SUBMISSION

TO

QUEENSLAND FLOODS COMMISSION OF INQUIRY

SUPPLEMENTARY SUBMISSION

by

Greg McMahon

30 March 2011

TERMS OF REFERENCE

UNDER the provisions of the *Commissions of Inquiry Act 1950*, Her Excellency the Governor, acting by and with the advice of the Executive Council, hereby appoints the Honourable Justice Catherine Holmes to make full and careful inquiry in an open and independent manner with respect to the following matters:-

a) the preparation and planning by federal, state and local governments; emergency services and the community for the 2010/2011 floods in Queensland,

b) the performance of private insurers in meeting their claims responsibilities,

c) all aspects of the response to the 2010/2011 flood events, particularly measures taken to inform the community and measures to protect life and private and public property, including

- immediate management, response and recovery
- resourcing, overall coordination and deployment of personnel and equipment
- adequacy of equipment and communications systems; and
- the adequacy of the community's response.

d) the measures to manage the supply of essential services such as power, water and communications during the 2010/2011 flood events,

e) adequacy of forecasts and early warning systems particularly as they related to the flooding events in Toowoomba, and the Lockyer and Brisbane Valleys,

f) implementation of the 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,

g) all aspects of land use planning through local and regional planning systems to minimise infrastructure and property impacts from floods,

h) in undertaking its inquiries, the Commission is required to:

- take into account the regional and geographic differences across affected communities; and
- seek public submissions and hold public hearings in affected communities.

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ABBREVIATIONS

Australian National Committee on Large Dams	**ANCOLD**
Brisbane City Council	**BCC**
Department of Harbours and Marine	**DHM**
Department of Local Government	**DLG**
Department of Mapping and Surveying	**DMS**
Department of Mines and Energy	**DME**
Department of Natural Resources Management	**DNR**
Department of Primary Industries	**DPI**
Gold Coast City Council	**GCCC**
Institution of Engineers Australia	**IEA**
Interagency Advisory Committee on Water Data in the US	**USIAC**
McMahon Original 11 March 2011 Submission	**REF A**
Probable Maximum Flood	**PMF**
Probable Maximum Precipitation	**PMP**
Queensland Public Service	**QPS**
Real Time Flood Model	**RTFM**
SEQ Water Report	**REF B**
Somerset Dam and Wivenhoe Dam	**SDWD**
Water Resources Commission	**WRC**

SUPPLEMENTARY SUBMISSION TO THE COMMISSION OF INQUIRY

References:

A. ***Submission to the Queensland Flood Commission of Inquiry***, by G McMahon dated 10 March 2011

B. ***January 2011 Flood Event***, Report on the Operation of Somerset Dam and Wivenhoe Dam, by SEQWater dated 2 March 2011

C. ***Manual of Operating Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam***, Revision 7, by SEQWater dated November 2009

D. ***Brisbane Floods January 1974***, Report by Director of Meteorology, Australian Government Publishing Service, Canberra 1974

E. ***Guidelines for Evaluating Hydrologic Hazards***, US Bureau of Reclamation, June 2006

F. ***Coping with Probable Maximum Flood – An Alliance Project Delivery for Wivenhoe Dam***, Chandler K, Gill D, Maher B, Macnish S and Roads G, ANCOLD Conference on Dams, October 2003

G. ***Wivenhoe Dam Flood Security Upgrade***, Gill D, Cooper B, Maher B, Macnish S and Roads G, ANCOLD/NZSOLD Conference, 2004

H. ***A Framework for Characterization of Extreme Floods for Dam Safety Risk Assessments***, Swain R, Bowles D and Ostenaa D, Proceedings of the 1998 USCOLD Annual Lecture, Buffalo New York, August 1998

I. ***Wyaralong Dam Design Flood Hydrology Summary Report***, Sunwater, September 2007

J. Probability of Occurrence of Extreme Rainfalls and Floods, by Kennedy, Pescod, Pearse, Laurenson, Canterford, Hall, Murley and Cummins, AWRAC Research Project P86/33, Department of Primary Industries and Energy, 1989

BACKGROUND

I seek to provide information and advice, further to my original 11 March 2011 submission ["**REF A**"], relevant to concerns that further flood events may occur in the forthcoming wet seasons, and that more might have been done in the past, and can be done in the future, to avoid and/or mitigate loss of life and damages from those events.

This submission is provided in the public interest and may be made a public exhibit. It should be read and understood against the unexpurgated contents of my original submission which has also been requested to be made a public exhibit.

In the week before the dateline for first submissions, SEQWater issued its report[1], dated 2 March 2011, about the January 2011 flood. It was an 1180-page document. Unfortunately, I was unable to refer to it in the few days available before making my first submission to the Commission of Inquiry.

The letter covering **REF A** requested that I be able to make further submissions in the above circumstance.

I have now analysed selected aspects of the SEQWater Report ["**REF B**"], and I believe that it is important to make this supplementary submission in the public interest.

SUMMARY

It is submitted that the SEQ Water Report ["**REF B**"] may be unsatisfactory with respect to the information and analysis that it provides about the subject flood, and is unsafe with respect of its failure to identify the deficiencies in the operation of the Somerset Dam and

[1] http://www.derm.qld.gov.au/commission/documents/report-append.pdf

Wivenhoe Dam ["**SDWD**"]. This failure may give rise to dangerous circumstances for future flooding.

In summary, the operation system established for the **SDWD** may only be at a '**PLANNED**' level of development against the assessment ratings of:

1. Ad hoc;
2. Planned;
3. Managed;
4. Integrated; and
5. Optimized

which hierarchy of assessment ratings was proposed in **REF A**.

Within the scale for the '**PLANNED**' rating [1.5 to 2.5], the **SDWD** may only be at the 40% level, with a score a 1.9.

It is further submitted that apparent deficiencies in the planning and management of the **SDWD** system may tend to undermine, for critical flood events, the capacity of the operating system to achieve a higher rating as an effective flood mitigation regime.

Two analyses are specified and recommended for the insight that they may bring to the capabilities of the **SDWD** system for mitigating floods.

It is a matter of concern that the records that have been provided by SEQWater, both during the flood event and also since that event (such as in **REF B**), may misrepresent critical aspects of those actual events.

It is submitted that any misrepresentations may give cause to the Commission to treat all data provided by SEQWater as meriting inspection and third party audit.

Such inspection from outside of SEQWater may present insurmountable difficulties for the Commission without the cooperation of individual public officers from within SEQWater.

For reasons set out in **REF A**, it is submitted that the Commission, as it is presently constituted, is unlikely to gain the confidence of public officers sufficient for such officers to come forward and provide the necessary answers so that the Commission can comprehensively fulfill its task in the public interest.

Another significant concern is that the information going to the public about the degree of protection against flooding being provided by the **SDWD** system may not meet the ethical standards required of a public authority staffed with registered professional engineers.

Recommendations are collected at the end of this submission.

REVIEW

Overview

Comment and concern is provided with respect to the following aspects of **REF B** and the analyses and practices that it describes:

1. Reporting of Flood Level Forecasts;
2. Accuracy of Rainfall Estimates;
3. Estimates of Probabilities and Probability Concepts;
4. Wivenhoe Rainfalls; and
5. The Strategy Options for Operating Wivenhoe Dam.

A preliminary rating of the **SDWD** as a flood mitigation regime is offered and explained.

Reporting of Flood Level Forecasts

Table 1 is an assembly of data from **REF B** pertaining to the derivation and reporting of forecasts of water levels in Wivenhoe Dam.

Figure 1 places this material in graphical form.

The data appears to be information tending to show that forecast reports of Wivenhoe Dam water levels were in significant error. The fact of the error arises when the reported forecasts are compared with the water levels forecast by the hydrologic modeling of measured and forecast rainfalls. These model runs were made before and immediately before the forecasts in error were reported in Situation Reports and Technical Situation Reports to other stakeholders.

The error appears to have originated after 3.30PM (or 15.00) on Sunday 9 January 2011.

This is the time when a last forecast was made where the reported forecast, and the estimated hydrologic model forecast (estimated from the sequence of forecasts from model runs), were approximately the same (see Figure 1).

The error, thereafter, ranged from 0.5metres to 1.5metres

The error appears to have been made by public officers with access to the forecasts that were being produced by multiple runs of the Real Time Flood Model [ñ**RTFM**"] used for operating the **SDWD**.

The conduct of each model run has been logged (see Appendix M to Ref B).

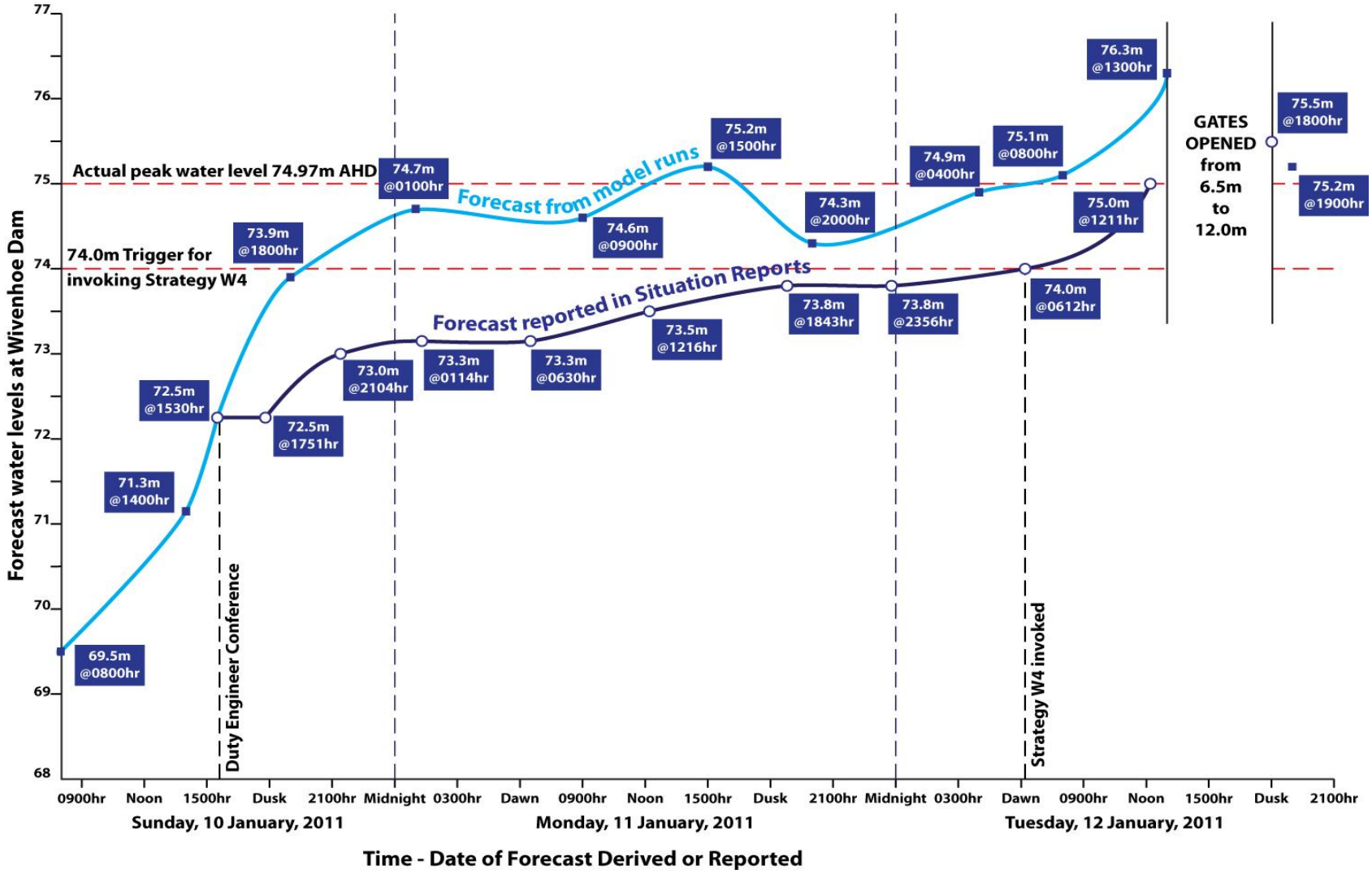
Forecast water levels at Wivenhoe Dam
77
76
75
74
73
72
71
70
69
68
Actual peak water level 74.97m AHD
74.0m Trigger for invoking Strategy W4
Forecast from model runs
Forecast reported in Situation Reports
69.5m @0800hr
71.3m @1400hr
72.5m @1530hr
73.9m @1800hr
74.7m @0100hr
74.6m @0900hr
75.2m @1500hr
74.3m @2000hr
74.9m @0400hr
75.1m @0800hr
76.3m @1300hr
72.5m @1751hr
73.0m @2104hr
73.3m @0114hr
73.3m @0630hr
73.5m @1216hr
73.8m @1843hr
73.8m @2356hr
74.0m @0612hr
75.0m @1211hr
GATES OPENED from 6.5m to 12.0m
75.5m @1800hr
75.2m @1900hr
Duty Engineer Conference
Strategy W4 invoked
0900hr Noon 1500hr Dusk 2100hr Midnight 0300hr Dawn 0900hr Noon 1500hr Dusk 2100hr Midnight 0300hr Dawn 0900hr Noon 1500hr Dusk 2100hr
Sunday, 10 January, 2011
Monday, 11 January, 2011
Tuesday, 12 January, 2011
Time - Date of Forecast Derived or Reported

TABLE 1: UNDERSTATEMENT OF FORECAST LEVELS FOR WIVENHOE DAM 9-11 JANUARY 2011					
Serial	**DATE**	**TIME**	**FORECAST fm MODEL**	**FORECAST REPORTED**	**COMMENT**
1.	Sunday 9 Jan	08.00	**69.5m** [~ Tuesday morning]		See Run 14, Ref B, Appendix A, p55
2.		14.00	**71.3m** [~ Noon Tuesday]		See Run 17, Ref B, Appendix A, p64
3.		15.30		**72.5m**	Confirmed at Duty Engineer Conference – see 3.30PM Log entry at Appendix M, p82
4.		17.51		**72.5m**	Situation Report 11 Ref B, Appendix E, p20 Author: Duty Engineer ERROR: **minus 0.9metres** (understatement of previous model run forecast)
5.		19.00	**73.9m** [~ Noon Tuesday]		See Run 21, Ref B, Appendix A, p73 Confirmed in Ref B, p192, which reports: ***the decision was made … to transition to a situation where minimizing disruption to downstream rural life was no longer a consideration*.** See Appendix M pp83-5 for logged reactions
6.		21.04		**73.0m** [Tuesday morning]	Situation Report 12 Ref B, Appendix E, p21 Author: Duty Engineer ERROR: **minus 0.9metres** (understatement of previous model run forecast) 12.45AM log entry states that the Duty Engineer ***confirmed that if flows were kept below 3500 the fuse plug*** (at 75.7m) ***would be triggered*** – see Appendix M p85 01.00AM first log entry about dam stability issues is recorded – see Appendix M p85
7.	Monday 10 Jan	01.00	**74.7m** [~ Tuesday night]		See Run 23, Ref B, Appendix A, p82
8.		01.14		**73.3m** [Tuesday morning]	Situation Report 13 Ref B, Appendix E, p24 Author: Duty Engineer ERROR: **minus 1.4 metres** (understatement of previous model run forecast)
9.		06.23		**73.3m** [Tuesday morning]	Technical Situation Report 10 Ref B, Appendix F, p80 Author: Dam Operations Officer ERROR: **minus 1.4 metres** (understatement of previous model run forecast)

10.	Monday 10 Jan [contin]	06.30		**73.3m** [Tuesday morning]	Situation Report 14 Ref B, Appendix E, p26 Author: Duty Engineer ERROR: **minus 1.4 metres** (understatement of previous model run forecast)
11.		09.00	**74.6m** [~Wednesday morning]		See Run 26, Ref B, Appendix A, p91
12.		09.38			Log entry indicates that, despite prediction made at Log entry 12.45AM (serial 6), a decision is agreed with BCC that ***the strategy is to limit the flows to 3000-3500*** for ***the next 24 hours*** – see Appendix M, p86
13.		12.16		**73.5m** [Tuesday morning]	Situation Report 15 Ref B, Appendix E, p29 Author: Duty Engineer ERROR: **minus 1.1 metres** (understatement of previous model run forecast)
14.		13.00	**???**		Result of model run not provided in Ref B
15.		14.58		???	Situation Report not provided in Ref B, and is not given a number – serial 13 is Report 15 and serial 18 is Report 16
16.		15.00	**75.2m** [~ Noon Wednesday]		See Run 28, Ref B, Appendix A, p100
17.		15.27	m	**73.8m** [Tuesday morning]	Technical Situation Report 11 Ref B, Appendix F, p82 Author: Dam Operations Officer ERROR: **minus 1.4 metres** (understatement of previous model run forecast)
18.		18.43		**73.8m** [Tuesday morning]	Situation Report 16 Ref B, Appendix E, p31 Author: Duty Engineer ERROR: **minus 1.4 metres** (understatement of previous model run forecast)
19.		20.00	**74.3m** [~Wednesday morning]		See Run 31, Ref B, Appendix A, p109
20.		21.00			Discussion with Dam Safety Regulator to obtain permission to exceed 74m for a short period without invoking Strategy W4 See Ref B, p193 09.00PM Log entry also states that a condition on this permission was stated as ***providing levels did not rise too high (ie less than 74.2mAHD)*** – levels higher than 74.2m had been forecast since 1.00AM

21.		23.56		**73.8m** [Tuesday afternoon]	Situation Report 17 Ref B, Appendix E, p32 Author: Duty Engineer ERROR: **minus 0.5 metres** (understatement of previous model run forecast). Wivenhoe Dam level reported as 73.2m
	Tuesday 11 Jan	04.00	**74.9m** [~ Noon Wednesday]		See Run 35, Ref B, Appendix A, p118
22.		06.12		**74.0m** [Tuesday evening]	Situation Report 18 Ref B, Appendix E, p35 Author: Duty Engineer ERROR: **minus 0.9 metres** (understatement of previous model run forecast). Wivenhoe Dam level reported as 73.5m
23.		06.38		**74.0m** [Tuesday evening]	Technical Situation Report 12 Ref B, Appendix F, p85 Author: Dam Operations Officer ERROR: **minus 0.9 metres** (understatement of previous model run forecast)
24.		08.00	**75.1m** [~ Noon Wednesday]		See Run 37, Ref B, Appendix A, p127 **Strategy W4 invoked** – see Ref B, p194
25.		08.10			Wivenhoe Flood Operations Directives 12 and 13 direct gates to be opened by 1.5 metres over next 3 hours – see Appendix L pp13-14. 08.10AM Log entry: Duty Engineer advises Director Dam Safety that ***Will exceed EL 74m. Ramping up gate opening to a minimum of 3700 cumecs*** – see Appendix M, p89
26.		12.11		**75.0m** [Tuesday morning]	Situation Report 19 Ref B, Appendix E, p36 Author: Duty Engineer ERROR: **minus 0.1 metres** (understatement of previous model run forecast). Wivenhoe Dam level was not included in the situation report
27.		13.00	**76.3m** [~Wednesday night]		See Run 39, Ref B, Appendix A, p136
28.		13.00			Wivenhoe Flood Operations Directives 15 to 24 direct gates to be opened by 5.5 metres over next 5 hours – see Appendix L pp16-25
29.		18.00		**75.5m** [Tuesday morning]	Situation Report 20 Ref B, Appendix E, p37 Author: Duty Engineer ERROR: **minus 1.4 metres** (understatement of previous model run forecast)

30.		19.00	**75.2m** [~Wednesday afternoon]		Actual Peak Level achieved of 75.0m [74.97]
31.	Wednes-day 12 Jan	05.49			Situation Report 21 Ref B, Appendix E, p38 Author: Duty Engineer **75.0m peak** level reported [74.97m]
32.		11.30			Technical Situation Report 13 Ref B, Appendix F, p86 **75.0m peak** level reported [74.97m]

Ref C appears to require the use of the forecasts made of future Wivenhoe Dam water levels when operating the SDWD in the flood management regime. Paragraph 9.3 of Ref C directs (Quote):

> ***"…The strategy chosen at any point in time will depend on predictions of the maximum storage levels in Wivenhoe and Somerset Dams which are to be made using the best forecast rainfall and stream flow information available at the time."*** (underlining added)

Wivenhoe Flood Strategy Flow Chart, at page 23 of Ref C, relies on the forecast:

Is Wivenhoe level likely to exceed EL 74.0? (underlining added)

as the determinant as to whether or not the operation strategy is shifted from Strategy W3 to Strategy W4.

The effect of the error was to maintain an answer of 'Noô to the above forecast, for a period from 19.30 hours on Sunday 10 January 2011 until 06.00 hours on Tuesday 12 January 2011 – 34.5 hours, when the correct answer, according to the **RTFM** hydrologic model runs, should have been 'Yes'.

Two possible reasons for this error have been considered and assessed as unlikely.

Firstly, the possibility that the operators were following past practice (that is, version 6 of Ref C), and were using actual water levels in Wivenhoe Dam, has been checked. The

forecast levels in the Situation Reports do not appear to match the reports of existing water levels at the time of the Situation Report given in the same Situation Report.

Secondly, it was conceivable that the model runs were causing changes to be made to the release rates, and that the forecasts in the Situation Reports were the forecasts from the model runs adjusted for the new settings. No model runs reported in **REF B**, however, showed a second model run producing a reduced Dam water level forecast just prior to the Situation Report. Instead, the driver for release rate changes appears to be the calculation of total flow from Wivenhoe and from other catchments passing Moggill and other downstream locations.

The outcomes from this apparent error may be that:

1. The Operating Strategy for Wivenhoe Dam appears not to have been followed;
2. Stakeholders (and readers of **REF B**) appear not to have been informed that forecasts being given by the **RTFM** were not included in the Situation Reports;
3. Stakeholders (and readers of **REF B**) appear not to have been informed that forecasts being given by the **RTFM** were significantly higher than the forecasts given in the Situation Reports;
4. Stakeholders (and readers of **REF B**) appear not to have been informed of any reason or rationale for reporting lower forecast figures than those forecasts being given by the **RTFM**;
5. Strategy W3 appears to have been maintained for up to 34 hours longer than it may have been if all stakeholders were appraised of the forecasts being provided by the **RTFM**; and
6. While discretions may be available to the operators to vary from the operational rules of the **SDWD**, according to procedures for exercising such discretions, the discretionary powers do not extend to any misrepresentation of the forecast information available, if this is what has occurred.

The concern exists that the above assembly of data may be information tending to show that the forecasts given in the relevant Situation Reports (and in the relevant Technical Situation Reports) may have been a deception upon

(i) the stakeholders, and

(ii) the Commission of Inquiry,

if no satisfactory explanation is provided for the practices followed in this regard.

A common situation that can occur with reporting, termed 'hope creep', is where initial misreporting is maintained in subsequent reporting, in the hope that the actual measurements will creep back to the reported measurements. The 'hope creep' situation can become undone when the actual results do not return to the pattern of reported results.

The possibility of political interference should not be discounted without examination.

Serials 6 and 20 in Table 1 may indicate that there was a voice or voices, amongst the public officers likely to have had knowledge of the model runs, that had regard for the implications of forecasts that were in excess of EL 74m AHD. The position reflected in serial 12 on Table 1 appears, however, to have had the ascendancy in any such discussion.

Accordingly, the Commission of Inquiry may be misled by the first 'Conclusion' in the Executive Summary of **REF B**, where it claims that the **SDWD** was operated for the January 2011 Flood Event in accordance with the Manual.

RECOMMENDATION 1: That an explanation be sought from the public officers who received the model run results as to the source of the Wivenhoe Dam water level forecasts provided in the Situation Reports with the reasons for not using the results of the RTFM model run results.

Accuracy of Rainfall Estimates

The second and third conclusions of the Executive Summary appear to be contradictory in important respects. The second conclusion as well may not be showing proper regard to important under-performances that may have prejudiced the soundness of some decisions made.

Contradiction regarding Rainfall Forecasts. Figure 1 indicates that, during the 34.5 hour period when the duty engineers were reporting forecasts well below that of those from the model runs, the model runs were giving values consistently approximating the actual peak level achieved by flood flows behind the Wivenhoe Dam.

There appears to be little scope for criticizing the modeling of the catchment upstream of Wivenhoe Dam in this important respect. The modeling, of course, was dependent upon, and benefited or suffered from, the quality of the rainfall forecasts provided by the Bureau of Meteorology.

The model runs using the rainfall forecasts appear to have outperformed whatever technique was going into the forecasts recorded in the Situation Reports. This is especially the case, it appears, during that critical 34.5 hours over Sunday, Monday and Tuesday (i.e. 9-11 January 2011), that determined the flood mitigation outcome.

It would appear to be a major omission for SEQWater to ignore, when evaluating the rainfall forecasts, the outcome that the modeling achieved with those forecasts. The fact that the modeling output may have been largely ignored during the event (particularly the fact that the forecasts appeared to be triggering the transition to Strategy W4) **does not entitle** any objective reporting, post the event, to omit this relatively accurate outcome achieved using the rainfall forecasts.

It follows that the Commission of Inquiry may therefore be misled by the third conclusion. The apparent failure to accept the forecasts of Wivenhoe Dam water levels,

derived through modeling from the rainfall forecasts, allowed the Wivenhoe Dam to be operated with Strategy W3. Strategy W3 appears, at least in practice, to restrict the release rate from Wivenhoe Dam to flow targets set for Lowood and Moggill.

If the operators had acted on the model runs using the forecast rainfalls, Strategy W4 may have been invoked sooner, which would have allowed greater releases sooner, thereby alleviating the need to release 7500 cumecs later when the operators may have judged that they were left with no other choice.

Performance of Data Collection and Modelling. With respect to the second conclusion offered by the Executive Summary in **REF B**, this assertion does not appear to be accurate with respect to modeling downstream of Wivenhoe Dam.

The flood height predictions made for Brisbane were higher than the actual flood heights, by over one metre. The height predictions appeared to influence decisions on releases from Wivenhoe Dam, causing operators to release at lower rates than they might otherwise have released if the predictions about downstream flood heights were (lower and) more accurate.

Collection of actual rainfall data was also unsuccessful. The critical rainfalls affecting Lockyer Creek and the Wivenhoe Dam area were not recorded. The number and spread of rain gauges deployed appear to be insufficient in total and unrepresentative of critical rainfall areas.

The damage sustained by the network of rain gauges and streamflow stations may indicate that these facilities are not designed with the largest floods in mind. This is another priority shortcoming for a flood mitigation regime, and ought to be addressed as a matter of urgency.

Concepts of Probability

REF A set out the history to the adoption of the practice of assigning a probability to the Probable Maximum Flood ["**PMF**"], and to the use of this figure to derive 'probability' for rare floods smaller than the PMF.

REF A also recalled alleged 'arm twisting' of Bureau of Meteorology extreme precipitation experts to give their imprimatur to the practice of giving a probability to the PMF.

The 1984 paper by Kennedy & Hart in the Civil Engineering Transactions of the Institution of Engineers is the one quoted by AR&R and ANCOLD when these organisations adopted the practice of assigning probability to the PMF. AR&R and ANCOLD did not base their practice on Kennedy & Harts earlier 1982 paper to Hydrology and Water Resources Symposium.

The 1984 paper is almost word for word the 1982 paper under the heading, 'ASSIGNING PROBABILITIES TO THE PMP ESTIMATES'. The word 'almost' is deserved, in part because there are some sentences in the 1982 paper that have been omitted in the 1984 paper, including:

A. When discussing the legitimacy of extending the record of rainfall for a catchment by transposing storms from a wider geographic area than the catchment at issue, the 1984 paper omitted the qualification:

> ***These considerations are offset to some extent, especially for small catchments, by the error due to the limited density of rain gauges. It is assumed that all heavy rainfall events have been observed.***

B. When discussing the legitimacy of the uses to which the probability figures could be put:

> ***In Table 1 rough probabilities for transposed and maximized storms are given for a range of catchment areas assuming a probability for in situ maximization of 10^{-3} and a transposition area of 10^{5} km^{2}. This table is***

> ***merely intended to show the effect of storm transposition on probability levels for different catchment areas. <u>The values in the table are not meant as recommendations for assigning probabilities to PMP estimates</u>.***
>
> [Note also that the Summary for the 1984 paper finished by describing the concept of assigning probabilities to PMP estimates as
> ***desirable for performing cost benefit studies***.]

It is not known, from the literature, how these omissions came to occur, whether during the authorship, as part of the gaining of organisational permission, or during the review processes used by the Institution of Engineers in deciding whether particular papers would be published in its Transactions.

The turnaround that has occurred is unexplained in the literature known to this author.

The warning in the first of these two omissions is prophetic with respect to the January 2011 Flood Event in the Brisbane River valley. This is because, for both the Wivenhoe and the Lockyer Creek Catchments, the heaviest rainfalls were not recorded. The rainfalls that were recorded do not represent the major rainfalls for the Flood Event in multiple catchments of the Brisbane River valley.

The rainfall record for these catchments is not representative of the heavier rainfalls that have occurred in these catchments.

This omission has long been recognized by practitioners, including Kennedy & Hart. The repeated error, over the years of 'record' from rain stations that have missed the heaviest rainfalls in their catchments, undermines the validity of estimates of probability using so termed 'extended records' drawn from storm transposition.

The 'extended records' can be regarded in this respect as an extended record of missed rainfalls of unknown strength and unknown frequency.

Regarding the second of these omissions from the 1984 paper, it has been recalled to this author that, about the time that **AR&R** and **ANCOLD** were adopting the practice of assigning probabilities to **PMFs**, an organisation in the United States, well credentialed in the analysis of rainfall data, was determining that such a practice **was not** within the state of the art.

In 1986, the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data reported on its examination of ó*Probable Maximum Flood Risk Assessment'*. The Sub-Committee stated that (Quote):

> ***"…It is not within the state of the art to calculate the probability of PMF-scale floods within definable confidence or error bounds.***
>
> ***Many professionals believe this transition (from events whose estimation errors can be defined to unprecedented events whose errors cannot be defined) begins at recurrence intervals of about twice the record length and is complete by recurrence intervals in the general area of about 1000 years. The Work Group finds no reason to contradict these general perceptions."***

SEQWater have adopted the practice, and assigned, without basis,

- 1in100,000 (or 1in100K) AEP to the current design flood for **SDWD**, identified as a 43,000 cumec peak flow flood (see Ref G, page 2), and,
- 1in200,000 (or 1in200K) approx AEP appears to be the current estimate of the **PMF**, identified as a 49,000 cumec peak flow flood (see Ref F, Figure 2)

In particular, as in page 4 of REF B, SEQWater has adopted the term, '1in100,000 years' in defining the design of the dam and its spillway:

> ***'The auxiliary spillway … gives the Dam Crest Flood an AEP of approximately 1 in 100,000 years'***.

It is this type of wording that causes dwellers on the floodplain to believe, and act on the belief, that there would be no flooding after the Wivenhoe Dam was built.

The statement is without basis. 100,000 years ago, mammoths roamed the earth. Regarding the next 100,000 years, the forecasts of future sea water temperatures and associated dew points 100,000 years from now is one question that captures, I submit, the lack of veracity in the figure itself and in the claimed expertise for offering such a figure.

In the Australian literature, the ownership of these probability figures for use in the design of large dams appears to belong to two experts who never stated the figures for this purpose.

Because this practice is without basis, theoretical or empirical, it is a concern that other probability concepts might also be applied to the hydrologic analysis of flows at the Wivenhoe catchment, also without any basis.

A leading example of any such propensity may be the use made of the concept of 'Credible Limit of Extrapolation'.

This has been set at 1in2,000 (or 1in2K) for Wivenhoe Dam inflows (see **REF B**, Executive Summary page ii).

The 'Credible Limit of Extrapolation' is ignored when assigning a 1in100,000 (or 1in100K) AEP to the 43,000 cumec event – 1in100K is clearly outside the 'Credible Limit' of 1in2K cited in **REF B**.

This is the primary contradiction within the **AR&R/ANCOLD** approach adopted by SEQWater. It gives rise to the reasonable suspicion that the **AR&R/ANCOLD** approach may lead to practices in hydrology that show a disregard for the credibility of the printout from computer programs about large floods that can kill.

The estimate that 1in2K AEP is the 'Credible Limit to Extrapolation' may also lack credibility.

For example, according to the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data in the US ["**USIAC**"], the credibility of extrapolations of flood frequency analysis starts to wane at 'twice the record length' and is lost at about 1000 years. The 1in1000 AEP is, according to the US authority, not a 'limit of credibility' at all, but is the beginning of the 'No Credibility' range.

In considering the safety of persons and families living on the floodplain, downstream of a Dam that can be overtopped, an important question arises, it is herein submitted:
How could the status of 'credibility' be responsibly given by any authority to an AEP of 1in2000 for any record from the Brisbane River valley. This AEP is twenty to forty times the record length of most rainfalls and streamflows in the valley. The AEP of 1in2K is **twice** the 'No Credibility' AEP set by USIAC.

An example of the situations that can occur may be found in the Report on the hydrology of the Wyaralong Dam (Ref I). This Report is currently available to the public on the internet. The Wyaralong Dam is also located in the South East Queensland Region.

This recent study also accepts the 1in2000 AEP as the credible limit of extrapolation, referencing rainfall studies by another Queensland Public Service organisations. Those origin studies do not appear to be before the Commission of Inquiry.

From 40 years of streamflow records, this analysis produces graphs of the frequency distribution of flows upstream of the Dam.

The 1in2000 AEP Credibility Limit adopted by the study is 50 times the length of record (accepting a definition of AEP to include the expression 'lin2000 years' used in **REF B**).

The **USIAC** statement quoted above, by comparison, would attribute credibility to any extrapolation out to 1in80 AEP, and set the 'No Credibility' limit at 1in1000 AEP.

Figure 6-3 in Ref I shows two attempts to fit different frequency distribution relationships to the 40 years of data. Figure 6-3 in Ref I has barely visible dotted lines describing the 95% confidence limits to the thick red line median estimates of flow for one of the two frequency distribution relationships trialled for that hydrologic study.

Table 2 sets out the readings of the flows at the confidence limits for AEPs referred to in guidelines from **USIAC** and **AR&R/ANCOLD** (as best can be done by eye).

TABLE 2: ESTIMATES OF FLOWS WITHIN THE 'LIMIT OF CREDIBILITY'

AEP	UNCERTAINTY OF FLOW ESTIMATES	RATIO: UPPER FLOW / LOWER FLOW	"BEST ESTIMATE"
1in40 Record length	580 to 2300 cumecs	4	1200cumecs
1in80 USIAC's Limit	700 to 4000 cumecs	5.7	1800 cumecs
1in500	880 to 15,000 cumecs	17	2700 cumecs
1in1000	This AEP not included on Diagram		
1in2000 AR&R's Limit	This AEP not included on Diagram		

It is interesting that Ref I does report a range of values for the floods of interest. This range, however, is produced, not from confidence limits, but from the "best estimates" of the different frequency distributions and analyses tried. That range was 1520 to 2060 for the 1in100AEP.

Even the range of available frequency distributions do not agree on the "best estimate".

That is the state of the art

In terms of credibility, the 1in1000 and 1in 2000 are not even plotted. The reading that the upper limit for the 1in500 AEP is 17 times the lower limit is a demonstration of how uncertain (or 'incredible') AEP "best estimates" can quickly become once extrapolation is used to extend estimates of probability.

The 1in2000 credibility limit has been derived by analyzing regional rainfalls, which assume in general terms that:

1. One of the catchments in the region has had the rare rainfall, that this was captured by a set of rainfall stations, and that this can be transported to all other catchments; and
2. The 1inY rainfall produces the 1inY flood.

Ref I shows good practice in attempting to reconcile the flow record with the rainfall generated flows. The report shows the difficulties of such reconciliations, but does so only at the much easier 1in100 AEP, and without addressing the confidence limits of those rainfall AEPs.

Estimates of Probability

The problem then occurs, as in the fifth conclusion of the Executive Summary of **REF B**, that SEQWater assigns an AEP to the 2011 Flood of 'rare', that is, somewhere in the range ***'easily exceeds 1in100 AEP'*** to '***as high as 1in1000'*** (or 1in1K) - (see Figure 8.1.1 on page 121, and at 'Conclusions' on p151, of **REF B**).

Some further perspectives supplied below may be helpful to the Commission of Inquiry in assessing this claim by **REF B**.

Volume AEP. Firstly, the essential parameter of the flood to be analysed, because of the issue of flood mitigation by dam storage, is the volume of the flood. Certainly, the peak of the flood is important, especially any late peak in the shape of the input flow (arising from the temporal pattern of the rainfall), but essentially it is the volume of the dam filling flood that threatens to fail the **SDWD** system and/or flood the floodplain downstream of the Wivenhoe Dam.

118 years ago, in 1893, three major floods occurred in the Brisbane River Valley within 12 days. The volume of the two peak flood arriving at Wivenhoe Dam in 2011, is only 96% of the volume of the largest peak of the first of these three February 1893 floods that flowed past the Wivenhoe site – see Table 8.5.1, p140.

This is a very restricted comparison, favouring the January 2011 event. On less restrictions as to the parts of the 1893 floods that could be included in the comparison, the ratio would be less than 96%.

Flow and Flood Height AEP. The largest peak of the first February 1893 flood had a flow estimated at 13,000 cumecs at Caboonbah (upstream of Wivenhoe), whereas the January 2011 had a flow at this point estimated at 8,500 cumecs, only 65% of the 1893 peak. Flood heights, too, were 11.73m for 1893 Flood at Woodford upstream of Somerset (see Table 8.6.1, p141), where the flood height for the January 2011 flood was only 80% of this value (that is, 9.44m).

Rainfall AEP. The rainfall AEPs set out in **REF B** do not include a comparison with the 1893 flood, because, **REF B** states, the rainfall records for 1893 ***'are inadequate to allow a proper comparison'***.

The Bureau of Meteorology was more generous in 1974 when reporting on the January 1974 flood (see Ref D). There does appear to be some differences in how the rainfalls were assembled (realized by comparing what each report stated about rainfalls in the January 1974 event). These differences do not rob the comparison of its value.

TABLE 2: COMPARISON OF RAINFALLS FEB 1893 AND JAN 2011			
REPORT	**Period of Rainfall**	**Stanley**	**Upper Brisbane**
Four (4) day rainfall events			
BOM 1974	1-4 February 1893	939mm	358mm
SEQWater 2011	9-13 January 2011	461mm	326mm
Three (3) day rainfall events			
BOM 1974	4-6 February 1931	452mm	219mm
BOM 1974	16-18 February 1893	430mm	252mm
SEQWater 2011	10-13 January 2011	412mm	307mm
Notes: 1.The SEQWater totals were calculated from the highest four day totals and three day totals from Table 8.2.2, p123. **2.**The three day flood event on 16-18 February 1893 was the third flood in that month			

Clearly, the rainfalls that led to the first flood in February 1893 were significantly larger than the January 2011 rainfalls, at least with respect to the Stanley and Upper Brisbane River catchments.

Rainfalls for other 72hour flood events rivaled the rainfalls for the January 2011 Flood Event.

Once the other major floods from the history of recorded floods are added to the AEP analysis, and once the current analysis is expanded to include the flow record from 2005 to 2011 (as properly noted by **REF B** at page 142), including the October 2010 and January 2011 events, the analysis of rainfalls will show two or more rainfall records of comparable and/or larger size to those recorded in 120 years of rainfall records. A proper analysis is therefore unlikely to find that the January 2011 rainfalls were greater than a

once in 100 years event when it has happened and been exceeded twice or more in 120 years.

The rainfall analysis is the most troublesome element for inferring an AEP for the Flood Event. For instance, the 16-18 February 1893 Flood, although smaller in rainfalls than the 1-4 February 1893 and the January 1974 floods, was greater in flood height than both these floods in parts of Brisbane, because of non-rainfall factors.

This outcome for very large floods supports the experience of most hydrologists that 1inY rainfalls do not usually yield 1inY floods.

Overall AEP. There appears to be no basis for any claim that the January 2011 Flood Event was anything like a 1in100AEP, let alone a 1in2K AEP event. The proposition in **REF B,** at its 'Conclusion' to section 8 (page 151) and at Appendix U, p237, that the 2011 Flood Event has a 1in100 AEP appears to be without basis, and the proposition that the AEP is 1in1000 appears to have been made without proper contemplation of the safety issues that might arise if this AEP was accepted and incorporated into the design and operation of the SDWD.

The true AEP of the January 2011 Flood appears to be more frequent than 1in100, and may be as frequent as 1in50, it is submitted, whether the criteria for assessment of AEP is flood volume, flood flow, flood height or rainfalls (intensity or depth).

And **REF B** properly advises that *'**estimates exists of possible larger floods occurring in 1841 and 1867 …'***.

Further -

Criticism of **REF B** about its use of notions of probability may be amplified by further comment on some particular matters raised by SEQWater.

Comparisons with January 1974 Rainfalls. As set out by the Bureau of Meteorology in Ref D, the reputation of the 1974 Flood in Brisbane is owed, in largest part, to outflows from the Bremer River and Brisbane Metropolitan Creeks than it is to outflows past Wivenhoe (see Ref D, Figure 8 at page 28). The 1974 Flood achieved its reputation from these flows, not from Stanley and Upper Brisbane catchments.

The 2011 Flood, by comparison, saw greater outflows from the Stanley and Upper Brisbane Catchments.

Such comparisons of the 1974 and 2011 flood events are of Flood Events that got their 'size' from different catchments.

Comparisons of rainfalls from the 1974 and 2011 Flood Events, for Bremer, Warrill, Purga and Lower on Table 8.2.2, page123 in **REF B**, support this description. Any inference, that the 2011 Event is 'greater' than the 1974 Event, because of comparisons of rainfalls in the Stanley and Upper Brisbane catchments, appears to be a misplaced inference.

The practice in **REF B** has been to compare the lower rainfall areas of the famous 1974 flood with the higher rainfall areas of the 2011 Flood.

The historical floods that gained principal rainfalls in the Stanley and Upper Brisbane catchments include two of the 1893 floods and the February 1931 Flood.

The comparisons actually made in **REF B** therefore appear not to have included more relevant or equally relevant floods from the historical record.

The comparisons actually made in **REF B** may act to mislead the Commission of Inquiry about the size of the 2011 Flood Event.

Double Peaks. Much is made in **REF B** of the two peaks in the 2011 Flood event.

The treatment of these two peaks within **REF B** appears to be inconsistent, arbitrary and/or contradictory in different analyses offered in that report.

Firstly, the volumes of the two peaks of the 2011 Flood are added together by **REF B** when arguing about the relative sizes for Flood Volumes from the historical record.

REF B then makes a comparison with the first February 1893 flood for which the volume of only the largest peak is calculated. This inconsistency appears to have the potential for favouring the argument being proposed by **REF B**, when even treatment of both floods might not support that same argument.

Secondly, **REF B** switches language from ***'two distinct flood peaks'*** to a ***'second flood'*** in framing an apparent joint probability calculation. The joint probability calculation appears to lead **REF B** to suggest ***'the rarity of the January 2011 Flood Event'*** and that the causative rainfall ***'may be well into the extreme category'*** (see pages iii and 142).

A proper analysis would decide whether the two peak 2011 flood hydrograph was one flood or two floods, and use that decision in determining the AEP by each and every AEP method employed. A proper analysis would apply the same criteria distinguishing double (or triple peaks) from separate floods to all other floods on record, so as to be consistent in obtaining an objective and safe comparison. The apparent practice of switching bases so as to maximize an argument is information tending to show bias in the reporting of AEP within **REF B** towards any selection of material that increases the relative ranking of the 2011 Flood.

The comment is also made (at page 142 of **REF B**) that ***'two new higher flood peaks occurring within 36 hours of each other'*** is considered to be ***'appreciably uncommon'***.

Such shapes to flood hydrographs are **not** ***'uncommon'*** in the major storms from the South East Queensland region. Per chance, while preparing this supplementary submission, Ref D showed up a diagram of a three peak flood down Kedron Brook, three peaks occurring within 36 hours, during the 1974 flood.

The flooding during February 1893 involved three separate floods within 12 days, two of which appear to have matched or exceeded the 2011 Flood within the Wivenhoe catchment.

Hydrographs with a second peak larger than (or equal to) the first, or rainfall temporal patterns that produce such design flood hydrograhs, are sought by engineers designing dams and flood structures. This is because these hydrographs commonly occur and can be more testing of such structures than early peaking, single peak floods.

Best practice in flood management includes the application of an intense short period local storm, coinciding with the arrival of the peak of the inflow to the area under flood management, because this often happens with flooding of a 1in100 AEP or larger.

It is commonly such shapes and coincidences that make some floods 'major' where other comparable floods without these features do not rise to the same flood heights and water velocities.

On the basis of the historical record of the three floods in February 1893, it appears difficult to justify using the expression, ***'two new higher flood peaks'***, when referring to the 2001 Flood Event within the Wivenhoe Catchment.

Gregor Creek Stream Gauging Stations. This stream gauging station is well placed to provide timely forecasts of flood volumes and flow rates approaching Wivenhoe Dam from the Upper Brisbane River Catchment.

The claims that the flood at this station during 2011 was the highest on record (Table 8.6.1, p141) needs to be read against the fact that the record at this station only covers a period of 49 years.

This record does include the 1974 flood for which average rainfalls in this catchment were the lowest from any of the Brisbane valley catchments, but, critically, it **does not** include the two 1893 floods, the 1931 flood, nor yet the 2011 flood.

The claim that the 2011 flood at this station has an AEP rarer than 1in 75 appears to be unlikely if these other floods are considered, off the historic record, from nearby stations in the same catchment, such as at Caboonbah. Nevertheless, this 1in75 AEP appears to be the closest estimate from **REF B** to what seems a reasonable AEP for any aspect of the 2011 Flood.

The Flood Hydrograph for Gregor Creek (see page 84) is a record of the natural flood. The hydrograph for the inflows into Wivenhoe Dam, however, is not a recorded hydrograph, but is instead a reversed calculation from the time series of Dam water levels (see Ref B, Section 8.9, page 146).

The Flood Hydrograph for Gregor Creek may indicate that the 2011 Flood Event is one flood with two major peaks, rather than two floods.

Gregor Creek Rainfall Stations. Any description of the length of records at Gregor Creek as a Rainfall Station could not be found in **REF B**. This inhibits comment on the rainfall analysis undertaken by SEQWater for the Gregor Creek rainfalls.

The estimates of rainfall AEP given in **REF B** for Gregor Creek are based upon regional precipitation probabilities (using the CRC-FORGE method). This approach has allowed itself to derive 1in2000 (or 1in2K) AEPs for rainfalls in SEQld (that is, to extrapolate regional records of rainfalls out to the 'Creditable Limit of Extrapolation'). From this approach, an estimate of the AEP for Gregor Creek rainfall comes in at 1in100 to 1in200.

This outcome allows others the opportunity to assess the CRC-FORGE method and its application by SEQWater.

Clearly, the AEP estimate from the CRC-FORGE method does not gel with all that we know about all flood and flow and height and rainfall histories in this catchment, especially regarding the three February 1893 floods.

The methodology appears to be in error by a factor of 2 to 3 times what might be a reasonable estimate of AEP for the 2011 flood passing the Gregor Creek station.

And that is one of the flaws in the **AR&R** approach to estimating rare floods – it assumes that 1inY rainfalls produce 1inY floods – pointed out by the US Bureau of Reclamation in Ref E.

This US authority also uses a 'credible limit to extrapolation' type concept, but they do it within a context of attempting a lengthening of the historical record using paleontological records.

The guidance given by this US authority sets the limit of extrapolation at twice the length of record for stream flows, as did USIAC. It does, however, describe as 'typical' for Western USA, 1in2K limits of extrapolation for 'regionalized rainfall data', which is twice the practice figure of 1in1K limit described earlier in this paper.

Exaggerations. Some apparent exaggerations in the text may also be misleading to third parties, again all tending to overstate the significance of the 2011 flows:

1. At page 124, relying on Figure 8.2.4 – the apparent claim that rainfall intensities of 24mm and 23mm at Somerset during the 2011 Flood Event are ***'more than double'*** the 18mm and 21mm figures for the 1999 Event and the 18mm and 18mm for the 1974 Event;

2. At page 145 – the apparent claim that the attainment of a peak water level at Wivenhoe of 74.97m AHD is consistent with the flood necessary to initiate the first plug flow at 75.7m AHD, which latter flood is rated by **REF B** as 1in6K.

Practices. The practice of stating the inappropriateness of the analyses being presented in **REF B**, but then going ahead with the inappropriate analysis anyway, may be a concern to the Commission of Inquiry and to stakeholders.

Stakeholders, and the Commission of Inquiry, must depend on the operator organisation for much of the information they are seeking about the **SDWD** flood mitigation regime. It is submitted that, by providing stakeholders and the Commission with flawed analyses, with an admission that the analyses could be better, SEQWater **has not met** the needs of parties seeking valid and unbiased data from the operator – SEQWater may be showing disregard to the needs and obligations of others to ensure that safe findings and recommendations are made.

Examples of such practices include:

1. The failure to include maximum information of rainfalls and flows and flood heights from the February 1893 floods when **REF B** embarked on their analysis of the AEP of the 2011 Flood Event;
2. The failure to include the recorded data from the 2010 and 2011 events in data for all AEP estimates (see page142).

The Wivenhoe Dam Rainfalls

A problem is reported in **REF B** about the water levels that occurred in the Wivenhoe Dam during the second flood peak of inflow.

According to **REF B**, the levels were higher than they should have been. **REF B** has concluded that the problem was a data problem caused by heavy rainfalls in the vicinity of the Wivenhoe Dam and Lake area.

REF B regrets that there were no rain gauges near Lake Wivenhoe to confirm these rainfalls.

The idea, that rainfalls in the area of the lake were the cause of these purportedly unforecast water levels rises in the Lake, appears to come from observed heavy rainfalls to the East of Wivenhoe at Mt Glorious. There were also heavy rainfalls downstream of Wivenhoe. There was no evidence of heavy rainfalls to the North and West of Wivenhoe Lake area, however (Quote):

> ***"…The rainfall was recorded in the rain gauges to the east and south of Lake Wivenhoe (around Mt Glorious and Lowood), however, it was not recorded in gauges to the north and west of Wivenhoe Dam."*** (**REF B**, page 146)

In restoring the estimates of water levels in the Dam to those reported, it was necessary, **REF B** explains, to apply to the Wivenhoe Lake and its surrounds, twice the rainfalls recorded at Mt Glorious (Quote):

> ***"…To model the rapid rise of the recorded Wivenhoe Dam levels between 03:00 to 15:00 on Tuesday 11 January 2011, the Mount Glorious rainfall data was repositioned to the ungauged area immediately upstream of the Dam, where the BOM radar indicated was the centre of the heavy rainfall during that period. It was then necessary to scale this rainfall up by a factor of two to match the rapid lake level rises. This factored Mt Glorious rainfall data had an average intensity of 68mm/hr, which exceeds an annual recurrence interval of 1 in 2000 years and may be well into the extreme category."***

(**REF B**, page 147)

Mt Glorious has experienced heavy rainfalls in the past – in the 1974 flood, rainfalls recorded at this station were 25% higher than those that fell during the 2011 Flood Event. The rainfall isohyets for the 1974 Flood reproduced in Ref D (Figure 7, page 27), however, indicate that, in terms of total rainfall, rainfalls in the Wivenhoe area for the 1974 Flood were 20% to 40% of the rainfalls at Mt Glorious.

Twelve hours (***03:00 to 15:00***) at 68mm/hr rainfall on Lake Wivenhoe comes to 816mm, and this 2011 rainfall total is 60% more than the 2011 Flood Event eight day rainfall totals (464mm, 513mm and 525mm) reported for the three Wivenhoe rainfall stations on Table 6.3.1, page 61 of **REF B.**

These figures and comparisons give rise to uncertainty about the ungauged 'extreme' rainfall scenario being adopted by SEQWater.

The period, ***'between 03:00 to 15:00 on Tuesday 11 January2011'*** coincides with the period of greatest error between the forecasts of Wivenhoe Dam level given by the model runs and the forecasts reported in the Situation Reports. Refer to Figure 1 or an abbreviation of Figure 1 at Figure 2 below.

A question then may arise as to whether or not there is any link between this error in reported forecasts of water level and the volume of water that needed to be found to explain the ***'rapid rise'*** in the water levels. The possibility may exist that the rapid rise may have been caused by the need to adjust across the difference in forecast water levels illustrated on Figure 1 (and on Figure 2).

Without a satisfactory explanation as to the differences between the forecasts of water level given by the model runs and by the Situation Reports, it may be reasonable to examine the accuracy of all levels reported in the Situation Report, including the water levels in the Dam reported as 'existing' at the time of each Situation Report.

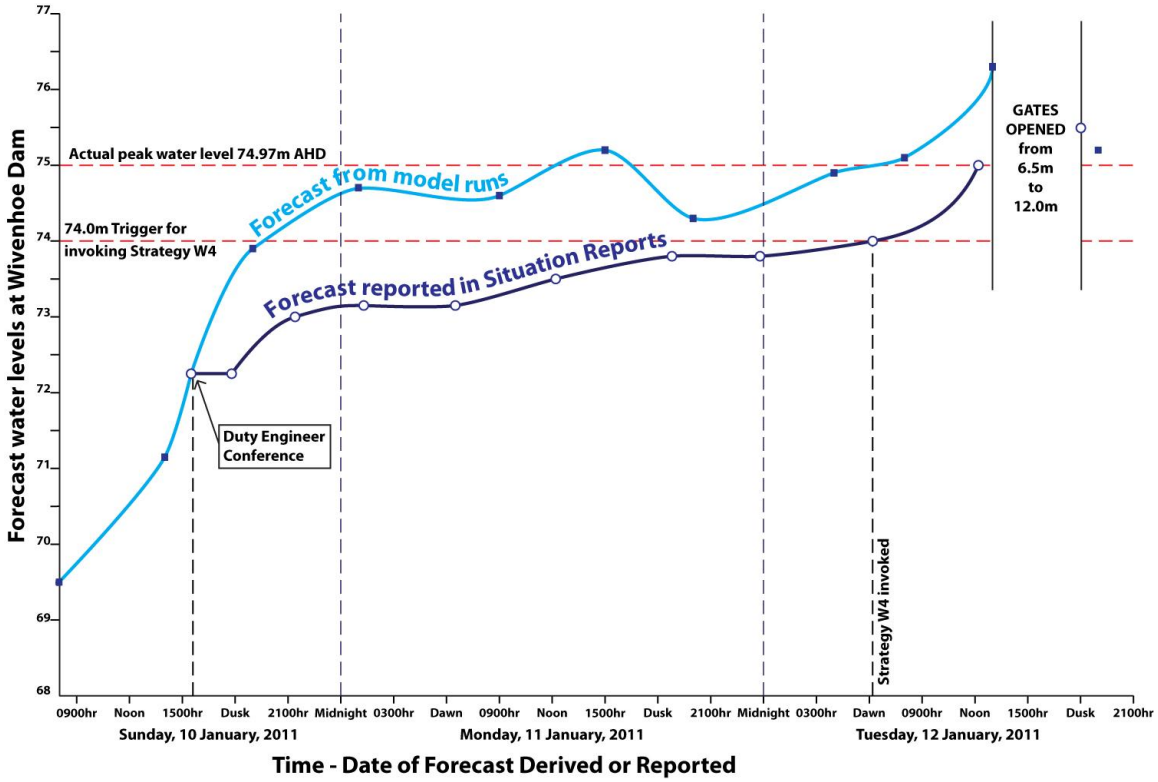

Figure 2: (abbreviation of Figure 1 on Page 8)

Problems (see Ref B, Figure 6.5.5, page 85) reported regarding the differences between the water levels recorded in the Dam by two automatic stations, versus the levels recorded manually, may or may not be related to this issue, but the Commission needs to be open to examining all possibilities in this regard.

It is a matter of concern that the two automatic water level devices on Wivenhoe Dam were either not working or not working accurately during the period at the peak of the flood level within Wivenhoe Dam (see REF B, Table 5.2.6, page 52). This means that the devices, established for informing decision-makers of that critical factor that triggers the fuse plugs into operation, were faulty.

If this issue of validity of measurements and reports of measurements can not be resolved, the Commission is advised to make inquiry into other possible causes of any unaccounted for water volumes.

Two other possibilities are:

1. Additional water volumes having entered from Stanley River; and
2. Additional water volumes having entered from the Brisbane River.

Stanley River Inflows and Somerset Dam. Procedurally, it is recommended that inquiry be made by the Commission into any error in, or under-reporting of, outflows from Somerset Dam during relevant times.

Power issues and communication problems occurred for the operations of the **SDWD** system at critical times, and directives were also going to other Dams and situations including the North Pine Dam – see Ref B, Appendix M, log entries during Tuesday & Wednesday 11&12 January 2011, pages 88-98.

Upper Brisbane River Inflows and Gregor Creek. The other possibility is that the flows entering into Wivenhoe Dam from the Upper Brisbane River, as recorded at the Gregor Creek Stream Gauging Station, were greater than reported.

There are at least two possible factors that could contribute to such an error, namely:

1. The rating curve for Gregor Creek; and
2. The non-linearity of the catchment employed by the hydrologic run-off routing model.

The rating curve is unverified for flows above 2198 cumecs (see Ref B, Appendix R, page 49). It is a strong positive for SEQWater's performance, during the 2011 Flood Event, that it undertook three streamflow measurement exercises at Gregor Creek during the Flood (see Ref B, Table 6.5.1, page 80). This effort raised the verified level of the rating curve to 30% of the maximum estimated flow that passed this station during January 2011.

The point is that the new rating at the 30% level may not have been incorporated into the rating being used by the **RTFM**, and that the rating curve above the 30% level has not

been verified at all. The estimates of flows obtained from the rating during the higher flows, as occurred with the passing of the two peak flows, may be in substantial error.

The related possibility is that the rating changed during the high flow regime, or that the first peak changed the rating for the passage of the second peak.

REF B does not appear to address any of these possibilities, not even to explain why they should be dismissed in favour of the ungauged extreme rainfall explanation.

SEQWater also appears to be assuming, in its modeling of rainfall runoff, a non-linearity in catchment response uniform for all catchments, using one value only for model parameter 'm', namely 'm' = 0.8. All calibrations for all catchments appear to assume this value of parameter 'm' and no other value (see Ref B, pages 100 & 102).

Differences in true non-linearity from catchment to catchment, or variations in non-linearity with increasing flows, may be affecting the outcome.

REF B does state, at page 111, that (Quote): ***"…the January 2011 Flood Event has a magnitude that requires extrapolation of the model parameters beyond previous benchmarks."*** Perhaps the model parameters did need to change.

In the modeling of the flows at Gregor Creek, it is noted that:

1. At 13.00 hours on 11 January 2011, the model gave an estimate for the second peak of 7,000 cumecs approx, compared to the recorded peak (off the unverified portion of the rating curve) of 5,800 cumecs – see **REF B**, Appendix S, page 197;
2. At 08.00 hours on 12 January 2011, these results were repeated – see **REF B**, Appendix S, page 213; and,
3. At 12.00 hours on 19 January 2011, the model was now predicting 5,800 cumecs approx, the same value as was recorded off the rating curve – see **REF B**, Appendix S, page 221.

This reduction in modeling outflows, 7 days after the event, is not explained in this author's reading of this voluminous report, such as at p111 of **REF B**. The Commission might inquire:

1. How has the calibration of the model or the rating at the gauging station or the rainfalls upstream of the station been changed to produce the 19 January modeling result? and
2. If the last mentioned is the case, how were adjustments to the actual rainfalls made in making the rainfall inputs into the model, and how were these adjustments reasoned?

If it is the case that:

- the modeling, on 19 January 2011, of the second flood peak down the Upper Brisbane River into Wivenhoe Dam has been achieved after reducing actual rainfalls recorded upstream of Gregor Creek Station (actual rainfalls of AEP 1in50), and then,
- the volume of this reduction in recorded rainfalls was replaced by increases of unrecorded 1in2000 AEP rainfalls at Wivenhoe Lake,

this may indicate the likelihood that **REF B** may have the wrong explanation.

The Strategy Options for Wivenhoe Dam

REF B does not join the public debate being held over the operations of the **SDWD** during the January 2001 Flood Event, it is submitted.

The model runs conducted by SEQWater for **REF B**, analysing the performance of the **SDWD** during the January 2011 Flood Event, do not come to the points at issue.

The SEQWater analyses compare the DAM and NO DAM situations in proposing the flood mitigation performance of the operating regime. This comparison is not under challenge.

The Dam already exists. It is not about to be dismantled, returning the Valley to a NO DAM situation. The DAM exists, and the issue is:

How well is the existing Dam being operated in the flood mitigation regime.

The issues under challenge, for which SEQWater have not put forward an analysis so as to assist the Commission of Inquiry, are:

1. What flood heights would have resulted downstream of Wivenhoe if the operation had released more flow much earlier in the flood event? and,
2. Has the establishment of the fuse plugs caused the flood mitigation level of the Wivenhoe Dam to be reduced from 77m AHD, as was in place before the fuse plugs were constructed, to 75.7m, the trigger level for the first fuse plug?

Both of these issues point to problems with the current Flood Mitigation Strategies, their design and implementation.

Each of these two issues is now considered in turn.

Earlier Releases. Strategy W3 allows more flexibility than was employed during the 2011 Event.

Figure 3 sets out the actual releases determined by the operators during the last 36 hours of operation of Strategy W3. The rationale for each of these release decisions, as explained in **REF B**, pages 18-23, is also abbreviated on Figure 2.

FIGURE 2: ACTUAL RELEASES, STRATEGY W3, WIVENHOE DAM

ACTUAL Releases from Wivenhoe, with rationale

1473 cumecs	1473 → 2015 cumecs	2087 cumecs	2087 → 2695 cumecs	2726 cumecs	2832 cumecs	W4 STRATEGY ADOPTED
Aim: Moggill Q < 3000	Aim: Moggill Q< 3500	Aim: Moggill Q< 3500	Aim: Moggill Q< 4000	Aim: Moggill Q< 4000	Aim: Transition to W4	

22.00	01.00	9.00	15.00	20.00	04.00	08.00
Sunday 9 Jan	Monday 10 January 2011				Tuesday 11 January 2011	

Strategy W3 appears to allow a wider scope of release rates of water from Wivenhoe Dam than were exercised during these 36 hours.

In particular, releases up to 4000 cumecs are permitted under Strategy W3. Such a release, however, would cause the flow at Moggill to exceed the [Q= 4000 cumecs] inundation level if there are any flows also coming down the Bremer River and / or Lockyer Creek.

During the last 36 hours of Strategy W3, leading up to invoking Strategy W4, the **SDWD** was operated to a limit of 4000 cumecs flow past Moggill. This limited the releases out of Wivenhoe to less than 3000 cumecs. For the first 24 of those 36 hours, the releases out of Wivenhoe averaged only 2000 cumecs approx.

The Manual of Operating Procedures in force at the time of the 2011 Event has the aim of **minimizing** flood inundation levels downstream, not of **preventing** inundation (see Ref C, p28), where it states (Quote):

> ***"…it should be noted that depending on natural flows from Lockyer and Bremer catchments, it may not be possible to limit the flow at Moggill to below 4000 m^3/s."***

The proposition put to SEQWater by members of the public, such as in *The Australian* article of 19 March 2011, ***'Engineer bores a hole in dam untruths'*** is that, if SEQWater had adopted a **'minimize inundation'** policy (as is incorporated into the W3 Strategy), rather than a '**prevent inundation'** objective, the need to invoke Strategy W4 may not have arisen.

It is submitted that what the 'prevent inundation' objective did was to store water in the Wivenhoe Dam to such a height as to trigger a threat to the Dam itself.

The asserted threat to the Dam then caused the operators to release through the gates a 7500 cumec plug flow (like pulling the plug from a bathtub) down the Brisbane River. At one stage, a 10,000 cumec 'gate plug' flow was contemplated (see REF B, Appendix M, page 92, Log entry at 3.49PM).

The 'gate plug' flow is quantified on pages 158-9 of **REF B**.

The 'gate-plug' flow actually used can be broken up into

- **a base** – volumes arising from release rates up to and including 4000 cumecs during the 'gate-plug' flow, and
- **a cap** - volumes arising from that part of the 'gate-plug' releases that exceeded 4000cumecs.

Say, when the flow was 7500 cumecs, the base component was 4000 cumecs and the cap was 3500 cumecs

During the 17 hour period, 1300 hours on 11 January to 0500 hours on 12 January, the cap of the 'gate plug' flow amounted to approx 34,000 cumec-hours.

It is submitted that the Commission could consider, in turn, the following information from REF B:

1. the period from when the **RTFM** model forecast a WD water level of 73.9m AHD, that is, from 1900 on 9 January 2011, to the beginning of the W4 'gate plug' flow – a total of 42 hours;

2. the W3 Strategy had a maximum release-to-rule rate of 4000 cumecs – there was a capacity to release-to-rule during this period of [42 hours X 4000 cumecs =] 168,000 cumec hours;

3. the releases actually made during this period in W3 amounted to approx 98,000 cumec hours;

4. the unused capacity for releases under the rules of Strategy W3, during this period, amounted to [168,000 – 98,000 =] 70,000 cumec hours;

5. The cap of the 'gate-plug' flow was 34,000 cumec hours;

6. The unused capacity for release-to-rule [70,000 cumec hours] during the last 42 hours when the operation was under W3, is twice the volume of the cap of the 'gate plug' flow [34,000 cumec hours] that was actually released during the period of operations under Strategy W4; and,

7. There thus existed capacity, within the W3 period <u>before</u> W4 was invoked, to release-to-rule the same volume of water as was actually released as an above 4000 cumec 'gate-plug' flow <u>after</u> the W4 Strategy was invoked.

None of this is using hindsight.

The **RTFM** forecast of 73.9m (and rising) was used as the trigger that the 'prevent inundation' objective was unlikely to be feasible, and that the objective thereafter was to 'minimize inundation' (within the W3 Strategy).

Using hindsight, the optimum release-to-rule rate, under the W3 rules, from the time of the 73.9m AHD (and rising) forecast by **RTFM** for WD peak water level, works out to be about 3,400 cumecs..

Using hindsight, all inundation appears to have been avoidable during the January 2011 Flood Event.

FIGURE 3: ALTERNATIVE RELEASE RULE FOR STRATEGY W3, WIVENHOE DAM

3000 cumecs → →→→→→→→→→→→→→→→→→→→→→→→→→→→→→→→

[or 3500, or 4000, if lower flows do not keep predicted WD Water levels below 74m AHD]

Aim: Minimise the peak flood level at Moggill that keeps WD Water level below 74m AHD

Sunday 9 Jan	Monday 10 January 2011	Tuesday 11 January 2011

Without using hindsight, one methodology that may have brought operational decision-making towards this result may have been:

1. Using the 74mAHD forecast rule to switch from the 'prevent inundation' objective to the 'minimize inundation' objective, as appears to be the intent of the current W3 Strategy;

2. Conducting model runs for 2000, 2500, 3000, 3500 and 4000 cumecs to identify which of these release rates was first to prevent the water level actually achieving 74mAHD;
3. If 4000 cumecs, the greatest of these release-to-rule flows, does not prevent the water level in the Wivenhoe Dam reaching 74m AHD, invoke Strategy W4; and
4. Repeat the analysis periodically during the period after the time of the 73.9m-and-rising forecast.

Importantly, such a methodology appears to be completely within the existing rules for Strategy W3.

Critically, the above methodology appears to be in compliance with the objectives and rules of Strategy W3. This is the case where the actions actually taken by SEQWater, during the 2011 Flood Event, appear not to be in compliance with the W3 Strategy.

SEQWater would have provided best assistance to the Commission of Inquiry if it had done this sequence of model runs, and had reported these results (or some equivalent analysis that addressed the possibilities arising from another 'minimise inundation' purpose, in lieu of the 'prevent inundation' purpose actually followed for large portions of the pre-W4 operations). There has been enough media attention to the claims to alert SEQWater to the issue.

Such an analysis would demonstrate whether an 'avoid inundation' outcome was also available to the **SDWD** operational system without hindsight, by compliance with the W3 Strategy.

RECOMMENDATION 1: That an analysis, using and building upon the Alternate W3 Strategy, as suggested by Figure 3 (or equivalent) be undertaken by the Commission using an independent third party authority.

Available Flood Mitigation Volume Behind the Wivenhoe Dam. The third alternative was to hold the release rate to 4000 cumecs and allow the water to fill Wivenhoe Dam.

This analysis too has not been run and reported in **REF B**, for the benefit of the Commission.

This may be a representation of an attitude or policy within SEQWater that the 'fuse plugs', now constructed within the Wivenhoe Dam embankment, are not to be utilized as part of the flood mitigation scheme. Such a policy, if it is real, appears to contradict the allowance for fuse plugs being triggered in Strategy W4 (under sub-Strategy W4B – see Ref C, page 30).

The characteristics of the fuse plugs appear to be (from Ref G):

1. First Fuse Plug, triggered at WD Water Level 75.7m AHD, with a release rate of 1,600 cumecs upon initiation;
2. Second Fuse Plug, triggered at WD Water Level 76.2m AHD, with a release rate of 4,900 cumecs upon initiation; and
3. Third Fuse Plug, triggered at WD Water Level 76.7m AHD, with a release rate of 8,900 cumecs upon initiation.

This author notes that Ref C (see Appendix C, page 57) may show different release rates than those at Ref G, but these need to be read off a graph, and the purpose of this submission is served with the figures available from Ref G.

If an error or misjudgment had occurred while in the Strategy W3 regime, and a large volume had been allowed to accumulate behind the Wivenhoe Dam wall, an alternative to sending a peak release 'gate-plug' flow of 7500 cumecs down the Brisbane River would be to consider activation of the fuse plugs instead.

A series of model runs for 4,500 cumecs, 5,000 cumecs, 5,500 cumecs and 6000 cumecs might be analysed to see if a combination gate-plug flow plus fuse plug flow would constitute less of a threat to inundation of the floodplain downstream of Wivenhoe.

Reports on the operation of the gates during fuse plug flows contemplate removing the gates from any play in the control of the flows.

The concern has been expressed that the fuse plug flows are uncontrolled. If it is practicable, partial closing of the gates during fuse plug flows would bring a measure of control to the total outflows that would not be available if the gates were completely opened.

If, say, the Dam water level rose to 75.7m AHD:

1. The level 1 fuse plug flow of 1600 cumecs would shortly thereafter be released;
2. The gates could be partially closed, say, so that the top of the gates are at 76m AHD;
3. The gate opening would then be 4 metres approx – see Ref C, page 56, ***'Top and Bottom Gate Levels for Various Gate Openings'***;
4. The release through each gate would be 528 cumecs – see Ref C, page 55, ***'Individual Radial Gate - Rating Table'*** ;
5. The release rate from all gates would be 2640 cumecs approx;
6. The total release rate, gates and fuse plug would be 4240 cumecs; and
7. Thus the gates would need to be opened a little more to provide 4500 cumecs,

Thus controlling flow to 4500 cumecs as part of a fuse plug release appears to be feasible at a Wivenhoe Dam water level of 75.7m AHD, engineering factors permitting. Controlling the flow to 5000 cumecs and to higher releases also appears feasible at this water level.

If then, say:

1. the W4 decision was taken to keep releases to 4,000 cumecs, from the time that the decision was made to invoke the W4 Strategy, that is, at 0800 hours on Tuesday 11 January 2011;
2. The size of the cap of the actual gate-plug flow that occurred in that Flood Event (above the 4000 cumecs level, from 1300 hours on 11 January to 0500 hours on 12 January 2011), was approx 34,000 cumec hours (see **REF B**, pages 158-9);
3. The additional releases effected before this period (from 0800 to 1300 hours on 11 January 2011) would have been approx 4,000 cumec hours (see **REF B**, pages 158-9);
4. The volume therefore that would need to be absorbed by additional storage in the Dam was approx [34,000 – 4,000 =] 30,000 cumec hours, or 108,000ML;
5. The peak water level reached in Wivenhoe Dam with the actual gate plug flow of 7500 cusecs was 74.97m AHD, say 75m AHD; and
6. 108,000 ML above this level would raise the water level to approx 75.66m AHD (see Ref C, page 53).

Under this application of the Strategy W4, the first Fuse Plug may not have been initiated during the January 2011 Flood Event, and the releases out of Wivenhoe Dam may not have exceeded 4000 cumecs.

This analysis is using some hindsight.

A methodology that may assist the operators to this result without hindsight is set out in Figure 4.

It appears that when the second fuse plug is initiated, controlled flow at release rates below 8000 cumecs may not be feasible.

It is not apparent that any option that relied on fuse plug releases was investigated.

FIGURE 4: ALTERNATIVE RELEASE RULE FOR STRATEGY W4, WIVENHOE DAM

4000 cumecs → →→

[or 4500, or 5000, if lower flows do not keep predicted WD Water levels below 76.2m AHD]

Aim: Minimise the peak flood level at Moggill that keeps WD Water level below the Trigger Level, 76.2m AHD, for the Second Fuse Plug

08.00	13.00		05.00			
Tuesday 11 January 2011			Wednesday 12 January 2011			

REF B has failed to analyse the availability of such an option, once SEQWater realized the situation that had been generated at the end of the Strategy W3 period.

The apparent determination not to rely on the first fuse plug may betray a absence of any confidence in the fuse plug option, and an attitude that equated of the fuse plug option with a high risk of dam failure or dambreak.

This author certainly agrees with any such risk assessment.

This author has designed rockfill dams for overtopping, and has researched the recordings of rockfill dams having been overtopped from around the world. This author would design and redesign such a dam, in this Dam's situation, **not to be overtopped by the PMF, as was the original design criterion for Wivenhoe Dam.**

SEQWater, however, have established such a fuse plug system into the Wivenhoe Dam, and would be expected to at least consider using the fuse plug mechanism before sending a 7500 cumec 'gate-plug' flood down the Brisbane River.

An unexplained fear of the fuse plug option appears to have prevented even a consideration of this option.

RECOMMENDATION 2: That an analysis, using and building upon the Alternate W4 Strategy suggested by Figure 4, be undertaken by the Commission using an independent third party authority.

Conclusions re Strategy

The operational focus of SEQWater, during the January 2011 Flood Event, appears to switch very quickly from an 'avoid inundation' objective during the W3 Strategy to an 'avoid fuse plug operation' objective in the W4 Strategy.

There does not appear to have been any consideration, during either the W3 or the W4 Strategies, to options that followed a 'minimise inundation' objective.

As a result, it appears that SEQWater may not have carried out analyses that might have identified, for SEQWater, options that may have avoided any release flows from Wivenhoe Dam in excess of 4000 cumecs.

These options appear to have been available at relevant times, whether in the operation was in the Strategy W3 or the Strategy W4 decision-making regime

OVERALL RATING OF SDWD AS A FLOOD MITIGATION SYSTEM

General

In the first submission made to the Commission of Inquiry ["**REF A**'], a proposal was outlined for a system of auditing flood mitigation schemes, leading to a rating of each such scheme against the following hierarchy of system descriptors:

1. **Ad hoc** – the system is piecemeal, without organisational involvement;

2. **Planned** – the system is planned but not implemented;

3. **Managed** – the system is being implemented, but without alignment, consistency, consolidation and/or balance;

4. **Integrated** – the system is holistic, but is in need of improvement; and,

5. **Optimised** – all aspects of the system are under continuous improvement and are open to updating, upgrading and innovation.

A preliminary rating of the **SDWD** flood mitigation regime, operated by SEQWater within the Brisbane Valley, is offered below.

It is submitted that the **SDWD** system may be assessed at 1.9, that is, at the 40% point of the scale [1.5 to 2.5] for the rating, '**PLANNED**'.

It is further submitted that deficiencies in the planning of the system are tending to undermine, for critical flood events, the capacity of the operating system to achieve a higher rating as an effective flood mitigation regime.

Comments in support of this preliminary rating are offered below.

Planning

Strengths. The following aspects may show strength in planning for the **SDWD** system for mitigating floods flowing into Somerset and Wivenhoe Dams, accepting the accuracy of some statements made by SEQWater about itself:

1. The Manual for Operating the **SDWD**, complete with Operational Target Line, Strategy options, provisions for discretionary variations, and guidance for decision-making;
2. A Communications Protocol at draft stage;
3. Staffing arrangements;
    a. for 24/7 operations upon the trigger of a Flood Event; and
    b. for streamgauging exercises during moderate and major flooding;
4. Redundancy arrangement for power; and
5. Completed calibrations of particular hydrologic models.

Improvements. The Planning regime for mitigating floods passing through the **SDWD** may benefit from actions to address the following:

1. Coverage of rainfall stations appears to be insufficient, deficient or non-existent in significant parts of the catchments feeding the **SDWD** infrastructure, and in catchments feeding flood flows outside of the **SDWD** infrastructure;
2. Operability of streamgauging stations may be at risk during the major flood events for which their operation is most critical;
3. Measurement of water levels at Wivenhoe Dam near and at the peak of the Dam water levels may be contradictory and confused;
4. Insufficient priority may be being given to obtaining flood flow measurements to improve the rating range of principal flood gauging stations. For example, the

primary Gregor Creek station was rated during the January 2011 Flood Event but only to a 30% rating ratio;

5. A hydraulic model capable of providing forecasts of floods downstream of Wivenhoe is not available;
6. The hydrologic modeling currently serving this purpose if performing poorly, and may have caused a credibility issue with the flood community the next time that severe flooding warnings are issued downstream of the Wivenhoe Dam;
7. Confusion exists as to whether the 'no inundation' flow at Moggil is 3500 cumecs or 4000 cumecs;
8. Flooding maps may not have been on hand for decision-making during the Flood Event;
9. Staffing of the operations function may be insufficient for three day flood events or longer, exercising technical control over **SDWD**, North Pine Dam and other dam and dam related infrastructure; and
10. Too many functions, important to the optimum functioning of an operations centre in critical times, had to fall back upon redundancy provisions and make-piece alternatives, including power, communications, and computing capabilities.

Further, an additional Strategy, between W3 and W4, may be advisable. It could be specifically devoted to the objective of minimizing inundation downstream of Wivenhoe.

This new Strategy might be triggered by an assessment that the objective of avoiding inundation was no longer feasible. It would also need a trigger, to determine when this new Strategy needed to be terminated because the flood mitigation purpose of the **SDWD** needed thereafter had to be surrendered to the objective of preventing Dam failure.

Managing the Scheme.

It is proposed that deficiencies in the Planning for the flood mitigation function of the **SDWD** system may be preventing the system improving to a level of "**MANAGED**" on the rating scheme for assessing systems proposed by Ref A.

The strategies for flood mitigation for the benefits of homes subject to inundation, and the decision-making applying these strategies, may be conflicted with and/or misaligned to the flood mitigation purpose.

REF B appears to refuse to acknowledge any of the problems that are within the current public debate, not even to dismiss these problems. Regrettably, **REF B** has opted instead to avoid the issues.

Two significant aspects to **REF B** that may demonstrate this avoidance are:

1. The failure to conduct and report any analysis that proves or dismisses the charge that the flood was avoidable. SEQWater was in the best position, objectively, to carry out this necessary analysis. Accordingly, it is submitted, SEQWater can not reasonably be trusted with the analysis, because of a perceived interest in one of the outcomes from such an analysis. An attitude of curiosity for any insufficiencies in existing methods and thinking is not apparent in **REF B** – a defensive approach appears to have been adopted;
2. A statement in the Executive Summary of **REF B,** page iii**,** (Quote):

   "…Had the rainfall on Tuesday 11 January 11 largely fallen in catchments downstream of the Dam the transition to an operating strategy to protect the safety of the Dam may have been avoided, however urban damage would have likely increased under this scenario due to a loss of the mitigation effects that were provided by the Dam."

   Was it the rains fault that we had a flood?

The most serious deficiency in the management of the **SDWD** may be a lack of ethics in the public information provided on the scheme. This failure of ethics may originate, it is

submitted, in the way that the characteristics of the **SDWD** are advertised to the public in probability terms.

This submission advocates the position that rare floods should be presented factually to the public, in terms of percentages of the current estimate of the **PMF**.

In modern governance, there is an unequivocal right of the public to know the facts, including the quality of any estimates of the facts.

Allowing a place for those who have a genuine preference for the use of probabilities, probabilities must also be expressed according to an ethic, this submission proposes, particularly when it impinges on public safety.

This ethic, as it happens, has been described by professionals who have been advancing notions of credibility limits criticized by this author, albeit in the context of paleofloods (Quote):

> ***"…Uncertainties associated with the descriptions of flood flow exceedance probabilities are likely to be substantial and an important attribute for the characterization of extreme floods. Flood characterization should include a "best estimate" of the annual exceedance probability of floods of different magnitudes and a description of the uncertainty in such results. Such uncertainties need to be honestly represented and considered throughout the risk assessment process."***[Ref H]

The information that is going to the public about the Wivenhoe Dam appears only to be the estimate of the annual exceedance probability of the **PMF,** without an 'honest representation' of the uncertainty in this single figure, it is submitted. Often AEP is expressed in terms of years, thousands and hundreds of thousands of years.

The continuing flow of words referring to a '1in6,000' AEP event, or '1in22,000 flood', the 1in100,000 design flood or similar, **do not carry** the uncertainty reminder that may properly be required for the information to be ethically presented, it is submitted.

This submission proposes that the uncertainty of the **PMF** value as a probability figure needs to be described. If the uncertainty is to be honestly represented to the appropriate standard of professional ethics for informing the public about probability estimates, providing information on the confidence limits is an unavoidable obligation.

The **PMF** for the Wivenhoe Dam, on an analysis sighted by the author during employment in the State Public Service, had a 95% confidence range of 8,000 cumecs to 300,000 cumecs.

It is proposed in this submission that descriptions of the **PMF** for Wivenhoe of

49,000 [95%:8000→300,000] cumecs

is an honest representation of the 49,000 **PMF** figure as a probability figure.

It is honest because it shows the true quality of what is being proposed as the ñbest estimate".

It is submitted that the public is entitled to be given the honest indication that the "best estimate" of **PMF** and its AEP, notwithstanding that, even if it is the "best", it is not very good.

Regrettably, this does not appear to be happening with respect to information about Wivenhoe Dam.

For rare floods less than the **PMF**, it is submitted, honest representations are also required for the **SDWD** to merit a rating of '**MANAGED**'.

Thus the diagram in Ref I, *'**Figure 2: Probability Log Plot of Design Inflows, Wivenhoe Dam'*** is unsatisfactory as a broadcast of information about the rare and extreme inflows estimated for Wivenhoe Dam, for several reasons:

1. The uncertainty limits have been reduced from 95% to 75% - sometimes 50% confidence limits are used by hydrologists who may be embarrassed by the meaninglessness that 95% confidence limits impose upon the ñbest estimate";
2. Dashed lines have been used for the confidence limits – actually, these lines are not hard to see, but other reports such as Ref I use faint dots that reproduce poorly; and
3. The Upper Confidence line is terminated at an AEP of 10^{-4}, and is not continued to show the Upper 75% Confidence Limit of the **PMF** just past the 10^{-5} vertical.

This diagram does allow (with a little extrapolation of the Upper Confidence Limit) an honest representation of the 1in22,000 AEP flow. This flow is expressed only as 25,700 cumecs in Ref G, but, as best can be read of Ref I, it could be represented as:

1in22K AEP Flow ≈25,700 [75%: 20,000→80,000] cumecs

The diagram also allows the range of the AEP of the flow, 25,700 cumecs, to be described, as

AEP of 25,700 cumecs ≈ 1in22K [75%:1in6K→1in80K]

Ref I, reporting upon the hydrology of another Dam in South East Queensland, may include a demonstration as to how quickly the approximate nature of these AEP figures can be left behind, where the range of AEP for the **PMF** is given as 1in183,000 to 1in18,300,000 [Ref I, page 21].

It is submitted that the practice of plotting the **PMF** on probability paper, and then drawing a line from the "best estimate" of the 1in100 AEP event to the **PMF,** so as to estimate the AEP of rare floods, is an application of GEOMETRY, not an application of PROBABILITY THEORY.

This should be stated to the public.

Representing such a plot as a product of PROBABILITY THEORY misrepresents the true nature of the method, it is submitted. The degree of misrepresentation may be fairly described as 'gross'.

If GEOMETRY is the basis for scaling floods below the PMF, it is logical and honest to express these scaled-off floods in geometric terms. The descriptor, say,

[x% of the current estimate of **PMF**]

has this measure of honesty.

If the approach instead is to choose a frequency distribution curve, sometimes by eye, through the probability plots of the historical flows, that intersect the probability assigned to the **PMF**, close to the **PMF** value, is this the application of PROBABILITY THEORY or is it a form of CURVATURE GEOMETRY?

If it is seen to be probability, then the description of rare floods needs to again describe the uncertainty in the estimated flow for that AEP. The uncertainty needs to be described, it is submitted, without diminution of that uncertainty by omission, reduction, termination or light shading of the 95% confidence limits. The public interest demands a full and honest description of the state of knowledge about the flooding situation that is faced, it is proposed.

It is submitted that only credible science should be used in any technical analysis. To engage in technical analysis of hydrology and dam design, using non-credible science, may only bring the profession into disrepute, it is further submitted, including a loss of public confidence in government and its instrumentalities responsible for water management.

Such disrepute appears to be an emerging outcome from the January 2011 Flood.

CONCLUSIONS

The following submissions by SEQWater in REF B should be dismissed by the Commission of Inquiry:

1. That the cause of the flooding was the rain or the inaccuracy of the rainfall forecasts provided by the Bureau of Meteorology
2. That the data collection and flood modeling systems overall performed sufficient for the purpose of an effective flood mitigation regime
3. That the January 2011 Flood Event has an AEP of 1in100 to 1in 1000
4. That a flood of the size of the January 2011 Flood Event would be expected to cause the damage that the January 2011 flood actually caused
5. The sufficiency of the staffing for major flood events simultaneously mobilizing flood mitigation operations for multiple major dams

The Commission should conduct independent analyses to test the positions that:

1. Outflows from Wivenhoe Dam, 4000 cumecs or less, could have handled the January 2011 Flood Event
2. The Flood Event could have been mitigated to the 4000 cumec limit or less in both the W3 and the W4 Strategies
3. The benefits of adding a new strategy to the Operational Strategies currently listed for the Wivenhoe Dam, one that had the single objective of minimizing inundation downstream of the SDWD
4. The AEP of the January 2011 Flood Event upstream of Wivenhoe, based on volumes of inflows, using techniques that allow the extension of the record, or that make allowance for the records that exist, of historic floods back to 1893
5. The AEP of the January 2011 Flood Event upstream of Ipswich and of Brisbane, based on volumes of inflows and /or flood heights, using techniques that allow the extension of the record, or that make allowance for the records that exist, of historic floods back to 1893 and, if possible, back to 1841

The Commission should make inquiry into:

1. The source and accuracy of the forecasts of Wivenhoe Dam water level contained in the Situation Reports and in the Technical Situation Reports
2. The factors that contributed to the purported ‘rapid rise’ in water levels in Wivenhoe Dam rising to the peak water level
3. The sources for any concerns, held by any registered professional engineers within SEQWater or other stakeholder State Government organisations, for employment of the fuse plugs currently installed into the walls of Wivenhoe Dam
4. The sufficiency of staffing, accommodation, capacities for communications and support for the operators at central locations and at Dam sites during major flooding lasting 7 days
5. The source and basis for the opinion that Somerset Dam can cope, without failure, with more than 2 metres of outflow overtopping the Dam wall
6. The real needs of the SDWD for data collection and modeling / forecasting systems that will be operable during very large floods up to the PMF (including facilities for stream measurements for rating priority streamgauging stations such as at Gregor Creek
7. The pressures, if any, that were brought to bear on experts within the Bureau of Meteorology and on other specialist professionals in the State Public Servants or consultancies for the State Public Service during the introduction and implementation of the practice of assignment of probabilities to PMFs
8. Which individual experts, not organisations, in the relevant field in Australia, if any, have ever recommended the assignment of probabilities to the PMF for the purposes of dam design or for purposes other than **comparative studies, not absolute decisions**, on matters such as cost benefit analyses of alternatives for controlling floods, and **relative impacts, not absolute impacts**, of factors upon technical estimates of precipitation
9. The legitimacy of claims that methods used to establish the ‘probability’ of rare floods is based on probability theory rather than drafting by eye on probability paper

10. The legitimacy of the basis for claims that estimates of 1in2000 AEP in Queensland are within a reasonably defined 'limit of credibility'
11. Any misrepresentations, errors and / or poorly defined concepts in the practices and writings of SEQWater, Bureau of Meteorology, AR&R and / or ANCOLD regarding the assignment of probabilities to large dams, including the statement in Ref J, page 27, for which Deputy Commissioner Cummins appears to be a co-author, that estimates of the probability for PMP were

    'previously recommended by Kennedy and Hart (1984)'

12. The information that should be given to the public so as to properly inform the public about the protection afforded to the public by Wivenhoe Dam and other major rockfill dams that can be overtopped by current estimates of the PMF.
13. The likely response by the public in the Brisbane River valley on the next occasion of a major flood when SEQWater provide warnings of flood heights in excess of the 1974 flood heights

[redacted]