South East Queensland Flooding, January 2011

11 March 2011

Pine Mountain Botanics Pty Ltd
[redacted]
Brassall Qld 4305

Revision	15 March 2011

Contents

1.0 Synopsis

This submission is considered relevant to the Queensland Floods Commission of Inquiry under Section 2(f) of the Terms of Reference –

> *Implementation of systems operation plans for dams across the state and in particular the Wivenhoe and Somerset release strategy and an assessment of compliance with, and the suitability of the operational procedures relating to flood mitigation and dam safety.*

In preparing this submission severe limitations have been imposed on the ability to prepare this submission, including

- The fact that we were flooded and living under very difficult and poor conditions that make it hard to make a well considered and timely submission;
- the time constraint in meeting the deadline for submissions;
- the limited access to timely information and data; and
- the small window of opportunity to consider the SEQ Water Flood Report prior to making this submission.

There are aspects to this submission that should be explored further, including in the context of identifying the various component parts of the flood storage capacity at Wivenhoe and attempting to relate these back to the actual events that unfolded from Sunday 9 January to Wednesday 12 January. This would greatly assist in more fully appreciating the practical difficulties of operating within the strategies of the Manual with a view to better identifying how those strategies could be improved and thereby benefit the local communities in future.

It is not the intention of this submission to, in any way implicate anyone, or apportion blame, but it is important to try and understand both the capability of the dams and the events that unfolded in order to put forward possible corrective measures and solutions.

2.0 Summary and Conclusions

The severe weather event from 6 January to 12 January was reasonably foreseeable but the intensity of storm events in some areas from Sunday through to Monday were beyond comprehension.

This submission is not complete but does focus on the catchment areas, and in particular those that relate to Wivenhoe and Somerset Dams. It seeks to understand the relevant functions undertaken by these dams with a view to ascertaining the extent to which these dams are capable of performing their flood mitigation roles. Also it seeks to identify some possible structural and operational deficiencies and address options that could be put in place prior to the 2012 wet season.

- The public in general may not have a good appreciation about the extent to which the mitigation capabilities of Somerset and Wivenhoe Dams have changed over the years and this should be address. This level of appreciation may also extend to businesses and local authorities who may not have considered revising their policies post those changes.

- Pressures to adjust the full supply level of Wivenhoe upwards as a future fresh water resource should be deferred until such time as the mitigation capabilities of these dams are restored and maintained or other valid options are implemented.

- The ideal solution would be to build another dam but the feasibility and desire to do so is uncertain. Alternate options may include:

    - Restoring or increasing the flood mitigation capacity of Wivenhoe by repositioning the fuses plugs higher and increasing the dam wall height;
    - Restoring the flood mitigation capability of Somerset's 524,000ML if it is assessed to be incapable of operation without considerable reservations;

    - Raising the low-level river crossings downstream from Wivenhoe to optimise Wivenhoe’s ability to perform its mitigation capabilities by discharging adequate outflows to better accommodate significant inflows during predicted severe weather events.

- In the interim, some measures should be put in place prior to the 2012 wet season to improve both the flood mitigation capacities of both Wivenhoe and Somerset dams and the effectiveness of the strategies that are applied under the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam:

    - Reduce the full supply level of both Wivenhoe Dam and Somerset Dam down to an appropriate level to enhance their flood mitigation; and
    - Modify the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam by way of -
        - Amending the objectives to include an overriding purpose that initial release operations should not adversely affect later operations in the event of later rain causing the peak inflow to significantly exceed the original estimate; and
        - Developing new procedures to enable this overriding objective to be applied to strategies W1 to W3.

3.0 Outstanding Questions

1. Why did SEQ Water allow the continuation of low releases under strategy W3 to occur for the period from Saturday 8 January to Tuesday 11? During this time SEQ was experiencing one of the most severe climatic events in its history with massive rain events, record catchment flooding, significant rises in the lakes of both Somerset and Wivenhoe and downstream flooding. Why didn't the Senior Flood Operations Engineer adopt such other procedures to ensure that the available flood mitigation capacity did not become exhausted, particularly during events and discussions that took place from late Sunday?

2. Why wasn't the flood storage capacities of Somerset and Wivenhoe fully utilized to provide greater protection to urban areas from flooding?

3. To what extent has the positioning of the fuse plugs impeded Wivenhoe's mitigation capability under W4? Prior to the installation of the fuse plugs it was possible for the two strategies covering the structural safety of the dam and protection of urban areas to co-exist.

4.0 The Brisbane River Catchment

The catchment area is 14, 038 km^2 (15,000km^2 according to BOM [1]) in size and extends from Moreton Bay to the Great Dividing Range. This catchment includes the sub-catchments of the Upper Brisbane, Stanley, Lockyer, mid Brisbane, Bremer River, and lower Brisbane rivers and Oxley creek. It includes 29,262 kms in length of stream networks. There are 850kms of river and lake banks as well as 50 major creeks.[2]

About one half of the catchment is below Wivenhoe Dam. Above Wivenhoe, the Stanley River catchment from Somerset Dam up represent about 22% of the combined catchment area and the Upper Brisbane about 78%.

Below Wivenhoe Dam the Lockyer Creek drains into the Brisbane River near Lowood. At the intersection of the Lockyer and Brisbane there is a very fertile flood basin area that is capable of storing a considerable amount of flood water that banks up against the Brisbane River. The mid Brisbane River catchment extends from the base of the Brisbane River to Mt Crosby Weir. The second major tributary, the Bremer River, flows into the Brisbane River at Moggill. The mouth of the Bremer River and upstream past Ipswich CBD is tidal. This tidal influence extends 17 kms up the river. These three lower catchments contribute 39.58% of the combined Brisbane River catchment.

The lower Brisbane River is tidal as is the mouth of Oxley Creek. Indeed, eighty kms of the river's lower reaches are tidal and flood prone. Flood records for Brisbane extend back as far as the 1840's and indicate that the city has a long history of flooding. The January 1974 raised the river height to 5.45 metres on the Brisbane City Gauge at the river end of Edward Street.

Catchment	Area km2	Stream network length	% of Area	% Stream network
Stanley	1535	3281	10.93	11.21
Upper Brisbane	5493	11368	39.13	38.85
Lockyer	2974	6056	21.19	20.70
Mid Brisbane	552	1135	3.93	3.88
Bremer	2031	4425	14.47	15.12
Lower Brisbane	1195	2475	8.51	8.46
Oxley	258	522	1.84	1.78
Total	14038	29262		

Source: SEQ Healthy Waterways Partnership

[1] BOM, Flood Warning System for the Brisbane River below Wivenhoe Dam http://www.bom.gov.au/hydro/flood/qld/brochures/brisbane_lower/brisbane_lower.shtml

[2] CRC for Catchment Hydrology, Brisbane River, http://www.catchment.crc.org.au/focus_catchments/brisriver.html

4.1 Stanley River Catchment

Stanley River catchment is situated in the steepest and wettest part of the catchment above Wivenhoe Dam. The river and its tributaries have a catchment area of about 1,535 km^2 flowing South from the Blackall range across the wide valley floor and floodplain wetlands to Somerset . It has a catchment population of 10,417.[3]The Stanley River tributaries include Ewen, Crohamhurst, London, Running, Blackrock, One Mile, Monkeybong, Delaney's, Neurem, Stony, Marysmokes, Scrubby, Sandy, Kilcoy, Sheepstation, Oaky, Byron and Reedy Creeks. The stream network length is 3,281 km[4] and the land area accounts for almost 11% of the Brisbane River catchment. The Stanley River is impounded by Somerset Dam just above its junction with the Upper Brisbane River at Lake Wivenhoe and eventually flows into Lake Wivenhoe. The catchment represents about 22% of the combined catchments above Wivenhoe dam.

4.2 Upper Brisbane River Catchment

The upper Brisbane River is generally flatter and drier than the Stanley River Catchment. The river and its tributaries have a catchment area of about 5,493 KMs and accounts for almost 40% of the Brisbane River catchment. It has a catchment population of 5,480.[5] The stream network length is 11,368km.[6] The upper Brisbane River is impounded by Wivenhoe Dam and extends from the headwaters along the Great Dividing Range in the west, Brisbane and Jimna Ranges in the North and the D'Angular Range through the wide valley surrounding the Brisbane River to Wivenhoe.

With its headwaters in the Brisbane Range, the Brisbane River flows South, where it is joined by major tributaries including the Cooyar, Monsildale, Emu, Ivory , Maronghi, Cressbook and Esk Creeks, before flowing into Lake Wivenhoe. The stream network length is 11,368km.[7] The catchment represents about 78% of the combined catchments above Wivenhoe dam.

---

3 Healthy Waterways http://www.healthywaterways.org/ScienceandInnovation/ConceptualDiagrams.aspx

4 SEQ Healthy Waterways Partnership, http://www.sunshinecoast.qld.gov.au/addfiles/documents/environment/waterways/stanley_river.pdf

5 Healthy Waterways

6 SEQ Healthy Waterways Partnership, http://www.healthywaterways.org/EcosystemHealthMonitoringProgram/2010ReportCardResults/CatchmentResults/WesternCatchments/UpperBrisbaneRiverCatchment.aspx

7 SEQ Healthy Waterways Partnership

4.3 Lockyer Creek Catchment

Lockyer Creek and its tributaries cover a catchment area of about 2,974 km^2 across steep ranges in the North, South and West areas. It has a catchment population of 33,331.[8] It accounts for about 21% of the Brisbane River catchment. Lockyer Creek flows in an easterly direction for some 100 km from the Great Dividing Range to its confluence with the Brisbane River near Lowood. Its major tributaries include the Laidley, Tenthill, Ma Ma and Buaraba creeks, which account for roughly half of the Lockyer Creek catchment. The stream network length is 6,056 km.[9]

4.4 Mid Brisbane River Catchment

The mid Brisbane River and its tributaries have a catchment area of about 552 km^2 It has a population of 8,174. [10]It is bounded on the north and east by the D'Aguliar Range and Brisbane Forest Park. Flow in this part of the river is regulated, depending upon releases from Wivenhoe Dam. The land area accounts for almost 4% of the Brisbane River catchment. The catchment encompasses some 65 kms of the Brisbane River from Wivenhoe dam wall to Mt. Crosby weir. Other main water bodies include Lake Manchester and seven main creeks: Lockyer Creek, Banks Creek, Black Snake Creek, Branch Creek, Cabbage Tree Creek, England Creek and Sandy Creek. The stream network is 1,135km.[11]

4.5 Bremer River Catchment

The Bremer River and its tributaries encompasses 2,031 km^2 and the area is bound by the Little Liverpool Range to the west, the Great Dividing Range to the south and south-west, and the Teviot Range to the east. The land area accounts for almost 15% of the Brisbane River catchment.

The general direction of flow of most major tributaries including Franklin Vale, Warrill, Reynolds, Purga and Bundamba creeks is to the north and north-east. The Bremer River flows in a northerly direction until near Rosewood, where it turns east and meanders through Ipswich to join the Brisbane River system at Adopted Middle Thread Distance (AMTD) approximately 73 km. The stream network length is 4,425km.[12]

---

[8] Healthy Waterways
[9] SEQ Healthy Waterways partnership, http://www.healthywaterways.org/EcosystemHealthMonitoringProgram/2010ReportCardResults/CatchmentResults/WesternCatchments/LockyerCreekCatchment.aspx
[10] Healthy Waterways
[11] SEQ Healthy Waterways Partnership, http://www.healthywaterways.org/EcosystemHealthMonitoringProgram/2010ReportCardResults/CatchmentResults/WesternCatchments/MidBrisbaneRiverCatchment.aspx
[12] SEQ Healthy Waterways Partnership, http://www.healthywaterways.org/EcosystemHealthMonitoringProgram/

3.6 Lower Brisbane River Catchment

The lower Brisbane River and its tributaries encompasses 1,195 km^2 and the stream network length is 2,475km.[13] Local creeks entering the river in this catchment include Oxley and Bulimba Creeks on the southside, and Kedron Brook, Moggill and Enoggera Creeks in the northern and western suburbs. During intense rainfalls, the suburban creeks rise very quickly and can cause significant flooding of streets and houses. It is a highly modified, urban catchment with large volumes of storm water runoff into the waterways during/after rain and storm events. The land area accounts for almost 9% of the Brisbane River catchment.

4.7 Oxley Catchment

The Oxley Catchment encompasses 258 km^2 and the stream network length is 522km.[14] It is a highly modified, urban catchment with large volumes of storm water runoff into the waterways during/after rain and storm events. The land area accounts for almost 2% of the Brisbane River catchment.

---

[13] SEQ Healthy Waterways Partnership, http://www.healthywaterways.org/EcosystemHealthMonitoringProgram/2010ReportCardResults/CatchmentResults/MoretonBayCatchments/LowerBrisbaneRiverCatchmentandEstuary.aspx

[14] SEQ Healthy Waterways Partnership, http://www.healthywaterways.org/EcosystemHealthMonitoringProgram/2010ReportCardResults/CatchmentResults/MoretonBayCatchments/OxleyCatchment.aspx

5.1 Wivenhoe Dam

5.1.1 History and Functions

Preliminary investigations into the construction of a dam at Wivenhoe were undertaken in the mid 1960's. The timeline of events were as follows:

- Government granted approval to proceed with the construction of the dam occurred in 1971;
- 1973 the Government commenced acquiring lands to be inundated;
- 1976 approval was given to proceed with the hydroelectric scheme;
- March 1977 the first contract was awarded; and
- the dam was officially opened in 1985.

The dam has five main functions by providing:

1. An allocation of raw fresh water supply to Brisbane and surrounding areas;
2. An allocation of water for irrigation purposes and environmental flows;
3. A flood storage capacity to mitigate downstream flooding risks;
4. A containment capability in the event Somerset dam failed by some event other than major flooding;
5. A water resource for hydroelectric power.

5.1.2 Full Supply Level

Since construction, the dam has a Full Supply Level (FSL) of 1,165 GL at a storage level of 67.0m AHD. This is the level when the water storage is at maximum operating level and the dam is not affected by flood. It represents 45% of the design capacity of the dam at 77m AHD.

In 2005 SEQ Water developed a preliminary draft discussion paper on raising Wivenhoe Dam. This lead to the development of a project called "Augmentation of Wivenhoe Dam Storage Volume." The options to be investigated were raising the FSL by 1 or 2m, 4m and 6m.[15] The study was subsequently widened to include Somerset[16]. Options investigated for Wivenhoe were raising FSL 2m, 4m and 8m. The Report recommended a 2m raising in the FSL could be achieved for Wivenhoe with minimal capital costs subject to addressing regulator and stakeholder concerns. The report rejected the raising of the FSL for Somerset due to the impacts on upstream population during flood events.

The recommendation to increase the FLS of Wivenhoe involves the following

[15] GHD, Augmentation of Wivenhoe Dam Storage Volume, http://www.qwc.qld.gov.au/planning/pdf/support-docs/section-3-15-wivenhoe.pdf

[16] Queensland Water Commission/Dept. of Natural Resources and Water. Provision of Contingency Storage in Wivenhoe and Somerset Dams. 2007 http://www.qwc.qld.gov.au/planning/pdf/support-docs/provision-of-contingency-storage-in-wivenhoe-and-somerset-da.pdf

actions:

- Raising the fixed concrete ogee crest of the gated spillway by 1.5m to EL58.5 to preserve the air space controlled by the radial gate above FSL for flood mitigation;
- Raising of the three fuse plug embankments in the secondary spillway by 1m to preserve the initiation level for the first embankment at approximately the 1 in 5,000 AEP flood event as per the current design constructed in 2004. The initial trigger for the lowest of these fuse plugs would then be EL76.7.
- Maintaining the current Maximum Design Flood Level (MDL) of EL80m adopted for the Stage 1 upgrade work to avoid any work along the crest of the existing dam.

On closer examination the proposal, if implemented, would consumed part of the fixed flood storage compartment available for protecting urban areas from inundation, measured from EL 67m to EL 69m and transferred about 167,000 ML for the purposes of protecting the structural safety of the dam and the balance of 63,000 ML represents lost capacity due to the lower positioning of the fuse plug.

AHD m	Storage Capacity x 10^3 ML	Flood Capacity x 10^3 ML	Height Change Difference x 10^3ML
Impact of a 2m increase in FSL Wivenhoe			
67	1165	0	
69	1393	230	230
Impact of a 1m rise in Fuse Plug 1			
75.7	2347	1182	
76.7	2514	1349	167
Lost flood storage capacity			63

In 2010 the Water Commission released a report called “The South East Queensland Water Strategy”. The Report states -

A detailed investigation will be conducted to determine the maximum level to which the working storage of Wivenhoe Dam could be raised without raising the dam wall. The investigation will be carried out in conjunction with Seqwater and the Brisbane and Ipswich City Councils. It will include detailed consideration of:

- the impact on frequency, severity and duration of flooding both upstream and downstream of the dam
- any effect on the structural integrity of the dam and its components or any required spillway upgrades

- environmental and social impacts, including adverse affects on any roads and crossings caused by flooding."[17]

Without pre-empting the outcome of such an investigation, any increase in the FSL without raising the dam wall suffers from the same potential consequences as the 2007 proposal.

It needs to be remembered that –

The dam has a HIGH hazard classification because of the significant development downstream in the Brisbane and Ipswich metropolitan areas, with the population at risk (PAR) numbering in the hundreds of thousands.[18]

and

Neither Wivenhoe nor Somerset currently satisfies the ANCOLD Guidelines on Acceptable Flood Capacity (2003). SEQ Water is committed to an agreed program of works to allow the dams to comply with both ANCOLD and the Spillway Adequacy Guidelines (NRW 2005) in the timeframe specified by NRW.[19]

5.1.3 Flood Mitigation

When constructed, 55% of the storage capacity of Wivenhoe was for flood storage. Above FSL the Dam had a flood storage capacity for an additional 1,450 GL at EL 77m bringing the total capacity of the dam to 2,615 GL. Set out below is an extract from the SEQ Water website:

> *During a flood situation, Wivenhoe Dam is designed to hold back a further 1.45 million megalitres as well as its normal storage capacity of 1.15 million megalitres. Floods may still occur in the Ipswich and Brisbane areas but they will be rarer in occurrence. Wivenhoe's flood control facility, together with the existing flood mitigation effect of Somerset Dam, will substantially reduce the heights of relatively small floods.*
>
> *It is anticipated that during a large flood similar in magnitude to that experienced in 1974, by using mitigation facility within Wivenhoe Dam, flood levels will be reduced downstream by an estimated 2 metres.*[20]

---

[17] Queensland Water Commission, The South East Queensland Water Strategy, 2010 at page 98 http://www.qwc.qld.gov.au/planning/pdf/seqws-full.pdf

[18] Queensland Water Commission/Dept. of Natural Resources and Water. Provision of Contingency Storage in Wivenhoe and Somerset Dams, 2007 at page 15. http://www.qwc.qld.gov.au/planning/pdf/support-docs/provision-of-contingency-storage-in-wivenhoe-and-somerset-da.pdf

[19] Ibid, at page (iii)

[20] http://www.seqwater.com.au/public/catch-store-treat/dams/wivenhoe-dam

It is not clear how it achieves this but I understand that as the inflows into the dam exceed outflows, the dam height increases and the five radial gates can move up to allow the flood storage compartment to hold 1,450,000 ML at EL 77m. During this period flood waters pass between the spillway fixed crest level and the bottom of the radial gates. As flood water inflows reduce and the flood compartment drains the radial gates can move down to ensure that the outflows do not exceed the inflows to the dam.

As the compartment fills the radial gates move up from 73m and the flow rates out of the dam must increase. At a lake height of 74m the strategy in the Manual moves from a primary consideration of protecting urban areas from inundation to the primary concern of protecting the structural safety of the Dam. So the amount Wivenhoe can store for the purposes of protecting urban areas before the strategy changes to protection of the dam is about 900,000 ML if the gates are only open by 1m. The balance of the storage compartment is available to safeguard the structural integrity of the dam.

During the January floods this 900,000 ML capacity was fully consumed by about 10.30am on Tuesday. That does not mean that the balance of the compartment was not available for flood mitigation prior to the installation of the fuse plugs but it would have meant that the main objective would had changed to the safety of the dam. Under that strategy, if releases could be modified and still meet that objective plus help protect urban areas then they could co-exist. But a time may come when damaging high outflows might be necessary to control inflows to outflows and arrest further increases in the lake level. But the 3m buffer between EL 74m and EL 77m buys time to gain control of the flows through the dam.

This all changed with the installation of the fuse plugs in 2005. The available time buffer measured in metres was essentially reduced to 1 m to EL 75m (because the operators would not want to get to close to initiating a plug.) The precise level of the buffer is a matter for the Commission to determine

Wivenhoe Dam is predominantly a central core rock fill dam and such dams are not resistant to overtopping.[21] A structural failure of Wivenhoe Dam would have catastrophic consequences. The consequences of failure were preliminarily assessed in 2000 as:

- 91,750 to 244,000 people depending upon the time of day and the nature of the failure and
- total financial damages of between $7 billion and $25 billion depending on the cause of the failure, and
- incremental financial consequences estimated between $5.1 billion

[21] SEQ Water, "Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam, rev.7 Nov. 2009, at page 9.

and $8.8 billion depending upon the cause of the failure.[22]

So it is vitally important from a safety perspective to undertake periodic reviews. From the mid 1990's dam safety reviews, flood studies and preliminary risk assessments were undertaken for Wivenhoe and Somerset Dams. These studies confirmed that the flood passing capacity of Wivenhoe was not in accordance with the ANCOLD guidelines.[23] The maximum discharge capacity was only 14,000 m^3/s and the dam would be overtopped by a storm event with a return period of 1:14,300 AEP. The Probable Maximum Flood (PMF) at that time was estimated at 30,670 m^3/s.

SEQ Water commissioned GHD in 2001 to carry out preliminary engineering assessments for options to upgrade the flood passing capacity of the dam and provide full PMF capacity for Wivenhoe. Whilst the preferred option was not accepted, details of aspects of the investigation are important to understanding how the ultimate design solution may impact on the flood mitigation capacity of Wivenhoe.

GHD identified 239 options ranging from raising the dam crest either to fully pass the PMF through the existing spillway or a lessor raising combined with a new auxiliary spillway to various types of new auxiliary spillways if the dam is left unraised to modifying Somerset and even constructing a new dam. The estimated capital cost of these options varied from $47m to $1110m. These options were short-listed to 11 options and the capital cost and consequences costs determined for each.

The favored option was a dam wall raising by 1.5m and a 170m wide fuse plug, at an estimated cost of $46.6 m. The report states "the preferred option initiates at the lowest probability of occurrence of all analyzed, that is an average return period of 1 in 10,000 years". The report further states –

> *That is, until the 1:10,000 year flood is exceeded the current operating rules for the existing spillway would apply and there would be no incremental flood consequences costs.*[24]

The report noted that all short-listed options with an auxiliary spillway that did not involve raising the dam pass flood waters at events with a frequency of occurrence less than the probably maximum flood's frequency of occurrence (1 in 100,000 years). The report noted a more frequent occurrence would be a lower capital cost solution. But more frequent flood occurrences would not minimize downstream consequences costs –

> *The ideal initiation level would be that at which the existing dam in its*

---

22 Sinclair Knight Merz, Hydro Consulting and Australian Power & Water Pty Ltd, "Preliminary Risk Assessment Wivenhoe, Somerset and North Pine Dams" March 2000 as reported in Crichton, Grant, Williams & Ford 2001 at page 3.

23 Crichton, Grant, Williams, & Ford, "Flood Passing Capacity Upgrade Considerations for Wivenhoe Dam", NZSOLD/ANCOLD 2001 Conference on Dams at page 1.

24 Crichton, Grant, Williams, & Ford, op. cit. at page 4.

existing configuration would be about to be overtopped. In this ideal situation, no downstream community would be more adversely affected compared to the current situation because the release of additional floodwaters would occur at the same flood event. In fact, because the dam would not fail with the augmentation works, all downstream communities would be made more immune to flood effects. However, it is not possible to design an auxiliary spillway with an initiation level at the existing overtopping event without also raising the dam to store more floodwaters.[25]

Following the release of revised 2003 rainfall predictions by BoM, an Alliance formed by SEQ Water estimated that the PMF had increased to almost 49,000 m3/s and this new flow estimate, like the previous one, when routed through the storage results in an overtopping of the dam.

The Alliance undertook an assessment of a large number of options:

Trials were undertaken with consideration different auxiliary spillway crests, crest levels (which include the possible loss of storage at remote flood events), and initiation levels.[26]

The reference to "possible loss of storage at remote flood events" is taken to mean a possible loss of some of Wivenhoe's flood storage capacity. The initial assessments for a fused gated spillway looked at initiation levels starting at 74.5m (an AEP of approximately 1:1,000).[27]

The Alliance investigation studies concluded that a two-stage upgrade program outlined below would provide a cost-effective risk reduction program:

Stage 1 Upgrade Works

- Construction of a new secondary spillway on the right abutment that would enable the dam to handle an inflow flood with an AEP of 1 in 100,000 at a Maximum Flood Level (MFL) of EL80. This spillway is controlled by three fuse plug embankments;
- Upgrading of the embankment crest to retain a MFL of EL80 with zero freeboard;
- Upgrading of associated structures as appropriate, including protection of the main spillway gates and bridge and strengthening of the spillway gravity structure.

Stage 2 Upgrade Works

- Reconstruction of Saddle Dam 2 as a fuse plug spillway such that the dam can accommodate the PMF.[28]

---

25 Ibid, at pages 6 to 7.

26 Ahmed-Zeki, Roads, "Option Investigation and Design Aproach on the Wivenhoe Dam Spillway Augumentation" at page 2.

27 Ibid, at page 3.

28 Queensland Water Commission/Dept. of Natural Resources and Water. Provision of Contingency Storage in Wivenhoe and Somerset Dams, 2007 at p16.

The installed secondary spillway was completed in 2005. Stage 2 is expected to be completed by 2035. [29]

The secondary spillway comprises three fuse plugs that sit above a concrete ogee crest at 76 ADH. The plugs have varying initiation heights and are separated by concrete dividers. They are designed to quickly empty the flood storage capacity of the dam by bringing water levels back to FSL at 67 AHD. Whilst the flows through the secondary spillway are uncontrolled discharges the operators of the dam are able to exercise some control over down stream flows by regulating the gates on the main spillway. The downside of initiating plugs is that once initiated the dam no longer has any flood storage capacity until new plugs are installed.

The plugs are designed to initiate with flood events with the following AEP's -

Fuse Plug No. Initiated	Approx. AEP (1 x X Years)
1	5,000
2	8,500
3	25,000

Source: Wivenhoe Dam Flood Security Upgrade (2004)

By way of comparison, the design option outlined in the GHD (2001) study was for a fuse plug that was 6 metres longer and initiated with a flood event with an AEP of 1 in 10,000 years.

Set out below are details on the fuse plugs.

	Spillway width (m)	Spillway Crest Level (m)	Peak Lake Level at plug initiation (m)
Fuse plug 1	34	67	75.7
Fuse plug 2	64.5	67	76.2
Fuse plug 3	65.5	67	77.2

Source: Wivenhoe Dam Flood Security Upgrade (2004)

The fuse plugs have been positioned below EL 77m and, as such, the balance of the flood storage compartment from EL 75m to EL 77m can no longer be used as a compartment within which the objectives of protecting the structural safety of the dam and protecting urban areas from inundation can

---

http://www.qwc.qld.gov.au/planning/pdf/support-docs/provision-of-contingency-storage-in-wivenhoe-and-somerset-da.pdf

[29] Howard, Logan, Watt, Riley and Stuart, " Northern Link Technical Report No 6 Flooding", May 2008 at page 15.

co-exist. This is so because once the fuse plug initiates the compartment drains back to 67m and even the allocation for urban protection is lost. In addition, the limited buffer height distance from EL 74m to EL 75m means that operators may have to resort to unprecedented high outflow rates to ensure the lowest fuse plug does not initiate. Such damaging outflows would come at a cost to downstream communities who may also sustain increased flooding frequency as a result of the lower positioning of the fuse plugs.

As mentioned above, substantial increased frequency of floods and flow rates could come at a cost to the downstream communities. The GHD (2001) report contains a flood damages estimates table for flow rates commencing at 5,000 cumecs and gives the following example –

> *The increased cost of flood damages for a spillway augmentation that results in the flood flow increasing from say 20,000 m^3/s to 25,000 m^3/s is $4.5 billion.*[30]

In undertaking research in this area it was noted that there is a lot of confusion about the various terms – flood storage capacity, flood storage compartment, flood storage component, mitigation compartment, etc. etc. it becomes very concerning when the references all relate back to the 1,400,000 ML at Wivenhoe and some of these publications relate it back to EL 77m and others MFL 80m.

No doubt some of these concepts mean the same thing like flood storage capacity and flood storage volume or flood storage component and flood storage compartment. But for the ordinary person they may mean one and the same thing, particularly if they relate back to the 1,450 GL.

Why the focus on these concepts? Because the general population believes –

- Wivenhoe dam has a FSC of 1,450,000 ML;
- Expressed as a percentage of FSL this is often reported at 223 to 225%.

In actual fact Wivenhoe only probably has a total "safe" FSC of about 192% of which about 178% is for urban protection from inundation and the balance for protecting the safety of the dam and urban protection if these objectives can co-exist at EL75m. The balance to EF 75.7m is a buffer to protect against unintended initiation of the fuse plug. Above EL75.7m the balance of the compartment is there to protect the structural safety of the dam by allowing flood waters to escape through the main spillway and the auxiliary spillways up to MFL of 80m.

[30] Crichton, Grant, Williams, & Ford, opt cite at page 4.

Unfortunately many people, including media commentators, on 10 and 11 January were advising the general public that Wivenhoe still had unused flood storage capacity as the dam was capable of storing 220% or more of its FSL. For example, at 3.05 pm on 11 January the Courier Mail posted an update that included a report by SEQ Water. I am not sure when Barry Dennien made that statement but here is an extract -

> *SEQ Water Grid spokesman Barry Dennien said Wivenhoe peak inflows had hit 1,032,000ML per day. Somerset Dam inflows were about 360,000ML per day.*
>
> *"Considering Wivenhoe's flood storage compartment holds 1.45 million megalitres, at this rate the compartment could fill within 1.5 days," Mr Dennien said.*[31]

More recently, the Report on the operation of Somerset Dam and Wivenhoe Dam states at page 3:

> The reservoir volume above the FSL that is used as temporary flood storage is 1,450,000ML How much of this flood storage compartment is utilised during a flood depends upon the initial reservoir level below SFL, the magnitude of the flood being regulated and the procedures adopted.[32]

Beyond the events of 2011, I wonder how may people and businesses may have relied upon statements centering around Wivenhoe Dam having a FSC of 1,450,000ML and continued to do so after the fuse plugs were installed? For example, the Brisbane City Council Flood Studies were done at a time prior to the installation of the fuse plugs. The Courier Mail recently reported:

> *The Q 100 – based on a 3.3m flood at the City gauge – has been used since the 1980's and takes into account the 1974 flood and the flood mitigating properties of Wivenhoe Dam.*[33]

---

[31] Courier Mail, "Flood Waters Hit Brisbane", 11 January 2011 http://www.couriermail.com.au/ipad/brisbane-threat-as-wivenhoe-fills/story-fn6ck51p-1225985249515

[32] SEQ Water, January 2011 Flood Event - Report on the operation of Somerset Dam and Wivenhoe Dam

[33] The Courier Mail, "Flood safety benchmark failed 10,000 homes", 8 March 2011, at page 1.

5.2 Somerset Dam

5.2.1 History and Functions

Somerset Dam is on the Stanley River just upstream from where the river flows into the Brisbane River. The dam was constructed by the Bureau of Industry Stanley River Works Board. Construction commenced in 1935 but had to be suspended due to World War II. Work resumed in 1948 and the dam was completed in 1959. The dam is a mass concrete gravity type, using a volume of 203 000 cubic meters of concrete which resists the thrusts of water by it own weight alone. It is 53 meters above the base foundation of the wall, 305 meters long and 41 meters thick at its base. The top of the 8 spillway crest gates (8x 17.97m x 7.01m) is 108 metres above sea level, and 47 metres above the original streambed.

The dam has a catchment area of 1330 square kilometers. The surface area of water covers 4210 hectares and reaches 55 km upstream.

The dam has four main functions by providing:

1. An allocation of raw fresh water supply to Brisbane and surrounding areas;
2. An allocation of water for irrigation purposes and environmental flows;
3. A flood mitigation capability to manage downstream flooding risks;
4. A water resource for hydroelectric power with a small plant of 4000 KA capacity.

This submission will focus on two areas:

- Full Supply Level
- Flood Mitigation

5.2.2 Full Supply Level

The dam has a FSL of 380,000 ML at a storage level of 99.0m AHD. This is the level when the water storage is at maximum operating level and the dam is not affected by flood. It represents about 42% of the design capacity of the dam at 107.46m AHD. This design capacity exists when the crest gates on the dam are closed.

In a report entitled “Provision of Contingency Storage in Wivenhoe and Somerset Dams” a number of options investigated for Somerset - raising FSL 2m, 4m and 6m. The report rejected the raising of the FSL for Somerset due to the impacts on upstream population during flood events. Issues associated with the raising of Somerset included –

- Flood Mitigation. Each of the options investigated for the raising of Somerset impact on the existing flood mitigation performance. This impact is greater as the proposed raising increases. This is due to constraints on the upstream flood levels imposed by Kilcoy and other upstream development.

- Equipment age. The gates and hoist equipment at Somerset Dam are of considerable age. There is some uncertainty whether it can be adapted as proposed.
- Dam condition. Cracking in a number of the dam monoliths and other stability concerns will be addressed concurrently with the raising proposals.
- Community opposition to the higher raising proposals is likely to be very strong.
- The indirect costs associated with the increased frequency of highway disruption have not been estimated.[34]

5.2.2 Flood Mitigation

The outlet works of Somerset dam consist of:

- Four cone dispersion regulator valves;
- Eight sluice gates; and
- Eight radial crest gates above the spillway bays.

When constructed, 58% of the designed storage capacity of Somerset was for flood storage. Above FSL the dam had storage capacity for an additional 524,000 ML at 107.46 AHD bringing the total capacity of the dam to 904,000 GL. During a flood situation the dam was designed to hold back flood flows equivalent to about one Sydney Harbour by closing the eight crest gates. As a mass concrete dam it was designed to permit some overtopping.

Like Wivenhoe, there appears to be some confusion about its flood storage capacity. The SEQ Water website states as follows:

> **Full Supply Capacity:**
> 379,849
> **Flood Mitigation:**
> 155,000ML above full capacity, totaling 524,000ML[35]

Also note the wording – flood mitigation whereas other documents refer to FSC being 524,000 ML, totaling 904,000 ML[36]. Somerset does have about 68,000 ML available being the difference between FSL and the top of the spillway crest as FSC when the crest gates are open. The balance only exists if the crest gates are closed to bring it to 524,000 ML. To the general public, there would be no real flood mitigation purpose if the gates are kept open and flood waters merely flow out or over the spillway crest in an uncontrolled manner.

Whilst there may be a reference in the SEQ Water Flood Report (2011) to the flood storage capacity of Somerset no such figure was immediately apparent.

---

[34] Ibid, at page vi.
[35] http://www.seqwater.com.au/public/catch-store-treat/dams/somerset-dam
[36] see http://wivenhoesomersetrainfall.com/images/Dam_features_from_SEQWater_Web.jpg

However, as one reads through that Report there is references to the radial crest gates, including:

- Dam inflow and flood release details refer to outflows from the radial gates on pages 169 to 173. For the period of the January flood the radial gates were never used for flood mitigation and flood waters were allowed to flow into the dam and flood waters not able to pass through the regulators and sluices merely passed over the spillway fixed crest at EL100.45m. When the lake level was over EL104m on the Tuesday afternoon when big releases were being contemplated for Wivenhoe, the flood waters were flowing about 3.55 m in height over the unclosed spillway bays at Somerset. It would appear that the crest gates were never closed and the flood storage capacity of about one Sydney Harbour was not utilized for flood mitigation at this crucial time or anytime during the January flood, in the context of the ordinary meaning given to "flood mitigation".

- The flood management strategies on page 184 for S1 state "The crest gates at Somerset are to be raised to enable uncontrolled discharge". A similar reference is provided for S2. S3 is where Somerset Dam is expected to exceed 99m and Wivenhoe Dam level is to exceed the fuse plug initiation level. Under this strategy consideration can be given to departing from the S2 strategy (which provides for uncontrolled releases through the radial gate bays) on condition that the safety of Somerset Dam is the prime consideration. But the Manual neither provides details about the opening and closing time intervals for operating the radial crest gates nor the procedures for the order of opening and closing the gates when used for capturing and releasing the flood storage capacity totaling 524,000ML. The Manual at page 42 does state under minimum intervals for normal gate operations that the "crest gates are normally open". Given that there are no procedures in the Manual and these procedures would be necessary for indemnification purposes, it would appear that the crest gates no longer serve a flood mitigation purpose.

The logic to not using the full 524,000ML may be partly found in this statement in the Manual:

> *Wivenhoe Dam and Somerset Dam are operated in conjunction so as to maximize the overall flood mitigation capabilities of the two dams. The procedures outlined in this Manual are based on the operation of the dams in tandem.*

But the purpose of the Manual is to define procedures for the operation of Wivenhoe and Somerset dams to reduce, as far as practicable, the effects of flooding associated with the dams. The prime consideration under the Manual, and rightly so, is to ensure the structural safety of the dams. The Manual recognizes failure of Somerset could have catastrophic consequences and the dam could withstand at least 2.2 metres overtopping without failure, provided all the radial gates are fully open.

There is no question that Somerset safely allowed the flooding in the Stanley

River to pass through into Wivenhoe and the operation of the sluice gates assisted in draining the lake after the peak was reached. However, there were some of operational and safety issues in the past about the use of the crest gates, for example,

> *SMEC, 2004 notes that should the spillway gates not operate as intended, the dam could become unstable and, "as part of its risk reduction strategy, SEQ Water needs to consider this aspect". Risk reduction methods considered included "removal of the sector (radial) gates, or anchoring the dam to the foundations".*[37]

There may be a belief amongst some in the general community that Somerset plays a vital role in the mitigation of flooding through the use of its 524,000 ML of flood storage capacity. For example, the communities below Somerset were advised during the January flood event that the flows out of that dam were reduced, then stopped and then advised the next day that was an error.

If that designed flood storage capacity can no longer be safely used without significant expenditure then all reference to Somerset having such capacity should be removed. Otherwise there may be some in the community that may place some reliance on that to their detriment.

---

[37] Queensland Water Commission/Dept. of Natural Resources and Water. "Provision of Contingency Storage in Wivenhoe and Somerset Dams", 2007 at Appendix H see http://www.qwc.qld.gov.au/planning/pdf/support-docs/provision-of-contingency-storage-in-wivenhoe-and-somerset-da.pdf

6.0 Review of Manual of Operational Procedures

"As soon as Wivenhoe Dam's flood storage compartment begins to fill, it has to be carefully emptied in order to make room for additional heavy rainfall events that may occur. Wivenhoe Dam's flood storage compartment can fill in less than three days following heavy rainfall. This highlights the need for strategic management of dam levels. Controlled releases consider the following flood factors: catchment runoff below the dam wall, urban runoff and river levels."

Source: SEQ Water Grid Fact Sheet – Wivenhoe ad Somerset Dams

6.1 Relevance of FSL

When Wivenhoe was constructed the Full Supply Level (FSL) was set at 45% of the total storage capacity of the Dam. Whilst there has been a number of reviews of the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam there has been no change to the FSL of 1,165,000 ML at Wivenhoe Dam until recently. The Flood Storage Capacity (FSC), on the other hand, was significantly altered with the commissioning of the fuse plugs from 2005.

Decisions regarding changes in the FSL at Wivenhoe also affect and change the FSC of the Dam. For example, a decision to increase the FSL by EL 2m without undertaking any capital works increases the FSL by about 230,000 ML but also reduces the FSC by the same amount, and to the detriment of that portion of the capacity dedicated to protecting areas from inundation.

SEQ Water is not charged with the responsibility to determine or vary the FSL at Wivenhoe and Somerset Dams. This responsibility rests with the State Government.

6.2 Comparison of Manuals

The Manual in its current form was developed in 1992 and since that time a number of revisions were made including complete revisions in 2002, 2004 and 2009 covering the construction of the auxiliary fuse plugs and after the fuse plugs were commissioned. Set out below are the differences between the 1998 and 2009 strategies.

Strategy	Strategies	1998	2009
W1 A	>67.25 & <67.5m - Max release	110 m^3/s	110 m^3/s
W1B	>67.5 & <67.75m - Max release	210 m^3/s	380 m^3/s
W1C	>67.75 & 68m - Max release	500 m^3/s	500 m^3/s
W1D	>68 & <68.25m - Max release	900 m^3/s	1900m^3/s
W1E	>68.25 & <68.5m - Max release	1500 m^3/s	1900 m^3/s
W2	>68.5 & <74m - Max release	3500 m^3/s	3500 m^3/s
W3	>68.5 & <74m - Max release	3500 m^3/s	4000 m^3/s
W4	>74m – Max release	No restriction	
W4A	>74 & < 75.5m - Max release		No restriction
W4B	>75.5m - Max release		No restriction

The differences between the strategies between 1998 and 2009 are –

- New rural river crossings enabling maximum release rates to be increased in some instances;
- Installation of the fuse plugs;
- W1 to W4 previously applied to actual storage levels whereas they now apply to predicted storage levels.

6.3 Purpose and objectives of the Manual

The purpose is to define procedures for the operation of Wivenhoe and Somerset Dams to reduce, so far as practicable, the effects of flooding associated with the dams. This is achieved by the proper control and regulation in time of the flood release infrastructure at dams, with due regard to the safety of the dams. The Senior Flood Operations Engineer has authority to depart from the procedures in the Manual to meet the mitigation objectives subject to certain conditions.

6.4 Application of Strategies

The strategies covered in the Manual have been comprehensively covered in the SEQ Water Flood Report of 2011 and will not be covered here.

The application of the strategies for Wivenhoe Dam from W1 through to W3 are designed to minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers and provide optimum protection of urbanized areas from inundation, subject to ensuring the structural safety of the dam.

These strategies have worked well in recent flooding events like October 2010 and December 2010 because the intensity of those events was a lot less and at no stage was it necessary to move to W4 to protect the dam.

The January 2011 event was different. The catchments had been subjected to above average rainfalls and flooding to varying degrees for months. And BoM issued a constant flow of severe weather warnings in the week prior to the flooding. The approaching severe weather event was very topical on Internet forums. On Weatherzone, for example, a forum was created on 4 January called “SE QLD/NE NSW FLOOD DISASTER 5-12 JANUARY 2011”. The discussion within this forum and other forums on this site concerning weather, flooding and dam operations in SE QLD provides valuable insights into events as they unfolded over the coming days and are commended to the Inquiry for consideration.

Strategy W3 started at 8.00am on Saturday and as there were still some bridges like the Fernvale and Mt Crosby Weir not yet closed, the lower objectives in the Manual are still to be considered and this included endeavouring to maintain those bridges as trafficable. The flows out of the Lockyer at this time also placed a further constraint on dam releases. Strategy W3 continued until 8.00 am on Tuesday 11 January at which time there was a transition to strategy W4 where the primary consideration turned to protecting the structural safety of the Dam.

What went wrong? To put it simply, as a result of the heavy rainfall and the adherence to strategy W3, inflows continued to exceed outflows and the dam level increased by over 5 metres in a period of about 48 hours and with further rain expected and with flows already in the catchments heading for the lake, the dam had already fully consumed the fixed flood storage compartment and the level was predicted to go over 74.0m so corrective action had to taken.

The strategy had moved from releasing about 1,400 cumecs on the Sunday to about 2,750 cumecs by the end of strategy W3. The Flood Event Log shows that a huge release was contemplated as there was a transition to W4. Yet less than 12 hours earlier the Dam Safety Regulator gave permission to exceed the 74m level for a short time without invoking strategy W4 and operate at minimum gate settings to allow the Lockyer peak to pass:

- *11.04am Tuesday Engineer 4 called Dam operator 7. Discussed if forecast rain falls, fuse plug likely to go.*
- *1.26pm SEQ Water CEO called and requested the FOC request BoM to consider if Wivenhoe is releasing 9,000 cumecs.*
- *3.14pm SEQ Water CEO called to discuss the proposed release of 10,000 cumecs.*
- *3.94pm BoM had a conference with engineer 1,2,3 & 4 about current release strategy and possible maximum release scenario of 10,000 m^3/s. This would be of a similar magnitude to the 1893 event (~ 8.36m in Brisbane Port Office).*

These huge releases were contemplated in order to avoid initiation of the 1st fuse plug. The current strategy W4 differs from the 1998 strategy in that there was a move away from the requirement that the 74m level being "actually exceeded" to "predicted to exceed". This change should provide some additional time to manage dam flows. In the case of the January floods that time period did not appear to be of much benefit due to the time taken in implementing W4.

And the lake has a history of rapidly filling see Fact Sheet extract above. During the February 1999 flood, the lake increased by about 3m in less than 24 hours from Sunday 7 February and the dam went from being about 75% on the Friday to 100% on the Monday morning. A similar situation arose in 2011 with an increase in the lake level of more than 3m in less than 24 hours from Sunday 9 January and the dam went from 106.3% on the Friday to 148.4% on the Monday morning.

Pre-fuse plug installation, the dam had a 3m buffer within which to adjust gate openings to arrest increases in the lake, from EL 74m to EL 77m. This 3m buffer buys operators more time to gain control of flows as it takes longer to fill than the 1m buffer that presently exists (because the operators would not want to get to close to initiating a plug for the reasons stated earlier). The precise level of the buffer is a matter for the Commission to determine.
To gain control over inflows within this shorten buffer time period it may be necessary to quickly increase the level of gated releases. Thomas Hedley of The Australian described it this way –

But it took until January 11, when levels in the dam were still rising and just 70cm away from triggering the fuse plug, for SEQWater to release huge volumes at a flow rate of an unprecedented 7500 cubic metres per second, which caused most of the flooding in the Brisbane River.

Whether or not it caused most of the flooding is a matter for the Commission to determine.

6.5 Possible solutions

Possible cost effective solutions to better managing flood mitigation include:
1. Restore Wivenhoe's FSC
2. Restore or partly restore Somerset's FSC
3. Raise the low level bridges
4. Reduce the FSL at Wivenhoe to provide more FSC
5. Design a new overriding strategy

6.5.1 Restore Wivenhoe's FSC

In order to restore the FSC to 1,450,000 ML it would be necessary to reposition the fuse plugs and increase the height of dam wall. Consideration could also be given to raising the auxillary spillway crest above EL 67m to ensure that the dam retains some mitigation capability after an initiation because there is a history for closely related severe weather events in SEQ. Whilst this option may appear expensive, there are significant benefits and savings to downstream communities and government infrastructure as the frequency of flooding would be less as would the frequency of large damaging releases. It may help restore confidence that some areas currently occupied for business or residential purposes are sustainable which in turn may help restore property values.

This option may not be implementable for the time being due to the strong La Niña cycle but is seen as the preferred short to medium term solution.

6.5.2 Restore or partly restore Somerset's FSC

It is not known the extent to which the 524,000 ML of FSC is available for use for reasons outlined earlier. If it is not possible to restore this FSC, then consideration could be given to lowering the FSL of Somerset to enhance the

FSC and provide an improved flood mitigation role to assist Wivenhoe in the management of downstream flows. No one wants to become a victim of flooding and adopting this strategy may help lessen the frequency of flooding in 2012 as an interim measure whilst medium term solutions are implemented.

If this option were to be adopted then the Manual would need to be amended to give Somerset Dam a mitigation capability up to the spillway fixed crest and thereafter Somerset would continue to work in tandem with Wivenhoe Dam to ensure the safety of both dams.

This option warrants further investigation. In the interim, lowering the FSL to provide Somerset with an enhanced mitigation role could be included in a package of measures that could be readily implemented for 2012.

6.5.3 Raise the low level bridges

Under the four sub-strategies of W1 the intent is not to submerge the bridges downstream prematurely –

- Twin bridges – deck level 20.0m – submerges $50m^3/s$
- Fernvale – deck level 33.8m - submerges $2000m^3/s$
- Savages Crossing – deck level 20.6m - submerges $130m^3/s$
- Burtons Bridge – deck level 19.6m - submerges $430m^3/s$
- Kholo Bridge – Deck level 11.9m - submerges $550m^3/s$
- Mount Crosby Weir – Deck level 12.4m - submerges $1900m^3/s$
- Colleges Crossing – submerges $175\text{-}200m^3/s$

Raising the height of the bridges would enable revisions to strategy W1 to enable increased releases to occur within a shorter time frame provided the Manual does not unreasonably limit the combined flows from Wivenhoe Dam and Lockyer Creek and the primary consideration to minimise disruption to downstream Rural life is maintained.

This option may not be able to be readily put in place for 2012 but warrants further consideration.

6.5.4 Reduce the FSL at Wivenhoe to provide more FSC

Establishing a lower FSL does not overcome the problems associated with the fuse plugs if the Manual strategies are not modified. For example, if the flood is mainly in the Wivenhoe catchment then strategies W1 to W3 may restrict discharges from the dam and act as a constraint to best practice in managing a major pending flood event. Those restrictions to releases are only lifted once the lake level is predicted to exceed EL 74m. But again the operators face the same shortened buffer interval of about 1m to control the flows of the dam before initiation of the 1st fuse plug.

As an interim measure, the FSL in Wivenhoe could be reduced in recognition of the loss in FSC but this by itself would not prevent the potential for large releases in order to avoid fuse plug initiation. Changes to the Manual are necessary to give the operators more time to control flows but relaxing constraints on maximum river flows in strategies W1 to W3 may result in increased flooding in the event that total river flows at Moggill went above 4.000 m^3/s.

6.5.5 Design a new overriding strategy

It is important that whatever overriding strategy is put in place, it does not unintentionally cause property damage that may have been avoidable had the original rules been followed, that is, avoidable risk. The overriding strategy should not allow releases from the storage to exceed inflows otherwise downstream flooding would be magnified. Also the overriding strategy should be robust and free from political and other influences to ensure the proper control and regulation in time of the flood release infrastructure at dams.

To assist in the design of the new strategy the matters considered relevant in the design of the operating rules post the construction of Wivenhoe Dam are constructive. These strategies were related to the predicted peak flood level at three key gauges on the major sub catchments. **The design purpose of the procedures was to ensure that initial release operations would not adversely affect later operations in the event of later rain causing the peak inflow to significantly exceed the original estimate.** The applicability of each strategy is detailed in the table below[38]:

Predicted Peak Gauge Height (m)			Operating Procedure	Resultant Peak Gauge Height. (m)	
Gregor's Ck.	Woodford	Lyon's Br.		Lowood	Brisbane
< 5	< 8	< 16.5	1	< 10	< 1.5
		16.5 - 19	2	< 15.5	< 2
		> 19	2	> 15.5	> 2
	8-12	< 19	2	< 15.5	< 2
		> 19	2	> 15.5	> 2
	> 12	< 19	3	15.5	2
		> 19	3	> 15.5	> 2
5-8	< 5	< 16.5	1	< 10	< 1.5
		16.5 - 19	2	< 15.5	< 2
		> 19	2	> 15.5	> 2
	> 5	< 19	3	15.5	2
		> 19	3	> 15.5	> 2
8-12	< 12	< 19	3	15.5	2
		> 19	3	> 15.5	> 2
	> 12	all	4	> 20	> 3.5
> 12	all	all	4	> 20	> 3.5

When Gregor's Creek has a predicted peak gauge height greater than 12 metres then operating procedure 4 must be used irrespective of the predicted

38 Hegerty, KL and Weeks, WD "Flood Mitigation Operation of Wivenhoe and Somerset Dams – Hydrologic Investigation", Hydrology and Water Resources Symposium 1986.

height levels in the Stanley River at Woodfood and Lockyer Creek at Lyon's Bridge. This is because the resultant peak gauge height at Brisbane was expected to be greater than 3.5m. Procedure 4 required a release from Wivenhoe Dam to achieve the maximum practical reduction of peak flow of a large flood.

Brisbane River at Gregor's Creek is the key gauging station upstream of Wivenhoe Dam. When combined with the outflow from Somerset Dam, this gauge represents almost 75% of the catchment of the dam. The SEQ Water Flood Report (2011) reveals that the largest previously recorded flood at Gregor's Creek was the January 1974 flood that reached a gauge height of 14.14 metres. The report goes on to state that the January 2011 flood peak was some 0.35m higher than 1974.

On Sunday 9 January 2011 the Gregor's Creek gauge moved up rapidly from about 3.00pm and reached a height level of about 12 metres by 6.00pm and continued to rise until it peaked later than evening. It would appear that the height of the Gregor's Creek gauge is a good predictor of a major flood in Brisbane if it originates out of the Wivenhoe catchment. It is noted that the Engineer 3's log that night confirmed that if the flows were kept below 3500 the fuse plug would be triggered. Perhaps he may have been aware of the importance of Gregor's Creek gauge height levels to the potential flooding of Brisbane?

The Commission could assess whether predictions of the gauge height for Gregor's Creek is a good predictor of the level of likely flooding in Brisbane by itself or in conjunction with other gauges on the Stanley and Lockyer Rivers. If it is then overriding strategies could be put in place on release strategies W1 to W3 to lift releases in an endeavour to avoid or mitigate the potential for later major flooding in Ipswich and Brisbane.

Illustrative example of a modification to the objectives in the Manual and part of a change to two of the W1 strategies-

> *The primary objective to minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers and elsewhere is subject always to the principle that release operations should not adversely affect later operations in the event of later rain causing the peak inflow to significantly exceed the original estimate.*

W1D	>68 & <68.25m - Max release	1900m^3/s
	>68 & <68.25 & Gregor's Ck predicted to be >8 m - Max release	2500m^3/s
W1E	>68.25 & <68.5m - Max release	1900m^3/s
	>68.25 & <68.5m & Gregor's Ck predicted to be >8m & < 12m - Max release	3000m^3/s

Other strategies to W3 could also be modified when Gregor's Creek is predicted to peak above 12m. Applying this principle to the current strategies may limit the extent of avoidable flood risk and ensure the proper control and regulation in time of the flood release infrastructure at dams.

Any modification of the strategies W1 to W3 should only be of a temporary nature until the FSC of Wivenhoe is restored. The objectives of the Manual should be amended to include an overriding purpose that initial release operations should not adversely affect later operations in the event of later rain causing the peak inflow to significantly exceed the original estimate. To further minimise the potential for avoidable property risk, the FSL of Somerset could be lowered to create a flood mitigation capability to help lower flows into Wivenhoe.

7. Abbreviations

AEP	Annual Exceedance Probability
BoM	Bureau of Meteorology
cumecs	cubic metres per sec, 1000 litres per sec
DERM	Department of Environment and Resource Management (Qld)
EL	Elevation
FSC	Flood Storage Capacity
FSL	Full Supply Level
GL	Giga litres, 10^9, thousand million litres
mAHD	metres Australian Height Datum
m^3/sec	cubic metres per sec, 1000 litres per sec
ML	mega litres, 10^6 litres, million litres
ML/d	mega litres per day