Tuesday 11 January."

"The strategy at 12.00 pm was to attempt to limit releases to 4500 m^3/s. Further rainfall prevented this being achieved, and by 6.00 pm, the flood engineers were predicting releases of around 8000 m3/s. Inflows actually peaked at 11 561 m^3/s at 1.00 pm, when outflows had increased to 4250 m^3/s. The lake peaked at 74.97 metres at 7.00 pm when outflows for the first time exceeded inflows: 7464 m^3/s to 6876 m^3/s. The flood engineers were reviewing strategies on flood gate openings every 30 minutes. By 9.00 pm the flood engineers were satisfied that the lake level had stabilised and would start to fall."

Lookout Brisbane

"The peak release from Wivenhoe was at 7.00 pm on 11 January (7464 m^3/s) and the peak flow at Moggill was 16 hours later at 11.00 am on 12 January (12 095 m^3/s). Drawing a conclusion from these figures is complicated by the fact that the flows from

the Lockyer Creek and Bremer River were also affecting Moggill at this time. However, those figures at least show that the water from Wivenhoe constituted a significant portion of the peak of 12 095 m^3/s at Moggill." [See Figure 2h on page 4.]

The Brisbane River at the City Gauge peaked early in the morning of Thursday 13 January at 4.46 metres, a metre less than in the 1974 flood.

In the flood peak, 14 100 Brisbane properties were affected. The CBD closed down.

The wisdom of hindsight

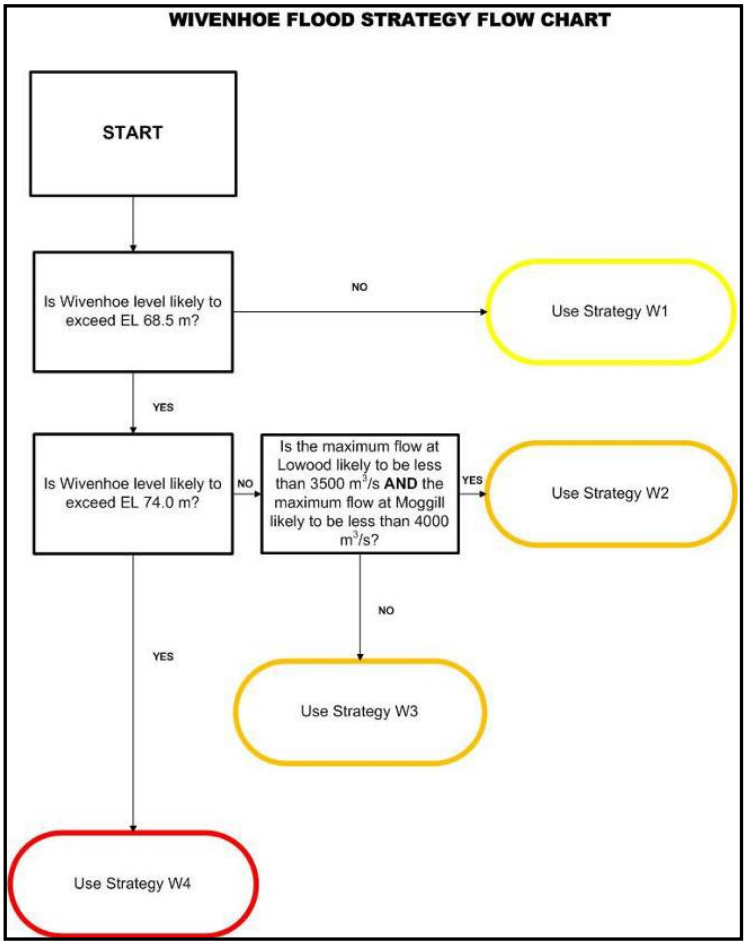
The Interim report notes on page 82:

> "It is arguable that, objectively considered, and taking forecast rainfall into account, the conditions existed at 3.00 pm, 10 January 2011 for a move to W4. The lake level was 72.54 metres, having risen more than a metre since 8.00 am that morning. The predicted peak, according to the 'without forecast' model was 73.6 metres; according to the 'with forecast' model it was 75.2 metres. The inflows far exceeded releases (8411 m^3/s to 2087 m^3/s) and had shown no sign of any consistent fall. The 10.00 am quantitative precipitation forecast was predicting 50 to 100 millimetres in the catchment; it was raining at the dam; the three day forecast, issued at 10.00 pm the night before, predicted peak inflows in the range of 8000 m^3/s. It was known that the lake level was capable of rising two or three metres in the space of 24 hours.
>
> However, hindsight judgment of this kind can be confounded by events. Had the engineers taken the approach suggested, the result for downstream communities might well have been worse, for the simple reason that there was an unknown factor at that stage. The extraordinary flooding in the upper Lockyer Creek had started about two hours earlier. Those flows would add significantly to the water moving down the Brisbane River. Meanwhile, the flows into the Wivenhoe Dam actually started to decrease from 3.00 pm on 10 January until the early hours of the following morning.
>
> The example is useful to illustrate this proposition: there will always be a range of possible judgments, and the one which might seem most appropriate on the evidence may not, as events unfold, produce the optimal outcome. The best approach is to ensure that the flood engineers are guided in their decision-making by a clear, unambiguous manual, based on the best available science, and are equipped with ample and up-to-date modelling tools."

The Final report of the Commission notes on pages 524-526:

> The Commission asked (expert consultant) Mr Babister to model the effects of a number of different gate opening strategies and show the effect such strategies would have on the maximum river heights in the Brisbane River relative to the way in which the dam was operated during January 2011. Mr Babister concluded, in light of the information available at the time, that, allowing for the limits of the strategies in the Wivenhoe manual, the flood engineers achieved close to the best possible flood mitigation result for the January 2011 flood event.
>
> Mr Babister's perception was that the flood engineers managed Wivenhoe Dam so that its flood mitigation effect was 'very close' to the maximum achievable within the constraints of the manual.
>
> A strategy that might provide flood mitigation in one flood may not work in different conditions, so this cannot be used as a firm guide for how future floods should be approached

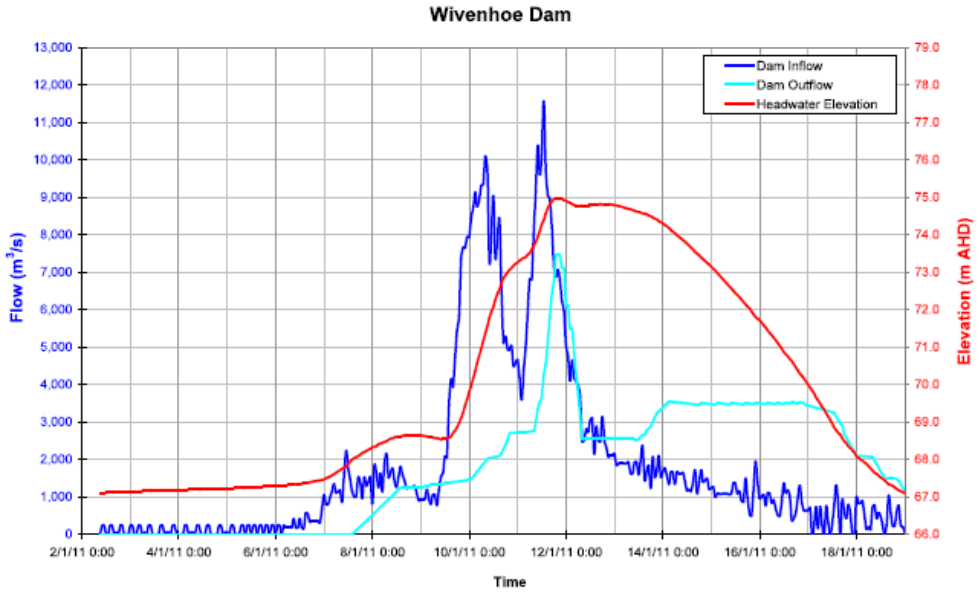
Roger Brewster
Technical and Best Practice Coordinator
Flood Taskforce
Department of State Development, Infrastructure and Planning



Source: Queensland Floods Commission of Inquiry Final Report Page 446

The figure below indicates the two peaks in inflow affecting the dam between 9 and 12 January.

Figure 2(h)



Source: Seqwater, January 2011 Flood Event Report on the operation of Somerset Dam and Wivenhoe Dam, 2 March 2011, page iv.

Source: QFCI Interim report page 79.