

**Second statement and attachment of Phil
Hennessy dated 1 February 2012**

**IN THE MATTER OF
THE QUEENSLAND FLOODS COMMISSION OF INQUIRY**

**A COMMISSION OF INQUIRY UNDER THE
COMMISSIONS OF INQUIRY ACT 1950**

**AND PURSUANT TO THE
COMMISSIONS OF INQUIRY ORDER (No. 1) 2011**

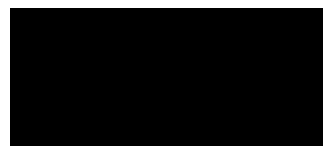
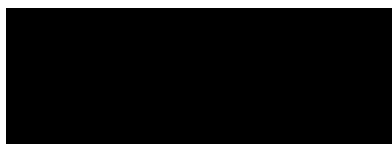
SECOND STATEMENT OF PHILIP ARTHUR HENNESSY

On the 1st day of February 2012, I, **Philip Arthur Hennessy**, of c/- 240 Margaret Street, Brisbane, state on oath:

1. I am the Chairman of the Queensland Bulk Water Supply Authority (*Seqwater*).
2. This statement is provided to the Queensland Floods Commission of Inquiry pursuant to a "Requirement to Provide Statement" issued by the Commission dated 31 January 2012 (the *Requirement*).
3. This statement has been prepared in a very short period of time in order to meet the Requirement's deadline. The statements I make below are my best recollections of the matters the subject of the Requirement, having regard to the documents I have been able to locate within the timeframe referred to in the Requirement.

My understanding, between 7 January 2011 to 12 January 2011, of which strategies referred to in the Manual were used and the times when each strategy was in use

4. Subject to the two matters I mention below, I did not have any understanding, during the period 7 January 2011 to 12 January 2011, of which strategies referred to in the Manual were used and the times when each strategy was in use. This is because during that period I did not know what strategies referred to in the Manual were used or when and I did not, to the best of my recollection, receive information from anyone, detailing those matters.
5. The two matters are these.
6. First, I knew the Manual contained a range of strategies which involved protection of rural areas, protection of urban areas and dam safety. My understanding was that these strategies would be deployed at different times depending upon the size of the flood. During the period

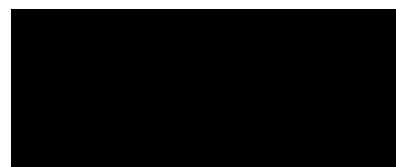
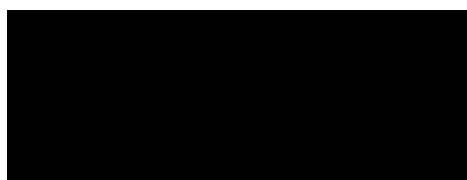


7 January 2011 to 12 January 2011, I expected, but did not know, that these strategies were in use. I did not know the times at which different strategies were in use.

7. During the period 7 January 2011 to 12 January 2011, I did not know the strategies referred to in the Manual by their labels (W1, W2, W3 or W4) and did not know the detail of the Manual. I had received a briefing from Seqwater previously as to my responsibilities under the Manual and I carried that briefing with me at the time. It is **Attachment PAH1** to this statement.
8. Secondly, although I cannot now be sure, my recollection is that I received at least daily telephone calls (and sometimes numerous calls each day) from Mr Borrows, the Chief Executive Officer of Seqwater, as to how the flood was developing. I was not in Brisbane at the time and only returned to Brisbane on 22 January 2011. I cannot remember the detail of those calls other than that I do recall:
 - (a) being told during one of the calls that Seqwater would be releasing damaging flows from Wivenhoe Dam to protect the safety of the dam; and
 - (b) confirming to Mr Borrows that I would be available for consultation at any time, if required.

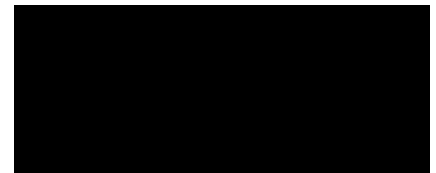
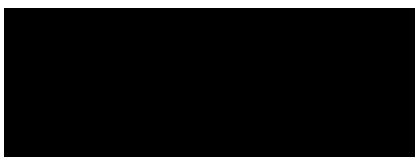
How has my understanding changed since 12 January 2011 and the reason for the change in understanding?

9. Following the flood:
 - (a) a flood event report was prepared for the Dam Safety Regulator; and
 - (b) this Commission of Inquiry process has been carried out.
10. As part of the Commission process:
 - (a) Seqwater has provided the Commission with witness statements, information and submissions;
 - (b) there have been public hearings; and
 - (c) the Commission has produced an Interim Report.
11. In the course of the preparation of the flood event report and the Commission process, I have gained a greater (albeit still high level) understanding of the Manual. I have also gained a greater understanding of what strategies might be used during a flood event.
12. I make further comments below about the extent to which my understanding has changed as a result of different accounts being provided to me of what strategies were used and when.



Differing accounts of the choice and timing of strategies, when I became aware of those differing accounts, all discussions and correspondence regarding the differing accounts and any decision taken by me in relation to the differing accounts

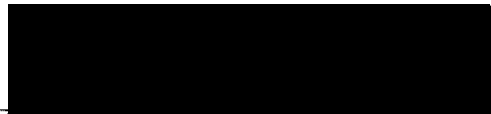
13. During the flood, I received from Mr Borrows a copy of a draft Ministerial briefing that he was having prepared. **Attachment PAH2** is a copy of the email I received from Mr Borrows. I cannot remember if I looked at it closely at the time, but I doubt that I did.
14. I was not aware at the time that the draft Ministerial briefing contained an account of what strategies referred to in the Manual were used and when. I am now aware of this. I explain when and how I became aware of this below.
15. At a meeting of the Board of Seqwater on 1 March 2011, the Board considered a draft of the flood event report. My understanding is that the draft report sent to the Board has been provided to the Commission by Seqwater. My understanding is that the Board did not receive the appendices to the draft report. The documents before the Board at the Board meeting included: a report which was prepared and delivered by Jim Pruss. This report is **Attachment PAH3**. During the delivery of this report, the Board was informed by Mr Pruss that each engineer who was involved in the management of the event had indicated that the report was correct and that peer reviewers had considered the report and not raised any issues, although their formal reports had not yet been received. I understand that copies of those peer reviewer reports were provided to the Commission after Seqwater received them.
16. My focus in reviewing the draft flood event report was upon the executive summary and the conclusions and recommendations. I did not review the other parts of the draft report in any detail. I was particularly interested in the executive summary as I wanted it to be capable of being easily understood by members of the public, given the technical nature of the dam operations.
17. At the board meeting on 1 March 2011, I was not aware that the account in the draft of the flood event report of what strategies referred to in the Manual were used and when differed from that contained in the draft Ministerial briefing in **Attachment PAH1**. At that time, I was not aware of the differences myself, and I was not made aware of them by anyone else. If I was aware, or had been made aware, of the differences, I would have asked for an explanation.
18. The first time I became aware that there were differences in the accounts in the flood event report and the draft Ministerial briefing was on 23 or 24 January 2012. This followed a discussion I had with Mr Borrows in which he indicated that there were alleged



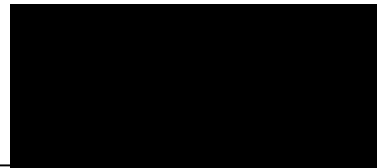
inconsistencies between certain Seqwater documents and the final Seqwater flood event report. I immediately asked Mr Borrows to have those matters investigated by our external lawyers.

19. After this time, the Commission announced it was holding further public hearings to address, amongst other things, these alleged inconsistencies. I am aware that the Commission has asked for the further documents and statements from Seqwater personnel as part of the Commission's investigation.
20. At the time of making this statement, I am not able to confirm personally what strategies referred to in the Manual were used during the January 2011 flood event and when.

SWORN by Philip Arthur Hennessy on 1 February 2012 at Brisbane in the presence of:



Deponent



Solicitor

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**STATEMENT OF PHILIP ARTHUR HENNESSY
INDEX OF ANNEXURES**

Annexure No.	Document	Date
PAH1	Briefing notes from Seqwater	--
PAH2	Email from Mr Borrows to me and others	16 January 2011
PAH3	Report prepared by Jim Pruss	3 March 2011

"PAH1"



**SEQWATER
FLOOD MITIGATION MANUALS
CHAIRMAN'S RESPONSIBILITIES**

FLOOD MITIGATION MANUALS PRESENTATION SUMMARY

- Explanation of Flood Mitigation Manuals.
- Dam operations during flood events.
- Chairman's responsibilities.
- Communications in practice during a flood event.



FLOOD MITIGATION MANUALS

EXPLANATION OF MANUALS

- Flood Mitigation Manuals are approved by gazette notice, in accordance with the provisions of Chapter 4 (Part 2) of the Water Supply (Safety and Reliability) Act 2008 (originally “City of Brisbane Flood Mitigation Act”).
- An owner of a dam who observes the operational procedures of a Flood Mitigation Manual does not incur civil liability for flood operations.

FLOOD MITIGATION MANUALS

EXPLANATION OF MANUALS

- Flood Mitigation Manuals only required for gated spillway dams providing flood mitigation benefits (in theory).
- Manuals approved by Gazette Notice are in place for Wivenhoe, Somerset and North Pine Dams.
- Only Wivenhoe and Somerset Dams provide flood mitigation benefits.

FLOOD MITIGATION MANUALS

DAM OPERATIONS DURING FLOODS

- Operations of North Pine Dam is relatively simple.
No flood water can be stored in the dam i.e. generally what comes in must immediately be released.
- Operation of Wivenhoe and Somerset is complex.
Aim is to maximise the potential of the combined flood storage (1,700,000 ML) to minimise flood impacts downstream of the dam.

FLOOD MITIGATION MANUALS

DAM OPERATIONS DURING FLOODS

FLOOD MITIGATION OBJECTIVES

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

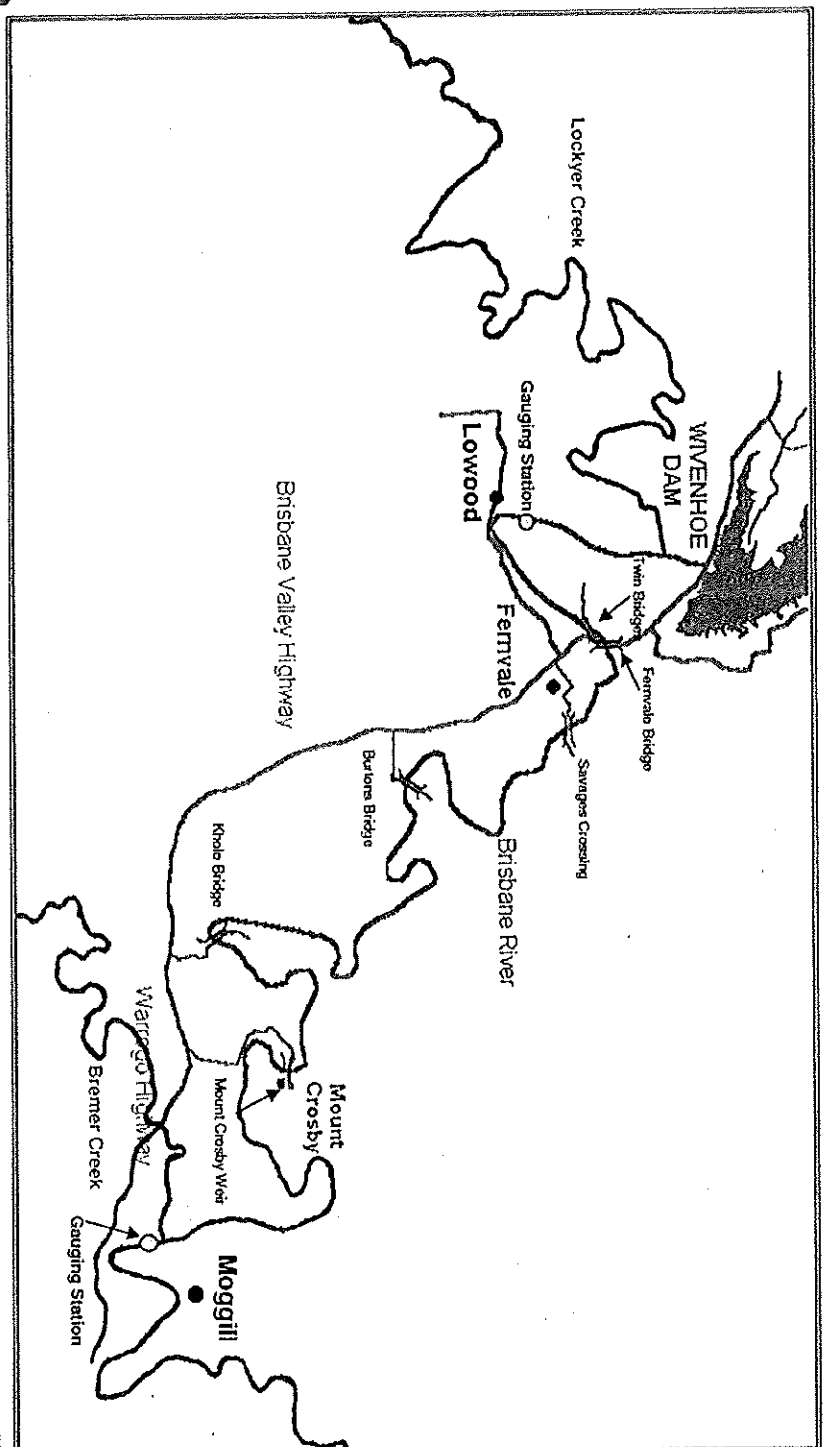
FLOOD MITIGATION MANUALS DAM OPERATIONS DURING FLOODS

**FLOOD MITIGATION OBJECTIVES ARE ACHIEVED
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- Obtaining real time rainfall and streamflow data from 140 gauging stations in the impacted catchment areas;
- Obtaining rainfall forecasts from BOM;
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DAM OPERATIONS DURING FLOODS



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CHAIRMAN'S RESPONSIBILITIES

For the purposes of operation of the dams during Flood Events, Seqwater must ensure that:

- All practical attempts are made to liaise with the Chairperson and the Chief Executive (DG DERM) if the release of water from the Dams during a Flood Event is likely to endanger life or property.

FLOOD MITIGATION MANUALS

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REASONABLE DISCRETION

If in the opinion of the Senior Flood Operations Engineer, it is necessary to depart from the procedures set out in this Manual to meet the flood mitigation objectives, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary subject to the following:

- Before exercising discretion under this Section of the Manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must make a reasonable attempt to consult with both the Chairperson and Chief Executive.
- The Chief Executive would normally authorise any departures from the Manual. However if the Chief Executive cannot be contacted within a reasonable time, departures from the Manual can be authorised by the Chairperson.
- If both the Chairperson and the Chief Executive cannot be contacted within a reasonable time, the Senior Flood Operations Engineer may proceed with the procedures considered necessary.

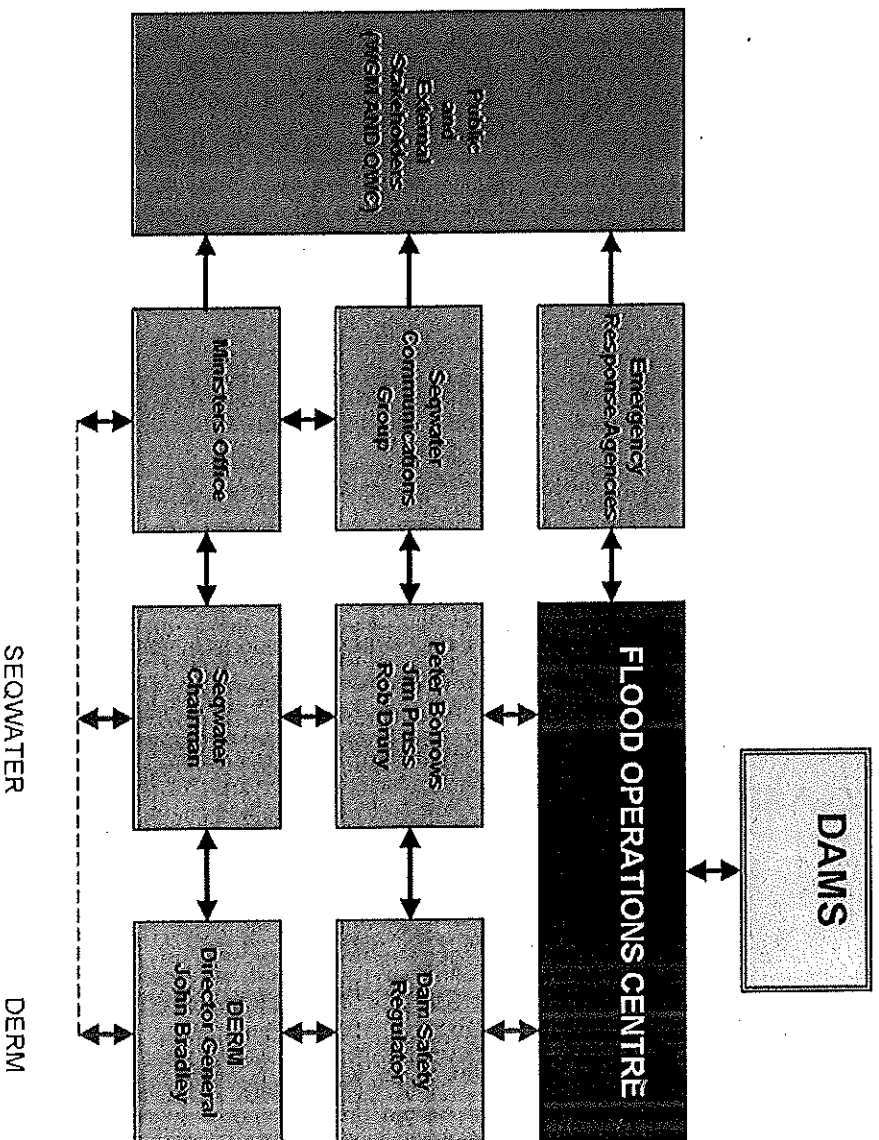
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- Only in large events ($\sim > 1$ in 50 year events).
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- During the drain down phase if significant urban damage has been experienced in Brisbane.

FLOOD MITIGATION MANUALS COMMUNICATIONS DURING FLOODS



"PAH2"

Toni Lake

From: Peter Borrows
Sent: Sunday, 16 January 2011 4:36 PM
To: Hennessy, Phil A; 'Tom Fenwick'; Leeanne Bond; Leith Bouilly; Ian Fraser
Cc: Peter Borrows; Toni Lake
Subject: Update - focus on release strategy from Wivenhoe: News tonight - Mt Crosby Interviews with Brett Myatt and Joe Meissner
Attachments: Background Briefing Jan 2011.docx; Brian Cooper - final report.docx; Brian Cooper - final report attachment.xlsx; Record of teleconference 12 January 2011.docx; Mt Crosby.pdf; LetterTurbidityMtCrosby.pdf; SeePage7Figure4.pdf; legislativeprotectionfloodopsFeb2011InfoPack.docx; Cabinet in confidence - Ministerial brief outline

This is an update on the event, in the form of the Ministerial briefing. I'll send the final when we receive it.

Section 5 will reference the Brian Cooper report and attachments. This is in the E Mail attached 'Cabinet in confidence.

I have attached 4 documents that relate to a relaxation in WQ parameters (below contract values) that occurred through the event.

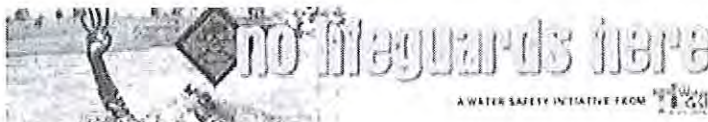
The legislative protection document covers flood releases in accordance with the manual.

Regards, Peter.

Peter Borrows
Chief Executive Officer
Queensland Bulk Water Supply Authority *trading as Seqwater*



[REDACTED]
Level 3, 240 Margaret St, Brisbane City QLD 4000
PO Box 16146, City East QLD 4002
Website | www.seqwater.com.au



Swimming in weirs and fast flowing water is FATAL.
rethink it.

"PAH1"



seqwater
WATER FOR LIFE

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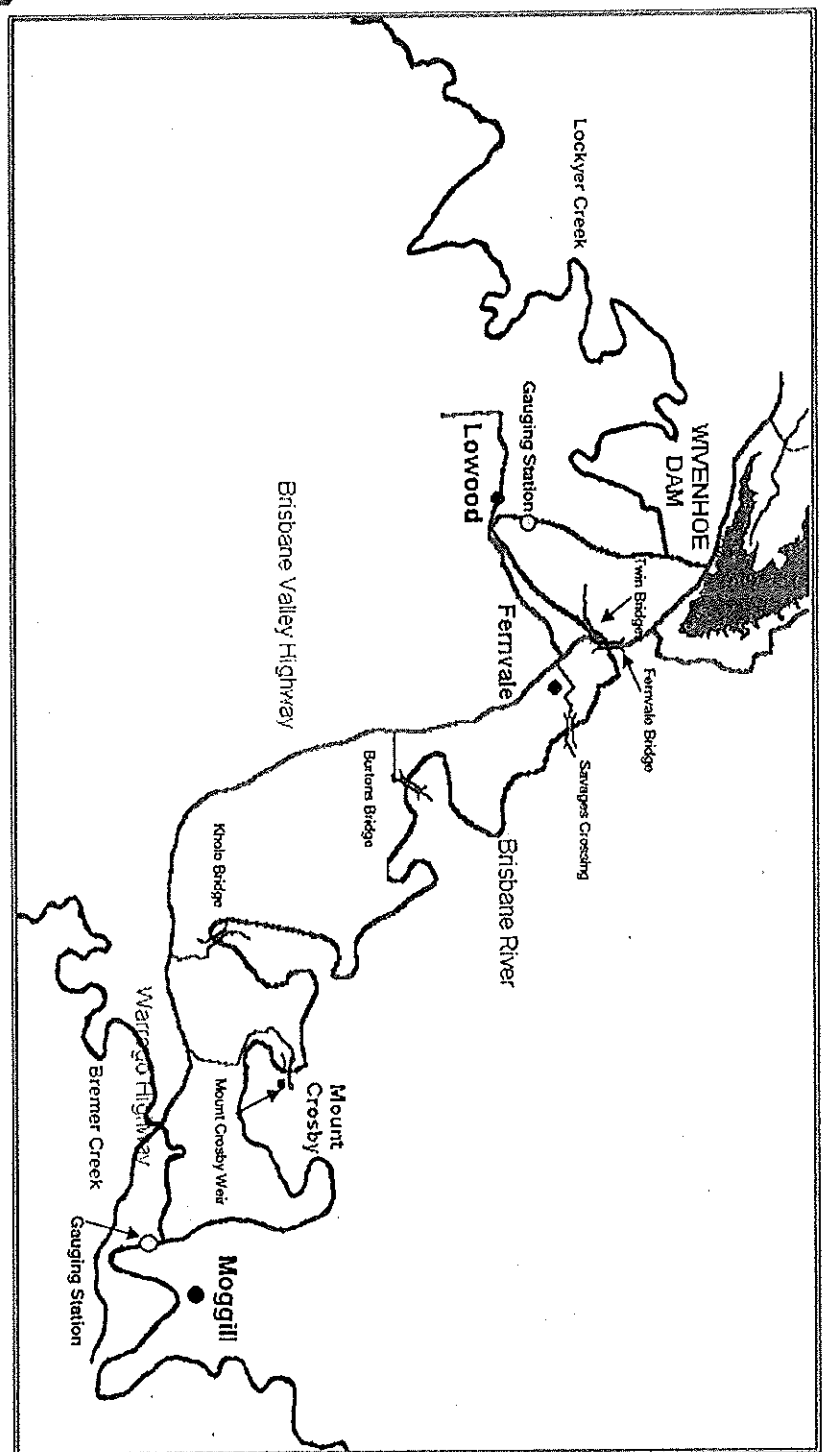
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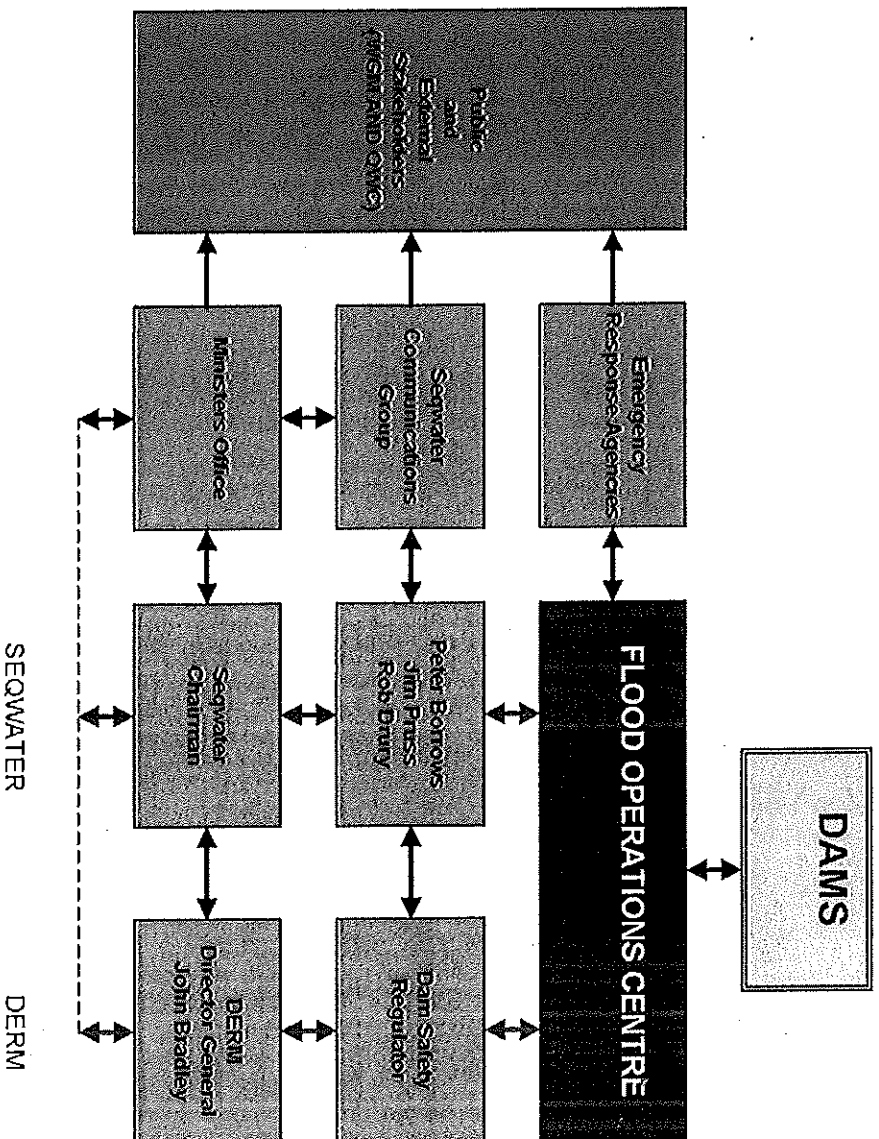
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Wivenhoe Dam – Development of Flood Operational Rules

1. Introduction

This briefing note has been prepared to detail the development of the flood operational rules for Wivenhoe and Somerset Dam and the extensive reviews undertaken for the studies.

The flood operational procedures were developed during an extensive hydrological study of the Brisbane and Pine Rivers catchments by the DPI, Water Resources between 1990 and 1994 which was reviewed by an external expert panel. Subsequently, the flood operational rules have been reviewed during the Brisbane Valley Flood Damages Minimisation Study in 2006 and the latest revision to the flood manual in 2009. Both reviews have included expert review panels comprising key stakeholders.

2. History

The Brisbane River Basin is the major water supply source for the City of Brisbane and many of the nearby local authorities. The major floods which are derived from the basin have a history of causing significant damage to the local communities.

Somerset Dam was constructed on the Stanley Rover over the period 1936 to 1954 and was the major regional water supply source up until the late 1970's

During the early 1970's it was identified that both the water supply and flood mitigation of Somerset Dam would need to be augmented. Shortly after the 1974 floods planning for the construction of Wivenhoe Dam began with construction commencing in 1979 and final completion being achieved in 1987.

The main functions of Wivenhoe Dam are to meet the water supply demands of the Moreton Region, provide the lower pool for the 500MW Wivenhoe Pumped Storage Project and provide flood mitigation for the cities of Brisbane and Ipswich.

Changes to the methods used to determine the rainfall for extreme events during the 1980's resulted in significant changes to the design flood for the newly constructed dam.

In 1990, the owners of the Dam, South East Queensland Water Board, undertook a dam safety review of the three dams owned and operated by the Board. A key component of this study was the Brisbane and Pine Rivers Flood Study.

3. Development of the Flood Operations Rules

In August 1990, the South East Queensland Water Board (SEQWB) commissioned the Department of Primary Industries, Water Resources Business Group (DPI,WR) to undertake the Brisbane and Pine Rivers Flood Study. The flood Study was initiated as part of an overall safety review of the Board's dams, Somerset Dam, Wivenhoe Dam and North Pine Dam. The need for the safety review of the dams stemmed from a number of factors including

- the emergence of new techniques for the estimation of probable maximum precipitation and subsequent flooding,
- the development of computer software capable of simulating the hydraulic behaviour of whole river basins and simulating dam failure scenarios,
- advancements in technology associated with real time weather monitoring.

The scope of the flood study was to review the hydrology for each dam and hydraulic aspects associated with the relevant flood studies and to develop real time model programmes for use in flood control operations and forecasting. Key aspects of the study were:

- hydrologic review
- flood operating procedure
- hydraulic analysis, flood studies
- dam break (failure) analysis
- flood inundation.

This study was undertaken from 1990 until 1994 and represented a thorough review of the flooding in the Brisbane and Pine Rivers and the associated role of the dams within the catchment.

i. Brisbane and Pine Rivers Flood Review

The Brisbane and Pine Rivers Flood Study comprise multiple reports, produced at the completion of each stage of the study. The reports were subject to extensive internal review by the Water Resources Group before being reviewed by an independent review panel comprising Professor Colin Apelt, Head of Department, Department of Civil Engineering, University of Queensland and Mr Eric Lesleighter, Principal Hydraulic Engineer and Chief Engineer Water Resources, Snowy Mountains Engineering Corporation.

ii. Real Time Flood Model

The outcome of the Brisbane River and Pine River Flood Studies were used to develop a real time flood model for the three dams. This real time flood model consists of alert stations within the catchment to provide real time rainfall and stream level data, a calibrated run off model to convert rainfall data into flows, a gate operating model to allow decisions on gate openings to be made and a downstream flood model to provide predictions on flood levels.

iii. Flood Operations Manual

The Flood Operation Manual is the key legislative document prepared by the owner of the dam and approved and gazetted by the Qld Dam Safety Regulator. The manual defines flood procedures, roles and responsibilities, staffing and operational requirements.

The manual in its current form was developed in 1992 using the operational procedures developed during the Brisbane and Pine Rivers Flood Study and a manual written in 1968 covering flood operations at Somerset Dam (Wivenhoe Dam was completed in 1984). Six revisions of the Manual have occurred since 1992 to account for updates to the Flood Alert Network and the Real Time Flood Models, the construction of an Auxiliary Spillway at Wivenhoe Dam in 2005 and to account for institutional and legislative changes.

The primary objectives of the procedures contained in the flood manual are, in order of importance:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

To meet the objectives, there are four strategies for Wivenhoe Dam defining the gate operations as a flood event unfolds. The first three strategies are focused on delivering the optimal flood mitigation outcomes based on inflows, downstream flooding and forecast rainfall. Once the water level in Wivenhoe Dam exceeds 7m above the normal operating level, the strategies shift from flood mitigation to ensuring that the dam is not overtopped.

4. Subsequent Reviews of the Flood Operational Procedures

iv. Brisbane Valley Flood Damage Minimisation Study

In 2005 and 2006, Brisbane City Council (BCC) undertook the Brisbane Valley Flood Damage Minimisation Study (BVFDMS) in conjunction with Ipswich City Council and Esk Shire Council. The study provided a flood damage assessment for Brisbane River floods. The study aimed to estimate the potential flood damage in the Brisbane Valley and then assess the flood operation rules for the Wivenhoe Dam flood gates to determine whether the current rules could be modified to reduce flood damage in the valley.

This extensive study involved detailed survey assessment of the flood damages within the Brisbane City and Ipswich City areas. A Project Technical Review Group was formed for the project involving:

- SEQWater Corporation
- The Bureau of Meteorology
- SunWater as the operator of the SEQWater Corporation Flood Control Centre
- NRM&W Dam Safety Regulator
- WRM Consultants

Key outcomes from this study for the Flood Operational Rules were:

- Confirmation of the 4,000m³/s flood adopted in the flood manual as the start of damaging flows in the Brisbane urban areas.
- Confirmation of the effectiveness of the existing flood operating rules as the optimal method of providing flood mitigation to Brisbane.

v. 2009 Review of the Flood Manual

In 2009, after the formation of the Queensland Bulk Water Supply Authority, a comprehensive review of the flood manual was undertaken. This review was focused on re-writing the manual and

refining the operational procedures. As part of this review Seqwater assembled an expert review panel comprising the following organisations.

- The Bureau of Meteorology
- SunWater as the operator of the Flood Control Centre
- DERM Dam Safety Regulator
- Brisbane City Council

Minor changes made to the manual were extensively tested to ensure that the flood mitigation outcomes from the operation of the dam were not compromised.

5. Conclusions

The flood operational procedures for Wivenhoe and Somerset Dam were developed by a comprehensive study undertaken by the DPI Water Resources between 1990 and 1994. These operational rules have been reviewed by independent parties to identify any opportunities to improve the flood mitigation outcomes including the Brisbane City Council.

Barton Maher (RPEQ 6833)
Principal Dams & Weirs Planning
Queensland Bulk Water Supply Authority trading as Seqwater

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phone [REDACTED]
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email: [REDACTED]
ABN: 56154707619

brian
cooper
consulting

12 January 2011

Mr. Barry Dennien
CEO, SEQ Water Grid Manager
PO Box 16205
City East QLD 4002

Dear Barry,

This letter report:

- presents my final findings on a review of the operation of Wivenhoe Dam (including controlled releases) for compliance against the Flood Mitigation Manual for the period 12 December 2010 to date (Flood Event), and;
- provides advice on the prudence and appropriateness of the decisions and actions taken during the Flood Event regarding the operation of Wivenhoe Dam in light of the Flood Mitigation Manual's requirements and the circumstances of the Flood Event.

The report follows on from my preliminary report sent to you earlier today. The findings and advice are provided on the basis of information provided by SEQ Water Grid Manager which comprised the Flood Mitigation Manual and Technical Situation Reports. The latter were daily (sometimes twice daily) reports for the subject period. They gave a log of rainfall over the dam catchments and the downstream river (Lockyer Ck. and Bremer R.) catchments; inflows to Somerset and Wivenhoe Dams; storage levels; releases from the dams; details of the operation of gates and other outlets (gate openings/discharges); proposed changes in operating strategies and impacts on the various access crossings downstream of Wivenhoe Dam. In reviewing the Technical Situation Reports, I prepared a spreadsheet (see separate attachment of Excel spreadsheet *Tech Reports – Summary*, summarising the reports so that a timeline of the Flood Event could be seen at a glance. This provided a good overview of the Flood Event as it unfolded and showed what information may or may not have been included in a particular report. The Queensland Director Dam Safety (Water Supply) informed me that the Flood Operation Logs contain much more detailed information including details of the communications that were carried out and some of the more detailed information that is not necessarily included in the Technical Situation Reports. I have been provided with a draft of the *"Protocol for the Communication of Flooding Information for the Brisbane River Catchment – Including Floodwater Releases from Wivenhoe and Somerset Dams"* developed in October/November last year and currently being used. The Technical Situation Reports appear to have been an outcome of that Protocol.

The various requirements and required actions detailed in the Flood Mitigation Manual are summarised in the Table given in Attachment A. The Table also gives my comments (where appropriate) on whether there is evidence from the information presented to me, that there is satisfactory compliance with these requirements and actions.

The main aspects of the Flood Mitigation Manual are the various strategies for operating Wivenhoe Dam and Somerset Dam as well as a number of requirements relating to flood operations personnel, flood preparedness and flood training.

At Wivenhoe Dam there are four main strategies for operating the dam (W1 to W4) and at Dam there are three (S1 to S3). These strategies are hierarchical and are based on a number of flood objectives. These in descending order of importance, are:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;
- Retain the storage at Full Supply Level (FSL) at the conclusion of the Flood Event, and;
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

Normal procedures require a return to FSL within 7 days of the flood event peak passing through the dams so that the potential effects of closely spaced Flood Events can be allowed for.

It is apparent from the Technical Situation Reports that emphasis has been given to communicating changes in flood operations strategies with local authorities and the Bureau of Meteorology (BOM).

Until the last day or so, Wivenhoe Dam has been below EL74.0 and accordingly, would be operating under Strategy W1 i.e. make releases such that bridges downstream of the dam do not have to be closed prematurely. For a few days at the end of December and for the last day or so before yesterday's big rise, Strategy W2 would be in place (restrain releases from Wivenhoe Dam such that Brisbane River flows are maintained within the upper limit of non-damaging floods at Lowood (3,500 m³/s)). At various times during the Flood Event some of the downstream bridges have been closed. However, it is evident that action has been taken to vary dam releases such that various bridges could be re-opened as soon as possible. This appears to have been done in accordance with the flood operating strategies. The operations then moved onto Strategy W4 when the storage in Wivenhoe Dam reached about EL 73.5 (before the W4 trigger level of EL 74) when yesterday's heavy rain came on and it was assessed that there was a chance that the first (central) fuse plug could be triggered. It was then a matter of juggling the radial gate openings in an attempt to circumvent any fuse plug triggering. A graph of storage levels for Wivenhoe and Somerset Dams (from information taken from the Technical Situation Reports) showing the limits for the various Wivenhoe Dam flood strategies is given in Attachment A. It is apparent from this graph, that the appropriate flood operation strategies were adopted. The Technical Situation Reports indicate that proposed changes in strategy were appropriately communicated with appropriate authorities in accordance with the new Communication Protocol.

Summary:

The Technical Situation Reports comply with the requirements of the new Communication Protocol. However, I feel that there could be more consistency in the information presented. There seem to be gaps in information presented such as storage levels (see spreadsheet and graph in Attachment A). It would be useful to specify the minimum information required to be presented in the Technical Situation Reports (storage levels, inflows, recent/current rainfall, forecast rainfall, releases from dams, estimated flows from downstream tributaries, current flood operating strategy for each dam and proposed change in strategy, gate and regulator operations, state of downstream road crossings etc). Most of the minimum information is already given, but not in a consistent manner. As a means of reviewing processes followed during a flood, it would be useful to present a timeline of the flood event showing graphs of storage levels and other data that can be easily presented in a graphical manner.

I am informed by the Queensland Director Dam Safety (Water Supply) that the various requirements of the Flood Mitigation Manual relating to requirements for flood operations personnel, flood preparedness and flood training have been adhered to. There are a number of other requirements however, that I am not able to say whether they were satisfied as I had insufficient information. These requirements (see Table in Attachment A) should be subject to a separate audit.

It appears to me that the decision to implement Strategy W4 was a prudent one. While it would cause some damage in the Brisbane River downstream, its implementation, considering forecast rainfalls and projected flows in Lockyer Ck. And the Bremer River, would allow reduction of the storage level in

Wivenhoe Dam. This reduction in storage level would hopefully provide a sufficient buffer that would minimise the chance of a fuse plug triggering in the auxiliary spillway. Triggering of the first (central) fuse plug would cause a sudden increase of flow of some 2,000m³/s from Wivenhoe Dam. This increase in flow would cause significantly more flooding in the lower Brisbane River than that caused by early implementation of Strategy W4.

Conclusions:

The strategies as set out in the Flood Mitigation Manual have been followed, allowing for the discretion given to making variations in order to maximise flood mitigation effects. The actions taken and decisions made during the Flood Event appear to have been prudent and appropriate in the context of the available knowledge available to those responsible for flood operations and the way events unfolded.

There are a number of requirements where there was insufficient time given the urgency of this review, to source the necessary information for me to demonstrate compliance. However, satisfaction or otherwise of these requirements would have had little impact on the operation of the two dams during this particular Flood Event. It is intended that they be audited when time permits, after the Flood Event.

There are aspects of the Technical Situation Reports that could be improved and these have been discussed above.

Regards,



Brian Cooper

ATTACHMENT A

Action Requirements extracted from the Flood Mitigation Manual:

Action	Comment
The Flood Mitigation Manual contains the operational procedures for Wivenhoe Dam and Somerset Dam for the purposes of flood mitigation and must be used for the operation of the dams during flood events.	Appears to have been done
Sufficient numbers of suitably qualified personnel are available to operate the dams if a Flood Event occurs.	Director of Dam Safety is satisfied
The level of flooding as a result of emptying stored floodwaters after the peak has passed is to be less than the flood peak unless accelerated release is necessary to reduce the risk of overtopping.	See Note 1
A regular process of internal audit and management review must be maintained by Seqwater to achieve improvements in the operation of the RTFM.	See Note 1
Seqwater must maintain a log of the performance of the data collection network. The log must include all revised field calibrations and changes to the number, type and locations of gauges. Senior Flood Operations and Flood Operations Engineers are to be notified of all significant changes to the Log.	See Note 1
Seqwater must maintain a log of the performance of the RTFM. Any faults to the computer hardware or software are to be noted and promptly and appropriately attend to.	See Note 1
Seqwater must ensure that all available data and other documentation is appropriately collected and catalogued for future use.	See Note 1
Seqwater must ensure that information relevant to the calibration of its field stations is shared with appropriate agencies.	See Note 1
Seqwater must liaise and consult with these agencies with a view to ensuring all information relative to the flood event is consistent and used in accordance with agreed responsibilities: <ul style="list-style-type: none"> Bureau of Meteorology (issue of flood warnings for Brisbane River basin); Department of Environment and Resource Management (review of flood and discretionary powers); Somerset Regional Council (flood level information for upstream of Somerset Dam and upstream and downstream of Wivenhoe Dam); Ipswich City Council (flood level information for Ipswich), and; Brisbane City Council (flood level information for Brisbane City). 	Required also by draft of Communications Protocol. Technical Situation Reports infer compliance
Seqwater must report to the Chief Executive by 30 September each year on the training and state of preparedness of operations personnel.	See Note 1
Seqwater must provide a report to the Chief Executive by 30 September each year on the state of the Flood Monitoring and Forecasting System and Communication Networks.	See Note 1

Action	Comment
After each significant flood event, Seqwater must report to the Chief Executive on the effectiveness of the operational procedures contained in this manual.	It is too early for this action to be implemented. Will be implemented when the Flood Event is finished
Prior to the expiry of the approval period, Seqwater must review the Manual pursuant to provisions of the Act.	It is too early for this action to be implemented
Strategies are changed in response to changing rainfall forecasts and stream flow conditions to maximise the flood mitigation benefits of the dams.	Technical Situation Reports indicate that this is done
When determining dam outflows within all strategies, peak outflow should generally not exceed peak inflow.	Information from Seqwater indicates that the requirement was satisfied
Protocol for use of discretionary powers (i.e. who gets told)	Director of Dam Safety is satisfied – I don't know whether Seqwater CEO or Chairperson approved – See Note 1

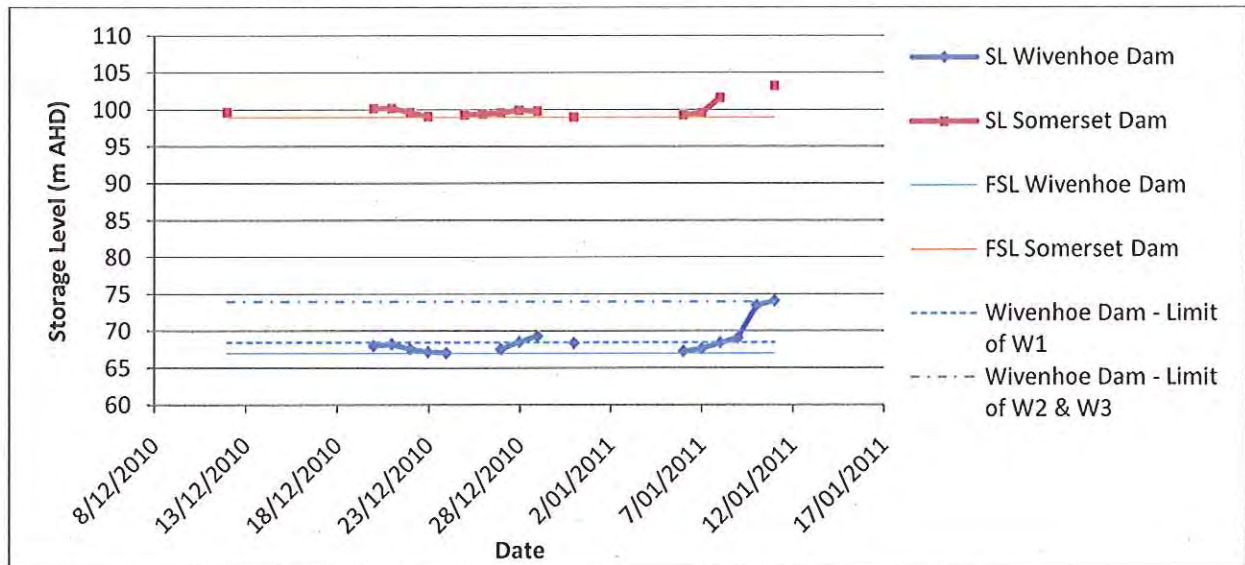
Note1: For a number of the above actions, given the short time frame for the review on compliance of actual flood operations with the Flood Mitigation Manual, it was not possible to source some of the information required to confirm that requirements had been fulfilled. These actions will be audited separately, when time permits.

Action	Comment
<i>Flood Strategies for Wivenhoe Dam:</i>	
<p>The intent of Strategy W1 is to not to submerge the bridges downstream of the dam prematurely (see Appendix I). The limiting condition for Strategy W1 is the submergence of Mt Crosby Weir Bridge that occurs at approximately 1,900 m³/s .</p> <p>For situations where flood rains are occurring on the catchment upstream of Wivenhoe Dam and only minor rainfall is occurring downstream of the dam, releases are to be regulated to limit, as much as appropriate in the circumstances, downstream flooding.</p>	Technical Situation Reports indicate that every attempt was made to keep the specified road crossings open
<p>The intent of Strategy W2 is limit the flow in the Brisbane River to less than the naturally occurring peaks at Lowood and Moggill, while remaining within the upper limit of non-damaging floods at Lowood (3,500 m³/s). In these instances, the combined peak river flows should not exceed those shown in the following table:</p>	Technical Situation Reports indicate that Wivenhoe Dam releases were made considering concurrent flows in the Bremer River & Lockyer Ck. To delay damaging floods as long as possible
<p>The intent of Strategy W3 is to limit the flow in the Brisbane River at Moggill to less than 4000 m³/s, noting that 4000 m³/s at Moggill is the upper limit of non-damaging floods downstream. The combined peak river flow targets for Strategy W3 are shown in the following table. In relation to these targets, it should be noted that depending on natural flows from the Lockyer and Bremer catchments, it may not be possible to limit the flow at Moggill to below 4000 m³/s. In these instances, the flow at Moggill is to be kept as low as possible.</p>	
<p>The intent of Strategy W4 is to ensure the safety of the dam while limiting downstream impacts as much as possible.</p> <p>This strategy normally comes into effect when the water level in Wivenhoe Dam reaches EL74.0 m AHD. However the Senior Flood Operations Engineer may seek to invoke the discretionary powers of Section 2.8 if earlier commencement is able to prevent triggering of a fuse plug.</p> <p>There are no restrictions on gate opening increments or gate operating frequency once the storage level exceeds EL74.0 AHD, as the safety of the dam is of primary concern at these storage levels.</p>	Technical Situation Reports indicate that Wivenhoe Dam releases were such as to delay adopting this strategy as long as possible
Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.	Technical Situation Reports indicate that this requirement was satisfied
The aim should always be to empty stored floodwaters stored above EL 67.0m within seven days after the flood peak has passed through the dams.	Technical Situation Reports indicate that

Action	Comment
	emphasis was given to satisfying this requirement
Flow in the spillway to be as symmetrical as possible with the centre gates opened first.	Technical Situation Reports indicate that this was done
The bottom edge of the radial gates must always be at least 500mm below the release flow surface.	See Note 1 above

Action	Comment
<i>Flood Strategies for Somerset Dam:</i>	
The intent of Strategy S1 (Somerset Dam Level expected to exceed EL 99.0 and Wivenhoe Dam not expected to reach EL 67.0 (FSL) during the course of the Flood Event) is to return the dam to full supply level while minimising the impact on rural life upstream of the dam. Consideration is also given to minimising the downstream environmental impacts from the release.	Technical Situation Reports indicate that this was done
The intent of Strategy S2 (Somerset Dam Level expected to exceed EL 99.0 and Wivenhoe Dam level expected to exceed EL 67.0 (FSL) but not exceed EL 75.5 (fuse plug initiation) during the course of the Flood Event). This to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams. The Flood Mitigation Manual contains a graph that shows the intended interaction of the Wivenhoe Dam and Somerset Dam storage levels.	Technical Situation Reports indicate that this was done – little information on the operation of the radial gates at Somerset Dam. How the graph was followed not really demonstrated
The intent of Strategy S3 (Somerset Dam Level expected to exceed EL 99.0 and Wivenhoe Dam level expected to exceed EL 75.5 (fuse plug initiation) during the course of the Flood Event) is to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams.	Not relevant at this stage
The safety of Somerset Dam is the primary consideration and cannot be compromised and its peak level cannot exceed EL 109.7.	Maximum level only EL103.3

Wivenhoe & Somerset Dams – Storage Level Behaviour (as presented in Technical Situation Reports)



Date	Time	TSR	Wivenhoe Dam Release (m³/s)				Gate No.	Opening (m)	Storage Level	Rainfall (mm)	Comments	Crossing Closures
			Regulators	Hydro	Gates	Total						
12/12/2010	1400	W1									45,000MI from Somerset; WL [Somerset to peak at 99.7 on 13/12/2010; 150m³/s expected through Brisbane; 30,000MI expected into Wivenhoe from upper Brisbane R.; peak WL in Wivenhoe expected to be 67.6; Releases expected from Wivenhoe on afternoon of 13/12/2010 ramping up to 300m³/s; Reg. will be closed & Gate 3 opened to 3m to get WL back to 67.25; Incr. release will impact on 3 crossings; Dam Regulator Informed	
13/12/2010	1300	W2		10	230	300					138m³/s from Somerset; Releases from Wivenhoe will cease on 16/12/2010; Hydro will continue during Fish recovery ops. Gate closed 1000	Gate release will impact on 3 crossings
15/12/2010	1600	W3									Decision to commence a release tonight was made this am by Duty Flood Engineers to provide as much notice to impacted Councils as possible; 60,000MI needs to be released from Wivenhoe & Somerset to maintain FSL	
16/12/2010	1600	W4			0						Need to release >60,000MI from Wivenhoe & Somerset to achieve FSL	
17/12/2010	1200	W5									Releases could increase to 300m³/s;	Would impact Twin Bridges, Savages Crossing, Colleges Crossing
17/12/2010	1800	W6	Closed	13	50	63	3	0.5			100,000MI to be drained in next 4 days; Q [Brisbane R. to be maintained at 300-350m³/s; Transfer from Somerset via 2 reg.; Wivenhoe Q Incr. to 150m³/s o/n; Will incr. further to 300m³/s as Q [Lock Ck. Subside over next 24 hrs; Q [Lock Ck. Currently 130m³/s	
18/12/2010	0700	W7									12,000MI/day from Somerset; Release expected until 22/12/2010;	Twin Bridges & Savages Crossing currently closed; Colleges Crossing to be impacted in afternoon
19/12/2010	0700	W8				350	350	3	3.5	40-50 since 16/12/2010	Somerset rel. steady (Q [reg =140m³/s); Q [Wivenhoe to be maintained at 300m³/s (Lock Ck. Permitting) to allow Burtons Bridge to remain open; WL [Wivenhoe expected to incr. to 67.4 over next 2 days;	Twin Bridges, Savages Crossing, Colleges Crossing currently closed
19/12/2010	1800	W9				300	300	3	3	20-30 upper Brisbane R.	Somerset risen to 100.2 - sluice gate releases to be made until am of 22/12/2010 when FSL expected; WL [Wivenhoe at 68 expected this pm; Q [Wivenhoe expected to be >1,200m³/s - discuss with impacted Cncls - strategy decision by 1000; Wivenhoe inflows excl. Q [Somerset peak tomorrow at 1800m³/s	Twin Bridges, Savages Crossing and Colleges Crossing are closed; closing of Burtons Bridge and Kholo Bridge will be considered if more rain or inflows
20/12/2010	0700	W10									Inflow to Somerset to peak today at 700m³/s; Somerset & Wivenhoe currently storing 140,000MI above FSL; further inflows occurring; releases to be incr. o/n to ~1,200m³/s; various Cncls. Given heads up; BOM advised	Both Burtons and Kholo bridges likely to be inundated
20/12/2010	0900	W11									Same as W11	Wivenhoe releases reduced slightly to keep Burtons Bridge open - then incr. releases after Somerset Regn/Cncl Inform residents affected by Burtons Bridge
20/12/2010	0900	W12									410m³/s from Somerset sluice gates; Somerset peaked @ 100.43 (1300 on 20/12/2010); currently @ 100.23 (114% of cap.); 110,700MI inflow to Somerset; 67,500MI discharged into Wivenhoe; Wivenhoe inflow (excl. Somerset releases) = 157,900MI; 103,000MI released; Total inflow to both dams ~310,000MI; Continued gate operations may be necessary if forecast rainfall results in subsequent river rises	
21/12/2010	0730	W13				peak 1,280 (0500)					110,700MI inflow to Somerset; 67,500MI discharged into Wivenhoe; Wivenhoe inflow (excl. Somerset releases) = 157,900MI; 103,000MI released; Total inflow to both dams ~310,000MI; Continued gate operations may be necessary if forecast rainfall results in subsequent river rises	Kholo Bridge is also expected to be inundated by mid-morning; In accordance with the adopted operational strategy these bridges should be back in service by late Thursday and all bridges (with the possible exception of Twin Bridges) should be trafficable for Christmas providing no further rainfall occurs.
22/12/2010	0830	W14									410m³/s from Somerset sluice gates; Somerset currently @ 99.68 (108% cap.); 121,500MI inflow to Somerset; 103,000MI released to Wivenhoe; Gate Ops. @ Wivenhoe; High tides expected to coincide with peak levels in Brisbane R.	Burtons Bridge & Kholo Bridge expected to be back in service by 23-24/12/2010. All bridges expected to be trafficable by Xmas provided no further rain
22/12/2010	1600	W15									BOM aware of all releases	Gate closing sequence to allow bridges to be accessible
23/12/2010	0800	W16									1 sluice open @ Somerset to be closed @ 0900 - WL will be 0.1m > FSL; Est. inflow to Somerset 135,000MI; majority discharged into Wivenhoe; Gate closure ops @ Wivenhoe in progress; Wivenhoe inflow (excl. Somerset inflow) = 204,000MI; A total of 324,000MI has been released; Contd. gate ops may be necessary if forecast rain results in river rises; Gate closure ops sequence to be reviewed	Projected crossing openings: Burtons Bridge - 18:00 Thursday 23 December 2010. Savages Crossing - 19:00 Thursday 23 December 2010. Kholo Bridge - 21:00 Thursday 23 December 2010. Colleges Crossing - 08:00 Friday 23 December 2010
23/12/2010	1430	W17				350		3	3.5	67.23 29/12/2010	Somerset gate ops ceased @ 0900, WL @ 99.1; Gate closure sequence extended to pm of 24/12/2010; Contd. Gate ops may be necessary if forecast rainfall gives incr. river levels	Projected crossing openings: Burtons Bridge - 18:00 Thursday 23 December 2010, Kholo Bridge - 21:00 Thursday 23 December 2010. Other bridges expected to remain closed until Xmas Day
24/12/2010	0630	W18									Gate ops @ Somerset ceased yesterday; reg. to be opened to bring lake to FSL; Gate ops continuing @ Wivenhoe - 1 gate incr. every 5-6 hrs to ensure Brisbane R. Q not incr. due to incr. Lock Ck. Outflows & maintain Burtons Bridge open;	Twin Bridges, Savages Crossing and Colleges Crossing are currently closed and should remain so for some time due in part to current outflows into the Brisbane River from Lockyer Creek that will peak in excess of 200 cumecs late today.
24/12/2010	1330	W19						3	zero		Flood Centre to monitor o/n & consider options tomorrow am based on inflows & rainfall; further gate ops may be necessary in coming days	Twin Bridges, Savages Crossing and Colleges Crossing may still be affected by flows from the Lockyer.
25/12/2010	0930	W20									Somerset WL incr. from 99.18 yesterday @ 0600 to 99.33 @ 0730 today; 99.5 tomorrow if no gate ops; Wivenhoe currently 4,200MI through hydro & reg.; 15,00MI expected just from upper Brisbane R. In next few days; WL cont. to fall in Lock Ck. Small rises expected in Bremer & Warrill systems; WL in Wivenhoe incr. to 67.28 @ 600	Twin Bridges, Savages and Colleges Crossing remain impacted by Wivenhoe releases and Lockyer and local runoff. Burtons and Kholo Bridges would be currently unaffected. Kholo will no doubt still be closed by Council regarding repairs.
26/12/2010	0800	W21									BOM issued severe weather warning @ 0.445; Somerset WL incr. to 99.45 (0.45m > FSL) - 2 regs. To be opened today (140m³/s); Wivenhoe WL incr. to 67.37 (0.37m > FSL); RG to be opened later today following discussions with local authorities; further gate ops may be necessary if rainfall incr. river levels	Crossings downstream of the dam are currently impacted primarily by non-controlled river flows only (no RG releases from Wivenhoe). Lockyer Creek outflows into the Brisbane River are currently in the order of 60m³/s. Twin Bridges, Savages and Colleges Crossings will be inundated but the plan is to release around 300-350m³/s depending on flows downstream so as to not impact Burtons Bridge
27/12/2010	0800	W22									BOM continues with severe weather warning & widespread rainfall over dam CA's; 2 regs. @ Somerset giving 135m³/s release, lake contd. To rise to 99.6 (0.6m > FSL); RG ops @ Wivenhoe commenced yesterday @ 0900, WL contd. To rise to 67.57 (0.57m > FSL); Q [Wivenhoe reduced o/n because of incr. Q [Lockyer to ensure Burtons Bridge remains open; RG @ Wivenhoe would back as Q [Lockyer incr. > 250m³/s; Q [Lockyer expected to peak 500m³/s later today/tomorrow - will inundate Burtons Bridge; When this happens, Q [Wivenhoe will be incr. to get WL back to FSL; further gate ops may be necessary in coming days	Twin Bridges, Savages Crossing and Colleges Crossing currently closed. Burtons Bridge is currently open, but will be closed later today/tomorrow; Kholo Bridge remains unserviceable due to flood damage. No current expectation that either Mt Crosby Weir Bridge or Fernvale Bridge will be impacted by the current event. An updated estimate of the time of closure of Burtons Bridge this afternoon will be provided to Council
28/12/2010	0700	W23									Sever weather warning no longer current; Somerset release through regs ~ 205m³/s; WL [Somerset incr. to 99.86 (0.95m > FSL) - inflows decreasing; RG opening dependent on Q [Lockyer; Wivenhoe WL currently @ 68.55 (1.55m > FSL); Inflows to Wivenhoe decr.	RG discharge dropped back to 46m³/s to ensure Burtons Bridge can remain open. Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge are currently closed. No current expectation that either Mt Crosby Weir Bridge or Fernvale Bridge will be impacted by the current event. Lockyer Creek outflows being closely monitored and may come close to impacting upon the Mt Crosby Weir Bridge; England Creek access is not impacted yet
29/12/2010	0700	W24									Further 2 sluices opened @ Somerset; WL @ Somerset 99.83 & falling slowly; 2 sluices to be closed @ 1200, intended to incr. Wivenhoe releases so Q [Wivenhoe+Q [Lockyer maintained @ 1,600m³/s (similar Q to mid Oct 8 mid Dec 2010)	Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge are currently closed. No current expectation that Mt Crosby Weir Bridge or Fernvale Bridge will be impacted by current event. At this stage, estimated that the flow at Burtons Bridge will fall below the bridge deck on Sunday morning
30/12/2010	0700	W25									2 sluices @ Somerset remain open (405m³/s) - FSL expected by 6/1/2011; RG closing sequence expected to start mid tomorrow - RG expected to be closed on 2/1/2011	Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge are currently closed
31/12/2010	0700	W26 W27									WL @ Somerset 99.01 (falling from peak of 100.0 - 1200 28/12/2010) - currently 2 regs;	Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge are currently closed due to inundation
6/01/2011	1200	W28									20-30 widespread with up to 50 on dam. Somerset @ 99.34 (0.34m > FSL) & rising slowly; Wivenhoe 67.31 (0.31m > FSL) & rising slowly; Gates will be opened in next 24 hrs; Lockyer Ck peak of about 100m³/s Friday afternoon	Not included Lockyer Ck peak or about 100m³/s Friday afternoon. This will take out twin bridges and nearly inundate Savages Crossing. Colleges Crossing could be taken out by a combined Lockyer and local runoff. Current strategy is to keep Burton Bridge free. Gate release would limit mid-Brisbane Q to 400m³/s ((Burtons capacity 450m³/s)
7/01/2011	0700	W29									100-200mm rain forecast for SE Q [d next 5 days; Somerset WL @ 99.58 (0.58m > FSL) rising slowly - currently releasing 35m³/s; Wivenhoe WL @ 67.64 (0.64m > FSL & > gate trigger level) rising slowly; u/s of dam river levels peaked @ Unwin and Gregors Ck gauges; A peak of about 470 cumecs is expected from Lockyer Creek by mid-afternoon; Wivenhoe gate releases will occur after the impact of Lockyer flows on Burtons Bridge has been ascertained and flood levels in the lower Lockyer subside Q [Wivenhoe may be as high as 1,200m³/s	Q [Lockyer may be of sufficient magnitude to inundate Burtons Bridge; Somerset Regional Council, Ipswich City Council and Brisbane City Council have been advised of the potential for gate operations during the next 24 hours. The relatively high Lockyer flows will adversely impact upon Twin Bridges, Savages Crossing, and Colleges Crossing for several days. may also later impact upon Burtons Bridge & Kholo Bridge; not expected to be any adverse impacts upon Fernvale Bridge or Mt Crosby Weir Bridge; Councils have been advised of this strategy and are contacting residents
7/01/2011	1500	W30									Somerset releasing 35m³/s; 50,000MI into Somerset; Gate release @ Wivenhoe - strategy to be reviewed tomorrow (dependent on further rainfall)	All of the crossings downstream of Wivenhoe with the exception of Fernvale and Mt Crosby Weir Bridge will be adversely impacted. Councils have been advised of this strategy and are contacting residents
8/01/2011	0700	W31									Somerset WL @ 100.42 & rising (0500) - 1 open sluice gate; Water temp. held in Wivenhoe - strategy may need to be reviewed (depend. On confidence in estimates of Wivenhoe inflows); Intended to ramp Wivenhoe up to 1,200m³/s by 1200 - likely to be incr. next week; since 2/1/2011, ~200,000MI has flowed into Wivenhoe (incl. Somerset releases); further 180,000MI expected based on recorded rainfall; ~50,000MI released via reg. & hydro (@ 35m³/s)	The projected Wivenhoe release of 1,200m³/s combined with Lockyer flows and local runoff will mean that all crossings downstream of Wivenhoe (Twin Bridges, Savages Crossing, Burtons Bridge, Kholo Bridge and Colleges Crossing) will be adversely impacted for several days. At this stage Fernvale and Mt Crosby Weir Bridge are not expected to be affected but they could potentially be affected if the predicted rainfall totals eventuate
9/01/2011	0700	W32 W33									For last 12 hrs. av. of 40 for Somerset CA & <10 for Wivenhoe CA	The current Wivenhoe Dam release combined with Lockyer flows and local runoff will mean that all low level crossings downstream of Wivenhoe (Twin Bridges, Savages Crossing, Burtons Bridge, Kholo Bridge and Colleges Crossing) will be adversely impacted until at least Wednesday 12 January. At this stage Fernvale and Mt Crosby Weir Bridge are not expected to be affected, but this may be revised if the predicted rainfall totals eventuate and higher releases from Wivenhoe Dam are considered necessary. Cncls advised of Wivenhoe op. strategy
9/01/2011	2100	W34 W35 W36 W37									Very heavy rainfall - totals for 24 hrs 100 - 300; Severe weather warning for heavy rainfall	The projected Wivenhoe Dam releases combined with Lockyer flows and local runoff will mean that all crossings downstream of Wivenhoe (Twin Bridges, Fernvale, Savages Crossing, Burtons Bridge, Kholo Bridge, Mt Crosby Weir and Colleges Crossing) will be adversely impacted until at least Saturday 15 January in varying degrees; Water levels in the lower Brisbane R. will be impacted by the combined flows of Lockyer Ck, Bremer River, local runoff and releases from Wivenhoe Dam
11/01/2011	0630	W38									20-60 last 12 hrs in Lockyer CA; 30 in Bremer R.; Isol. Falls of 125 in upper Brisbane R. & widespread falls of 40-70 in Somerset CA	The projected Wivenhoe Dam releases combined with Lockyer flows and local runoff will mean that all crossings downstream of Wivenhoe (Twin Bridges, Fernvale, Savages Crossing, Burtons Bridge, Kholo Bridge, Mt Crosby Weir and Colleges Crossing) will be adversely impacted. Water levels in the lower Brisbane River will be impacted by the combined flows of Lockyer Creek, Bremer River, local runoff and releases from Wivenhoe Dam
11/01/2011	1200	W39									74.1 (179.5% cap) rising @ 25mm/hr.	

Record of teleconference 12 January 2011

Key attendees:

Mick Young, Director General, Queensland Health

Dr Jeanette Young, Chief Health Officer, Queensland Health

Sophie Dwyer, Executive Director , Queensland Health

Andrew Wilson, Queensland Health

Arran Hieatt, Senior Environmental Health Scientist, Queensland Health

John Bradley, Director General, Department of Environment and Resource Management

Dr David Cunliffe, SA Department of Health

Dr Dan Deere, WaterFutures

Barry Dennien, CEO, SEQ Water Grid Manager

Dan Spiller, Director Operations, SEQ Water Grid Manager

Jim Pruss, Executive General Manager, Seqwater

Stan Stevenson, Seqwater

Arran Canning, Seqwater

Brett Myatt, Seqwater

Jeff Browne, Linkwater

Summary of outcomes

It was agreed by the Water Grid, Queensland Health and Department of Environment and Resource Management that:

- The primary objective is to maintain supply within the connected area. Production at the Mt Crosby WTP will at least match demand, subject to operational constraints.
- The secondary objective is to maintain drinking water quality, minimising public health risks. However, production will not cease due to treated water quality issues.
- For the duration of the current flood event, the operating rules for the Mt Crosby water treatment plants are:
 - Minimum production of 150 ML/day
 - Achieve and maintain stable operation
 - Shutdown for operational reasons only, not treated water quality

- Target of below 1 NTU in treated water
- Periods of up to 2 NTU in treated water tolerable
- Disinfection residual maintained at standard operating procedure
- Note some discolouration may occur

Queensland Health advised that:

- Based on these operating rules, water supplied from the Mt Crosby water treatment plants is considered to have taken all necessary precautions to minimise the public health risk.
- Further advice should be sought from Queensland Health should there be a prolonged trend to above 1.5 NTU in treated water. Production should not cease while this advice is sought. An evaluation will be made at that time to determine if water of above 2 NTU may still be safe to supply.



13 January 2011

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Public Health

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Dear Dr Young

Re: Operation of Mt Crosby Water Treatment Plant

Based on the information provided in yesterday's meetings I consider that a target upper turbidity limit of 1NTU combined with existing disinfection procedures at the Mount Crosby Water Treatment Plant should produce safe drinking water. In addition an increase to 2NTU for periods of time can be accepted

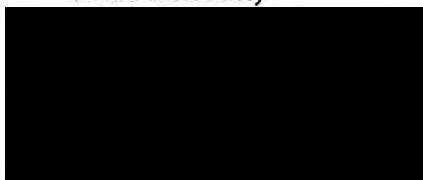
This assessment is based on the following:

- Turbidity limits applied to filtered water in Australia are based on USEPA standards. These are intended to ensure a minimum 3 log reduction of *Cryptosporidium*. The turbidity in the source water is currently over 1300NTU and may reach 1700NTU or even higher. Achieving 1-2 NTU in filtered water will provide a 3 log reduction in turbidity indicating effective filtration and substantial removal of *Cryptosporidium*.
- Although recent practice has been to move to turbidity limits of 0.3NTU in filtered water (based on the latest USEPA standards) in previous years turbidity targets of 0.5NTU-1NTU with higher upper limits were commonplace in Australia with no evidence of associated drinking water outbreaks.
- *Giardia* reductions are expected to exceed those of *Cryptosporidium*. Disinfection will also provide a further partial barrier to *Giardia* which is not as resistant to chlorine as *Cryptosporidium*.
- The free chlorine concentrations and minimum contact times are sufficient to inactivate enteric viruses and bacteria
- Although there has been reported contamination of the Brisbane River this is likely to have been greatly diluted by the massive volumes of water currently in the River and its tributaries

In summary, the water produced by the plant under the agreed operating conditions should be safe. While turbidity should be kept as low as possible, subject to practical constraints, providing it is maintained with the identified limits public advice to boil the water is not required. This situation should be reviewed if the 1NTU target is consistently exceeded or if the upper limit of 2NTU is exceeded for more than 30-60 minutes.

I hope that this advice is useful. If you need further information or clarification please contact me again.

Yours sincerely



Dr David Cunliffe
Principal Water Quality Adviser
SA Department of Health



Dr Jeanette Young
Chief Health Officer
Queensland Health
147-163 Charlotte Street
Brisbane
Queensland 4000

13th January 2011

Dear Dr Young,

Re: Public health risks associated with the Mt Crosby Water Treatment Plant.

It is my understanding that at the present time the raw water being abstracted into the Mt Crosby Water Treatment Plant is of the order 1,300 NTU and is anticipated to reach 1,700 NTU. I understand that the filtered water turbidity is approaching 1 NTU and may soon reach 2 NTU. I understand that the chlorination process is functioning appropriately and providing a free chlorine dose of over 15 mg•min/L.

In my best professional judgement, the current level of risk to consumers of drinking water supplied by the Mt Crosby Water Treatment Plant is not sufficient to warrant a boil water order for the following reasons. The following set out my reasoning.

All relevant viruses and bacteria will be adequately inactivated by the free chlorine disinfection process. Filtering to below or close to 2 NTU will adequately remove particulates and the disinfection will be effective.

Giardia is relatively rapidly inactivated by natural processes in SEQ summer temperatures and is somewhat susceptible to chlorine and is relatively large and quite well removed by filtration even at 2 NTU.

The only hazard of any potential significance is *Cryptosporidium*.

There are two elevated risk conditions for *Cryptosporidium*:

- The high rainfall causing failure of manure and sewage retention and treatment systems so that elevated *Cryptosporidium* will be released into waterways rather than retained in pondages and sewerage systems.
- The elevated filtered water turbidities implying less than optimal removal of oocysts.

However, all other risk factors are low. For instance:

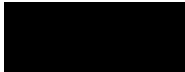
- *Cryptosporidium* is easier to remove in turbid waters, all other things being equal, since there is more particulate matter to assist in floc formation and oocysts sedimentation. Therefore, dropping turbidity from over 1,000 down to 1 NTU demonstrates extensive particulate removal and much *Cryptosporidium* removal would be achieved. It would be reasonable to expect at least two log₁₀ reduction across the plant under these circumstances and potentially three log₁₀. There is a reasonable correlation between turbidity removal and oocyst removal (see attached paper, noting Figure 4, page 7).
- There are many water filtration plants across Australia that have 1 NTU turbidity as their target and a value up to 2 NTU as their critical limit for operation. Detectable waterborne disease is not seen in these townships.

- The driver for tighter filtered water turbidities, such as 0.3 NTU, is to meet long-term endemic disease burden targets of around 1 in 10,000 infections or 1 in one million DALYs per person per year, not to avoid outbreaks. A 1 NTU target and 2 NTU short-term limit is not uncommon historically in Australia and is commonly practiced in many Australian towns and does seem to be able to prevent short-term outbreaks.
- Dilution factors are high during these very large flood events leading to levels of contamination that would not be at their worst case. The outer catchment with relatively low population densities is probably contributing most of the water. Risks are much lower than a situation in which a flash flood occurs in a small, highly polluted catchment.
- *Cryptosporidium* is appreciably inactivated by natural processes in SEQ summer temperatures and only the last weeks of pathogen shedding would be relevant. Material deposited weeks or months ago would not be relevant.
- Almost all outbreaks of waterborne cryptosporidiosis occur in lower temperature conditions, such as Canada, northern Europe or the northern North American states, and typically in early Spring, e.g. after snow melt during lambing and calving seasons. This is not comparable to the situation in SEQ during mid-summer.
- It is not a mass calving or lambing season so we are not likely to be seeing high numbers of human-infectious strains *Cryptosporidium* (i.e. certain genotypes of *C. parvum*) that are seen in other environments or in early Spring.
- We are probably just prior to the annual swimming pool-related outbreak peak that occurs in humans around February and leads to a peak source concentrations in sewage of around two log₁₀ above normal background, so we are not in the highest risk period for *C. hominis* and human-derived *C. parvum*.

It is plausible that levels of *Cryptosporidium* passing through the filtration plant are higher than those levels required to achieve a 1 in one million DALY disease burden, as per the long term risk targets used for setting normal treatment requirements. However, it is not likely that these levels are high enough to lead to detectable increases in notified cases of cryptosporidiosis. Therefore, issuing a boil order would be unnecessary from a utility and government reputation perspective. Furthermore, from a public health and public convenience perspective, cryptosporidiosis is a self-limiting disease in the Australian context and issuing a boil water order would be a disproportionate response.

In summary, given the above information, my perception is that issuing a boil water order for the Mt Crosby water supply at this time would not be warranted on either public health grounds or in order to protect the reputation or the utility or government at large. I do not foresee a waterborne disease outbreak eventuating under the current circumstances. The situation should be reviewed should turbidities remain consistently elevated above 1 NTU, e.g. for more than several hours, or rise above 2 NTU for more than 1 hour.

Yours sincerely



Dan Deere PhD

Consultant, Water Futures Pty Ltd

Visiting Fellow, Centre for Water Research, University of New South Wales

Member NSW Health *Cryptosporidium* and *Giardia* Testing Independent Expert Panel

Chair NATA *Cryptosporidium* and *Giardia* Proficiency Testing Program Technical Group

Lead Auditor and Technical Professional: Water Quality, Water Licensing and Technical Services Panel, Independent Pricing and Regulatory Tribunal, NSW Government

Lead Auditor, Drinking Water Quality Management Systems: ID 022400, RABQSA



Project Summary

Removal of Cryptosporidium and Giardia through Conventional Water Treatment and Direct Filtration

Eva C. Nieminski

Pilot- and full-scale evaluations of Giardia and Cryptosporidium cyst removals through direct filtration and conventional water treatment were conducted by the Utah Department of Environmental Quality. Cysts were seeded continuously in a step dose at a 0.5 gpm pilot plant, and in a spike at a 900 gpm full-scale plant; both plants were operated under conventional treatment and direct filtration regime. The results of 20 pilot-scale cyst seeding trials and 8 full-scale trials indicated that source water quality (turbidity and algal content), as well as treatment effectiveness in removing turbidity, controlled the removal of seeded Giardia and Cryptosporidium. Changes in source water quality influenced removal rates more than the mode of treatment. Higher removal rates were consistently observed for Giardia cysts (3.3-log) than for Cryptosporidium oocysts (3.0-log). A high correlation was found between cyst removal rates and removal of the respective size particles; poorer correlation existed between cysts and turbidity removal, while no significant correlation was established between the removals of cysts and heterotrophic bacteria.

To assure that the best available detection method was used in enumeration of the cysts in raw and treated water, two versions of the immunofluorescence staining method were evaluated for their efficiencies in detecting Giardia cysts and Cryptosporidium oocysts seeded at known concentrations

in water: (1) the ASTM method for detection of Giardia cysts and Cryptosporidium oocysts in low-turbidity water and (2) a modified Sauch's procedure employing sampling by 2.0 μ m membrane filters, Percoll/Percol step gradient flotation, and immunofluorescence staining on 2.0 μ m porosity polycarbonate membrane filters. The second method was selected, since it was characterized by higher recovery rates in all three types of waters tested: raw surface water, partially treated water from a flocculation basin, and filtered water. Cyst and oocyst recovery efficiencies decreased with increasing water turbidity regardless of the method used. Recoveries of seeded Giardia cysts exceeded those of Cryptosporidium oocysts in all types of water sampled.

This Project Summary was developed by EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at the back).

Introduction

Problem Statement and Study Objectives

The Surface Water Treatment Rule requires all public water system treating surface water to effectively remove enteric viruses and Giardia cysts. The removal of microbial contaminants by filtration is being re-evaluated by the U.S. Environmental Protection Agency in conjunction with

the publication of the proposed Interim Enhanced Surface Water Treatment Rule. While the removal requirements for *Giardia* may be increased depending on cyst concentration in raw water, additional, more stringent regulations may be developed to control *Cryptosporidium* in response to health concerns surrounding this pathogen. As new rules are being developed, allowable filtration credits should be revisited and possibly revised. Also, as the analytical methods for detection of *Giardia* and *Cryptosporidium* cysts in water are being improved and new methods developed, surrogate water quality parameters should be established to allow for an accurate, economical, and practical evaluation of cyst removal effectiveness through treatment.

The project objectives were designed to address some of the questions associated with the development of the new regulations. The specific tasks were to examine the most critical relationships in removal of *Giardia* and *Cryptosporidium* by comparing the effectiveness of *Giardia* and *Cryptosporidium* removal through conventional treatment with that resulting from direct filtration, the effectiveness of *Giardia* removal with *Cryptosporidium* removal, and the effectiveness of *Giardia* and *Cryptosporidium* removals with the removals of turbidity, cyst-size particles, and heterotrophic bacteria.

To enable accurate evaluation of *Giardia* and *Cryptosporidium* removal efficiency in water treatment processes, a reliable method for measuring the concentration of these pathogens in water must be used.

Therefore, another objective of this project was to select an analytical method capable of measuring the concentration of *Giardia* cysts and *Cryptosporidium* oocysts that would be accurate, reliable, flexible, and verifiable, and could be applied to measuring the cyst/oocyst removal performance of water treatment processes.

Procedure

Evaluation of Analytical Methods

Two methods for finding *Giardia* cysts and *Cryptosporidium* oocysts in water were compared. Both methods follow flotation steps and immunofluorescence staining. These methods were 1) The American Society for Testing and Materials (ASTM) method and 2) another immunofluorescence antibody (IFA) method, referred to as the alternate method, and applied principally by Ongerth and Stibbs. The objective was to evaluate the two IFA methods

using three factors as criteria for comparison. First, the applicability to cyst seeding experiments in full- or pilot-scale water treatment plant was evaluated. Second, the applicability of the methods to cyst detection in environmental water samples of varying water quality was assessed. The third criterion was the economics associated with the two methods. The superior method was then used in the cyst seeding experiments in the pilot- and in the full-scale treatment plant.

The ASTM method involves sampling 100 L or more of water through a 1.0 μm porosity polypropylene yarn cartridge filter, extracting the particulates from the cartridge filter, and concentrating the extracted particulates by centrifugation. The concentrated particulates are then processed to selectively concentrate cysts and oocysts by flotation in 50 mL tubes on a Percoll/sucrose gradient. The particulates recovered at the interface of the Percoll/sucrose are stained with fluorescent-tagged antibodies on 25 mm diameter, 0.2 μm pore size cellulose acetate filters. After mounting on slides, the membrane filters are scanned using a UV epifluorescent microscope for objects of the right size, shape, and fluorescence characteristic as *Giardia* cysts and *Cryptosporidium* oocysts. On finding such objects the microscope optics are switched to phase contrast to look for internal characteristics of the organisms.

The alternate method involves filtration of the water sample through either a 293 or 142 mm diameter, 2.0 μm pore-size polycarbonate membrane filter; recovery of particles from the filter by rinsing and scraping them from the surface; and concentration of the particulates by centrifugation. The cysts and oocysts are then selectively concentrated from other particulates by flotation in 15 mL tubes on a two-step Percoll/Percoll gradient, followed by IFA staining on 13 mm diameter, 2.0 μm pore-size polycarbonate membrane filters. After mounting on slides, the membrane filters are scanned using an UV epifluorescent microscope for objects of the right size, shape, and fluorescence as *Giardia* cysts and *Cryptosporidium* oocysts. Confirmation of internal structures is not performed in this method.

Cyst Seeding and Sampling Procedures

Monitoring of raw and filtered water quality was conducted throughout the seeding trials. In addition to monitoring the major water quality parameters, particle counting in four size

ranges (2-4 μm , 4-7 μm , 7-14 μm , and 14-25 μm), was performed during the seeding trials. Raw water sources were sampled and analyzed for background count of *Giardia* and *Cryptosporidium*, naturally occurring in the two watersheds.

Inactivated, formalin-fixed *Giardia lamblia* cysts and *Cryptosporidium parvum* oocysts were used in seeding experiments in a pilot- and a full-scale treatment plant. A total of 20 trials were conducted in the pilot plant, and 8 trials in the full-scale plant, alternating between conventional treatment and direct filtration.

The first site for testing was a pilot plant residing at the 180 MGD Jordan Valley Water Treatment Plant in Bluffdale, UT. The pilot plant simulated the actual, conventional treatment plant, treating Provo River water downstream from Deer Creek Reservoir. Water flow rate was maintained at 0.5 gpm. Alum was used as a coagulant, at dosages established through jar testing. After each seeding trial using the conventional treatment train, the water was re-routed through the direct filtration train for seeding trials the following day. Alternating between the conventional treatment and direct filtration allowed for a comparison of treatment effectiveness of the water of comparable quality.

The second site was a 900 gpm Huntington Water Treatment Plant, situated near Price, UT. The plant was operated at 600 gpm for cyst seeding experiments. Polyaluminum chloride was used as a coagulant. The Huntington Plant was operated by conventional treatment during the first four seeding trials. After converting the plant to direct filtration mode, another four seeding trials were performed.

Detection of *Giardia* and *Cryptosporidium* Cysts

The alternate IFA method for sampling processing, and detection of *Giardia* and *Cryptosporidium* cysts was chosen for the seeding trials, based on results of the method comparison. Samples were collected by membrane filtration through 2.0 μm porosity, 293 mm diameter polycarbonate membrane filters, processed on Percoll/Percoll step gradient in 15 mL centrifuge tubes, stained on 2.0 μm porosity, 13 mm diameter polycarbonate membrane filters, and enumerated under an epifluorescent microscope.

In calculations of cyst removal through treatment, a direct ratio of the difference between the cysts seeded and the cysts detected was calculated for each run in the pilot plant. Two cyst removal rates were determined based on two different

initial cyst concentrations: concentration in the seeding solution prior to being pumped into the raw influent, and concentration in the seeded influent already mixed with the raw influent. The cyst removal rates, achieved in the full-scale plant, were also calculated as relative differences between the influent and effluent concentrations, but the influent concentrations were adjusted for dilution of cysts in respective basins.

Three conservative assumptions were made for data interpretation in calculations of the removal rates, both in the pilot- and full-scale plant. First, the removals based on the cyst concentrations found in the seeded influent were used in data analysis. Otherwise, the higher cyst concentrations found in the seeding solutions would result in higher removal rates reported. Secondly, cyst removal rates were calculated only for trials in which cysts were detected in both influent and effluent samples. Otherwise, calculations of removals during trials when cysts were not detected in the effluent would be based on very low detection limits, and therefore would result in higher removal rates. Finally, no adjustments were made for the differences in cyst recovery efficiencies in turbid raw influent samples versus clean filtered effluent samples. Adjusting for low recovery rates in influent samples would also result in higher removal rates being calculated.

Results and Discussion

Evaluation of Two IFA Methods for Detection of *Giardia* and *Cryptosporidium*

The effectiveness of cyst recovery from spiked water samples was impacted primarily by the number of analytical steps involved in the cyst detection. Both IFA methods were characterized by low recovery efficiency, when seeded raw water samples were filtered, then concentrated, transferred to gradients, stained, and enumerated. Higher recovery rates were observed in detecting *Giardia* cysts when the alternate method was employed (Figure 1). In spiked raw water samples, an average 12% of the seeded *Giardia* cysts were detected by the ASTM method, while the alternate method was characterized by an average 49% *Giardia* cysts recovery efficiency. Recovery rates for *Cryptosporidium* oocysts in spiked raw water averaged 8% detected by the ASTM method and 9% detected by the alternate IFA method. The recovery rates in filtered water were 14% and 52% for *Giardia* and 12% and 12% for *Cryptosporidium*, using the ASTM, and the alternate method, respectively. In flocculated water samples, an average 22% of *Giardia* cysts were detected using the ASTM method and 40% using the alternate method. The recover-

ies of *Cryptosporidium* in flocculated water were 7% with the ASTM method and 1% with the alternate method.

Losses were demonstrated to occur due to incomplete yarn cartridge filtration. In sampling raw water, 5% *Giardia* cysts and 6% *Cryptosporidium* oocysts were captured from the yarn cartridge filtrate by passing it through a 293 mm diameter 2.0 μ m pore size Nuclepore membrane filter. An average 7% of *Giardia* and 8% of *Cryptosporidium* were recovered from membrane filters after cartridge filtration.

The sampling step resulted in a high loss of seeded *Giardia* cysts and *Cryptosporidium* oocysts. When the sampling step was eliminated and cysts were seeded directly onto flotation gradients, the resulting recovery rates increased dramatically (Figure 2). An average 53% of *Giardia* cysts and 27% of *Cryptosporidium* oocysts was detected from seeded Percoll/sucrose gradients used in the ASTM method. The alternate method employing Percoll/Percoll flotation, yielded recoveries of 82% for seeded *Giardia* cysts and 69% for *Cryptosporidium* oocysts.

The highest cyst recovery rates were reported when both sampling and flotation steps were avoided and spiked with *Giardia* cysts and *Cryptosporidium* oocysts samples were stained directly onto the membrane filters used for IFA assay. The ASTM method resulted in recoveries of 72% and 56% for *Giardia* cysts and *Crypto-*

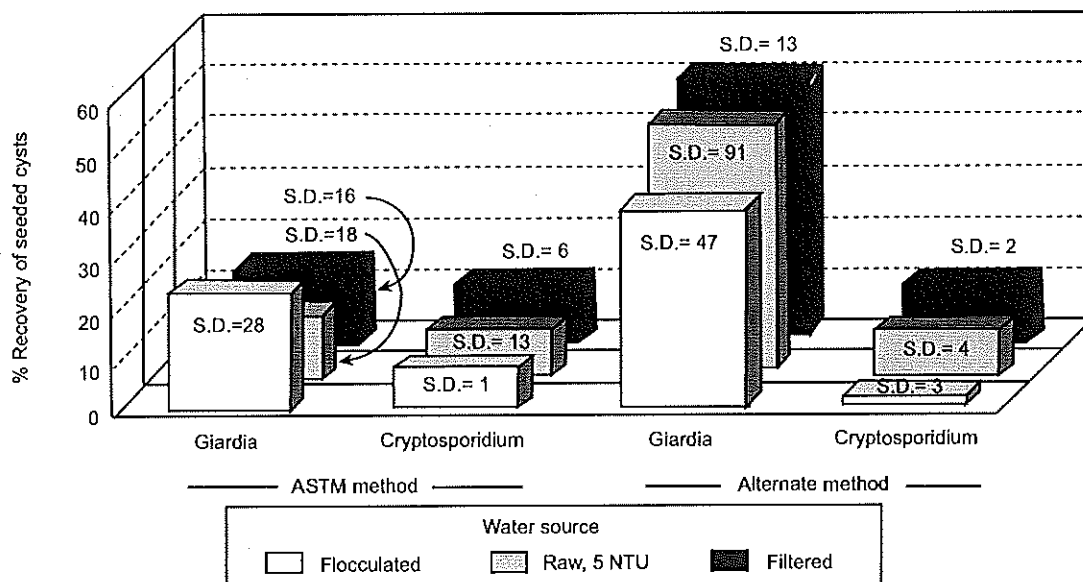


Figure 1. Water quality vs. recovery of cysts seeded into water.

sporidium oocysts, respectively. The alternate method was characterized by an average recovery of 86% for *Giardia* cysts and 78% for *Cryptosporidium* oocysts.

Testing of cyst recovery efficiencies from raw, flocculated, and filtered water indicated that any increase in water turbidity, whether due to presence of algae or to that of chemical floc, resulted in a significant decrease in parasite recoveries. The results also indicate both methods were more effective in detecting seeded *Giardia* cysts than *Cryptosporidium* oocysts.

The results of testing the processing and detection methods indicated that recoveries of cysts were substantially and consistently higher with the alternate method, employing Percoll/Percoll step gradient combined with IFA on 13 mm polycarbonate filters, than with the ASTM method, in all three types of water. Consequently, the alternate method was selected as the method of choice for seeding experiments. Added support for this choice was provided by a comparison of the qualitative advantages and disadvantages of the two methods. In summary, the main advantage of the ASTM method was its ability to confirm presumptive cysts and oocysts. The most serious disadvantages of this method were its relatively high cost and the amount of time required to complete it. The alternate method, on the other hand, was found to be less expensive and required less time to complete than the ASTM method. Attractive

features of the membrane filter sampling method include relatively small sample volumes, flexibility, and compatibility with frequent seeded controls. The major limitation of the alternate method was its lack of a confirmation step.

Experience with detecting *Giardia* cysts and *Cryptosporidium* oocysts in the waters tested during this study and the results generated during this part of the study, indicate that the alternate method be recommended to evaluate water treatment processes that use high concentrations of seeded parasites in which algae, occurring in concentrations much lower than the seeded parasites, are not of concern. The alternate method can be considered for analysis of environmental samples, particularly for low-turbidity waters. When high water turbidity requires higher-volume samples to be collected and examined, and when cross-reacting algae should be differentiated from the organisms of interest, the ASTM method should be used with environmental samples.

The results of this stage of the study have indicated *Giardia* cysts and especially, *Cryptosporidium* oocysts are lost during the gradient flotation steps of both methods. Therefore, it is recommended that the flotation step should be avoided, whenever possible when processing treated (filtered) water samples.

A hybrid method, combining the most efficient steps from the two methods, should be investigated. Such a hybrid

method should include sampling by membrane filtration only for low-turbidity waters. High-turbidity waters should be sampled by the ASTM cartridge sampling method. Since the Percoll/Percoll step gradient in 15 mL tubes is more economical and had higher cyst recovery than the Percoll/sucrose gradient, it should be used. Staining on cellulose acetate membranes, as opposed to polycarbonate membranes, allows the demonstration of the internal morphological characteristics of the organisms. Consequently, staining on cellulose acetate membranes should be incorporated into a hybrid method. Elvanol mounting medium should not be incorporated into a hybrid method. As a water-based medium, it is not compatible with the dehydrated cellulose acetate membrane and does not allow the membrane to be cleared so that the cyst's internal structure can be visualized by contrast microscopy.

Removal of *Giardia* and *Cryptosporidium* through Conventional Water Treatment and Direct Filtration

A general observation about removal of seeded *Giardia* and *Cryptosporidium* was made that was valid in both pilot- and full-scale plant throughout the entire seeding studies. Consistent removal rates of *Giardia* and *Cryptosporidium* were achieved, when the treatment plant was producing water of consistently low turbidity (0.1-0.2

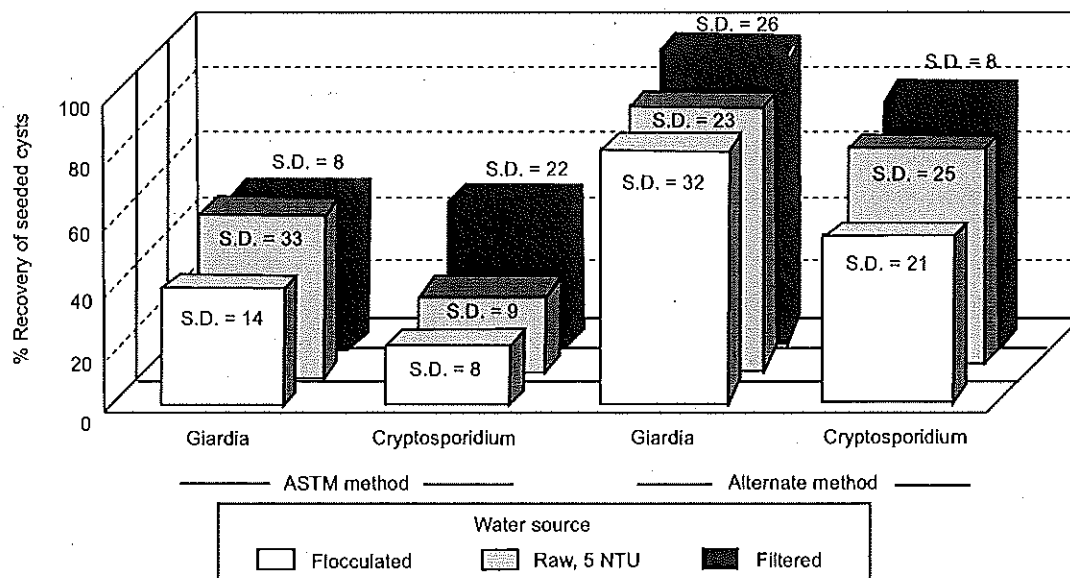


Figure 2. Water quality vs. recovery of cysts seeded into flotation gradients.

NTU). As soon as the plant's performance changed, and resulting filtered water turbidity fluctuated, a high variability in cyst concentrations was detected in collected samples.

Removal of *Cryptosporidium* was compared with removal of *Giardia* by both methods of treatment, conventional and direct filtration, at both the full-scale plant, and the pilot plant. Trials at the full-scale plant were impacted by the change in seasonal water temperature and algal content. Because of the need for a construction to bypass the sedimentation basin, the first four trials by conventional treatment were conducted from June through September, while the four trials using direct filtration were conducted in November and December. Greater flexibility of

the pilot plant allowed trials by both treatment methods to be conducted within one day of each other and enhanced not only the comparison between removal of *Cryptosporidium* with *Giardia* removal, but also the comparison between conventional treatment and direct filtration, as well as the comparison of cyst removal with removal of other water quality indicators.

Removal of Seeded *Giardia* and *Cryptosporidium* During Pilot-Scale Seeding Trials

Table 1 summarizes cyst removal rates calculated based on cyst concentration in seeded influent (after mixing the cysts with the incoming raw water). These removal rates, based on seeded influent concen-

tration, were consistently lower than the removal rates based on cyst concentrations in seeding solution (indicating 99.99% or 4 log removal for both *Giardia* and *Cryptosporidium* regardless of the treatment mode). Calculations of cyst removals, observed during seeding experiments, can also be highly impacted by measurements of cyst concentration in filter effluent samples. When cysts were not detected in filter effluent samples, their concentration could be estimated based on analytical detection limits, determined for each sample batch. Such estimates lead to underestimation of cyst concentration in finished water samples and in turn, result in overestimation of calculated cyst removal rates.

Removal of Seeded *Giardia* and *Cryptosporidium* During Full-Scale Seeding Trials

Table 2 presents a summary of results and removal rates calculated only from the trials where cysts were detected both in influent and effluent in the full-scale plant. Similar to the pilot-scale experiments, the removal of *Giardia* and *Cryptosporidium* can be overestimated when calculations are based on estimated effluent concentrations. Removal rates based on cyst concentrations detected and enumerated both in influent and effluent can be considered conservative.

Several factors impacted the results of the full-scale seeding trials, which made the comparison between conventional treatment and direct filtration more dependent on uncontrolled variables. Changes in raw water quality, observed from the time the plant was in operation by the conventional mode, compared to raw water quality during operation by the direct filtration mode, influenced removal rates more than the mode of treatment. The water was treated in the conventional plant during summer, when treatability was more difficult, while direct filtration was used in late fall, when the water was easier to treat. The presence of prolific algal blooms in samples collected during the first four trials, and the lack of algal content in samples from the last four trials, was another variable making the comparison of removal data problematic.

The results of the pilot-plant experiments indicate that *Giardia* cysts were removed more effectively than were *Cryptosporidium* oocysts. This observation was valid regardless of the treatment mode. The difference between log removals of *Giardia* and *Cryptosporidium* ranged from 0.1

Table 1. Removal of *Giardia* and *Cryptosporidium* Through Conventional Treatment and Direct Filtration at Jordan Valley

Trial No.	Date	Giardia removal		Cryptosporidium removal	
		Percent removal	Log removal	Percent removal	Log removal
Conventional treatment					
1-C	4/27/93	ND	ND	99.65	2.81
2-C	5/11/93	99.16	2.20	98.66	1.94
3-C	5/25/93	ND	ND	99.87	2.94
4-C	6/8/93	99.98	3.90	99.95	3.98
5-C	6/22/93	ND	ND	ND	ND
6-C	7/6/93	99.95	3.69	99.88	2.94
7-C	7/20/93	99.95	3.69	99.45	2.64
8-C	8/4/93	ND	ND	ND	ND
9-C	8/17/93	99.91	3.03	99.69	2.84
10-C	8/31/93	99.98	3.90	99.96	3.78
Average log removal			3.40	2.98	
Standard deviation			0.67	0.64	
Direct Filtration					
1-D	4/29/93	ND	ND	99.95	3.60
2-D	5/13/93	ND	ND	ND	ND
3-D	5/28/93	99.78	2.90	92.06	1.31
4-D	6/15/93	ND	ND	99.96	3.78
5-D	6/23/93	ND	ND	ND	ND
6-D	7/8/93	ND	ND	ND	ND
7-D	7/22/93	99.90	3.00	99.80	2.90
8-D	8/5/93	ND	ND	ND	ND
9-D	8/19/93	ND	ND	99.92	3.31
10-D	9/2/93	99.99	4.00	99.84	2.93
Average log removal			3.30	2.97	
Standard deviation			0.77	0.89	

ND indicates that cysts were not detected in filter effluent.

Table 2. Removal of *Giardia* and *Cryptosporidium* Through Conventional Treatment and Direct Filtration at Huntington

Trial No.	Date	Giardia removal		Cryptosporidium removal	
		Percent removal	Log removal	Percent removal	Log removal
Conventional treatment					
1-C	6/11/92	99.95	3.7	99.60	2.78
2-C	7/7/92	ND	ND	99.05	2.07
3-C	8/5/92	ND	ND	97.87	1.89
4-C	10/6/92	99.66	2.82	ND	ND
Average log removal			3.26	2.25	
Standard deviation			0.67	0.47	
Direct Filtration					
1-D	11/10/92	99.97	3.87	99.75	2.88
2-D	11/20/92	ND	ND	99.82	2.92
3-D	12/8/92	99.97	3.87	99.37	2.57
4-D	12/22/92	ND	ND	ND	ND
Average log removal			3.87	2.79	
Standard deviation			0.00	0.19	

ND indicates that cysts were not detected in filter effluent.

to 1.1 log and averaged 0.3 log, as calculated across all seeding runs. The difference between cysts and oocysts removals were even more pronounced in the full-scale plant than those observed in the pilot plant.

Among the seeding trials, where the cysts were detected both in influent and effluent, the following average removals were calculated for the pilot plant runs:

- average removal of *Giardia* through conventional treatment: 3.40 log; S.D. = 0.67
- average removal of *Cryptosporidium* in conventional treatment: 2.98 log; S.D. = 0.64
- average removal of *Giardia* through direct filtration: 3.30 log; S.D. = 0.77
- average removal of *Cryptosporidium* through direct filtration: 2.97 log; S.D. = 0.89

Similarly, the following average removals were reported from the full-scale seeding trials:

- average removal of *Giardia* through conventional treatment: 3.26 log; S.D. = 0.67

- average removal of *Cryptosporidium* in conventional treatment: 2.25 log; S.D. = 0.47
- average removal of *Giardia* through direct filtration: 3.87 log
- average removal of *Cryptosporidium* through direct filtration: 2.79 log; S.D. = 0.19

Taking into consideration that the reported removal rates of *Giardia* and *Cryptosporidium* were calculated very conservatively, the values presented above can be interpreted as expected removals, resulting from a consistent performance and steady operation of the treatment plants.

Surrogate Parameters for Evaluation of *Giardia* and *Cryptosporidium* Removal

Both surface water sources treated in the treatment plants were characterized by a high quality water, with low levels of inorganic, organic, and microbial contamination. Both sources, however, were tested positive for both *Giardia* and *Cryptosporidium* cysts, confirming previous hypothesis and observations

about these pathogens being ubiquitous in surface waters.

Both effectiveness and consistency of removal of seeded *Giardia* and *Cryptosporidium* cysts depended on the effectiveness and consistency of the removal of turbidity. When raw water turbidity was high and it could not be removed by direct filtration, resulting removals of seeded cysts were low and inconsistent. On the other hand, if treatment by direct filtration consistently produced low turbidity effluent, resulting cyst removals were comparable to those achieved from conventional treatment.

The results of seeded cyst removals, generated throughout the study regardless of treatment mode, were compared with the respective results from particle counting, turbidity measurements, and heterotrophic bacteria counts. Correlation between *Giardia* and *Cryptosporidium* cyst removal and removal of these potential surrogates are presented in Figures 3 through 5.

The analysis of correlation between cyst removal and particle removal was performed separately for *Giardia* cyst and cyst-size particles, and for *Cryptosporidium* oocysts and oocyst-size particles (Figure 3). High correlation was reported between both sets of data. A correlation coefficient of 0.82 was calculated ($p < 0.1$) for the relationship between *Giardia* cyst removal and removal of particles ranging between 7 μm and 11 μm . Similarly, a correlation coefficient for the relationship between *Cryptosporidium* oocyst removal and removal of 4 μm to 7 μm particles was 0.79.

The results indicated that particle counting could serve as a reliable indicator of cysts and oocysts removal. Particle counters, even though capital intensive, are cheap to operate and are more sensitive than the assays used in *Giardia* and *Cryptosporidium* analyses.

Much lower correlation was established between removals of *Giardia* and *Cryptosporidium* and removal of turbidity (correlation coefficients of 0.64 and 0.55, respectively). As presented in Figure 4, log removal of turbidity can be used as an indicator of cyst and oocyst removals, but with lower accuracy than particle counting. The most pronounced differences between removal of *Giardia* and *Cryptosporidium* and the expected removals of turbidity were observed, when very high cysts removals (4-log) were reported.

Heterotrophic plate count was not shown to be a surrogate in evaluation of cyst removals (Figure 5). No correlation was found between log removal of seeded cyst and log removal of HPC. Despite the fact that the filters in both pilot- and full-scale plants were backwashed with chlorinated water, a growth of heterotrophic bacteria was reported in the filters during the seeding experiment and plant run.

Plant performance evaluation using particle counting and turbidity measurement can be an effective tool in evaluating expected removals of Giardia and Crypto-

sporidium. The search for a biological surrogate for Giardia and Cryptosporidium should continue and result in identification of a parameter that defines both occurrence and removal of Giardia and Cryptosporidium. The results of the study coincide with previously reported relationships between cysts and particulates. Effective removal of Giardia and Cryptosporidium from the water would, however, require treatment plants to consistently produce very low turbidity (0.1-0.2 NTU)—much lower than the levels currently required.

Conclusions and Recommendations

Analytical Procedures for Detection of Cysts in Water

Based on the results generated during the evaluation of the effectiveness of the IFA methods in enumeration of Giardia cysts and Cryptosporidium oocysts, it was concluded that the alternate IFA method was more suitable for meeting the project objectives. This method employed sam-

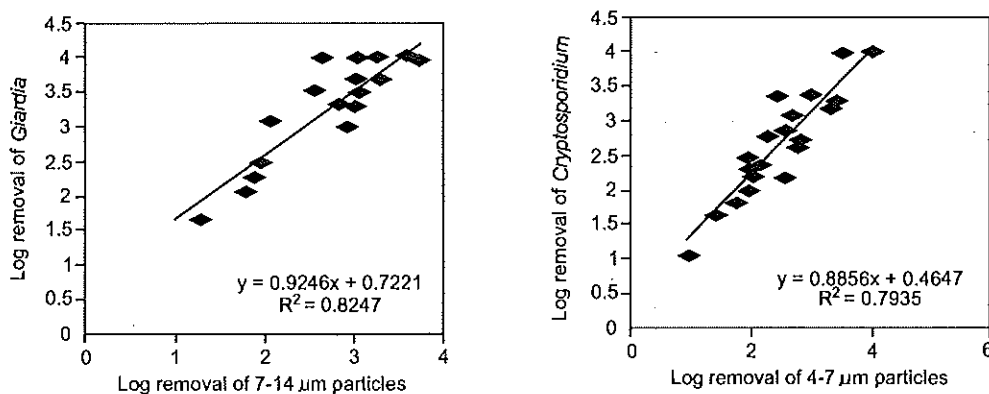


Figure 3. Relationship between removal of cysts and particles.

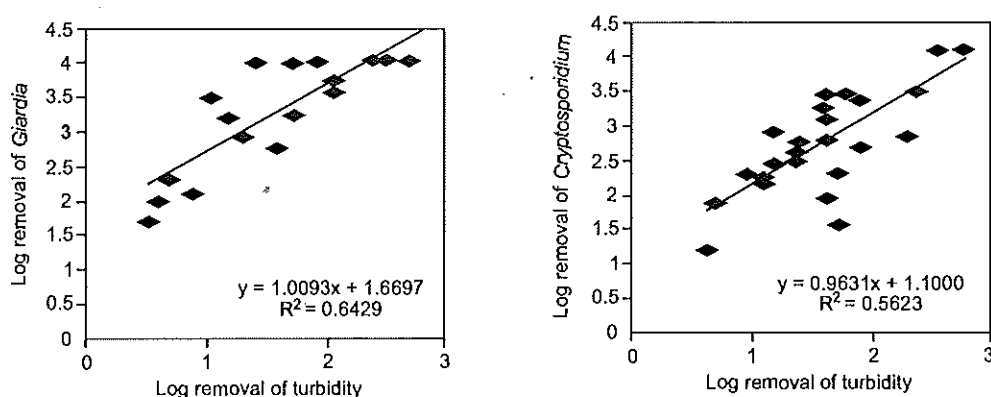


Figure 4. Relationship between removal of cysts and turbidity.

pling through a 2.0 μm polycarbonate membrane filter, centrifugation in 15 mL tubes, flotation on a two-step Percoll/Percoll gradient, IFA staining on 13 mm diameter, 2.0 μm pore-size polycarbonate membrane filters, and enumeration under an UV epifluorescent microscope. The following conclusions were formed:

- The membrane filtration for low turbidity samples outperformed the polypropylene yarn sampling method in terms of recovery efficiency of seeded organisms.
- The Percoll/Percoll step gradient had better recoveries of seeded organisms than the Percoll/sucrose gradient. Since 15 mL tubes were used in place of 50 mL tubes, the procedure of the step gradient flotation was more economical.
- The alternate method has proven more effective in recovering seeded cysts, and therefore, was considered more suitable in parasite seeding experiments, where evaluation of water treatment process efficiencies was conducted using high concentrations of seeded cysts.

The ASTM method, employing staining on cellulose acetate membranes, had the advantage since the gradients could be cleared and the internal structure of the

organisms could be visualized under the phase- or differential-interference contrast microscopy. The ASTM method, due to its ability to confirm presumptive cysts and distinguish between algal cells and the cysts by contrast microscopy, was found very applicable in testing of the environmental water samples.

Based on the above results, it is recommended that the alternate method should be used in evaluating water treatment process efficiencies using high concentrations of seeded parasites. The ASTM method is recommended in analyses of environmental samples where the confirmation step is essential.

A hybrid method, combining the most efficient steps from the two methods, should be investigated. The membrane filtration for low turbidity samples, which far outperformed the polypropylene yarn sampling method in terms of recovery efficiency of seeded organisms, shows promise in sample collection. Similarly, Percoll/Percoll step gradient, used in the alternate method, had better recoveries of seeded organisms than the Percoll/sucrose gradient. Since 15 mL tubes were used in place of 50 mL tubes used in the ASTM method, the procedure of the step gradient flotation was more economical. On the other hand, staining on cellulose acetate membranes used in the ASTM method, had the advantage since the gradients could be cleared and the internal

structure of the organisms could be visualized under the phase- or differential- interference contrast microscopy.

The results of the testing of IFA method effectiveness have indicated that *Giardia* cysts and especially *Cryptosporidium* oocysts are lost during the gradient flotation steps of both methods. Recovery efficiencies increased dramatically in samples, did not contain much debris, and could be processed without the flotation steps and stained directly on membranes. Therefore, it is recommended that the flotation step should be avoided when processing treated (filtered) water samples whenever possible.

Removal of *Giardia* and *Cryptosporidium* through Conventional Treatment and Direct Filtration

The following conclusions were formed from the pilot- and full-scale study on *Giardia* and *Cryptosporidium* cysts removal through conventional treatment and direct filtration:

- In a properly operated treatment plant effectively removing turbidity to 0.1-0.2 NTU, either conventional treatment or direct filtration can result in a 3-log removal of *Giardia*.
- *Cryptosporidium* oocysts are more difficult to remove than *Giardia* cysts,

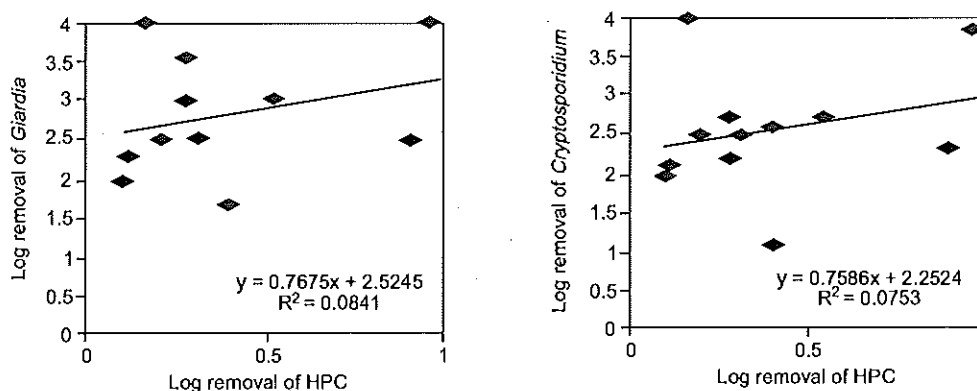


Figure 5. Relationship between removal of cysts and heterotrophic bacteria.

both in a conventional plant and through direct filtration (up to 1.0-log difference).

- Removals of cyst-size particles and removal of turbidity can be used as indicators of cyst removal effectiveness.

A general observation about removal of seeded *Giardia* and *Cryptosporidium* cysts was made that was valid in both pilot- and full-scale plant throughout the entire seeding studies. Both effectiveness and consistency of removal of seeded *Giardia* and *Cryptosporidium* cysts depended primarily on the effectiveness and consistency of the removal of turbidity. When treatment by direct filtration consistently produced low turbidity effluent (0.1-0.2 NTU), the resulting *Giardia* and *Cryptosporidium* cyst removals were consistent and comparable to those achieved from conventional treatment. As soon as the plant's performance changed, and resulting filtered water turbidity fluctuated, a high variability in cyst concentrations was detected in collected samples. When raw water turbidity was high, and it could not be removed by direct filtration, result-

ing removals of seeded cysts were low and inconsistent.

A high correlation coefficient was calculated for the relationship between *Giardia* cyst removal and removal of particles ranging between 7 μm and 14 μm , and similarly, for the relationship between *Cryptosporidium* oocyst removal and removal of particles of 4 μm to 7 μm in size. Much lower correlation was established between removals of *Giardia* and *Cryptosporidium* and removal of turbidity. Heterotrophic plate count was not shown to be a surrogate in evaluation of cyst removals, with no correlation found between log removal of seeded cyst and log removal of HPC.

A combination of particle counting and turbidity measurement was shown to be an effective tool in water treatment plant performance evaluation in terms of predicting removals of *Giardia* and *Cryptosporidium*. Effective removal of *Giardia* and *Cryptosporidium* from the water would, however, require treatment plants to consistently produce very low turbidity (0.1-0.2 NTU)—much lower than the levels currently required. The results of the study indicate that the removal of particulates, measured through particle counting and turbidity monitoring, should be a critical

factor used in the evaluation of plant performance in *Giardia* and *Cryptosporidium* removal. Continuous and consistent removal of particulates should be monitored by continuous particle counting and turbidity monitoring.

The results of the project imply that the credits given for *Giardia* cyst removal in direct filtration plants, may be similar to credits obtained in conventional treatment plants, and also may be higher than the credits applicable under the current regulations. Since *Cryptosporidium* is more difficult to remove than *Giardia*, and it is also more resistant to disinfection than *Giardia*, new requirements need to be developed to control this pathogen. Finally, due to the need of further defining the credits given to treatment plants for physical removal of *Giardia* and *Cryptosporidium*, a study on evaluation of removal of these pathogens through pre-sedimentation should be conducted.

The full report was submitted in fulfillment of CR818895-010 by the Utah Department of Environmental Quality under the sponsorship of the U.S. Environmental Protection Agency.

Eva C. Nieminski is with the Utah Department of Environmental Quality, Salt Lake City, UT 84114.

Kim Fox is the EPA Project Officer (see below).

The complete report, entitled "Removal of Cryptosporidium and Giardia through Conventional Water Treatment and Direct Filtration," (Order No. PB97-162507; Cost: \$35.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

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LEGISLATIVE PROTECTION FOR FLOOD MITIGATION ACTIVITIES

Seqwater's flood mitigation manuals for Wivenhoe/Somerset Dams and North Pine Dam have been approved by the Chief Executive under the *Water (Safety & Reliability) Act*.

That legislation provides the following protection to the dam owner/operator in undertaking flood operations –

374 Protection from liability for complying with flood mitigation manual

(2) An owner of a dam who observes the operational procedures in a flood mitigation manual, approved by the chief executive, for the dam does not incur civil liability for an act done, or omission made, honestly and without negligence in observing the procedures.

(3) If subsection (1) or (2) prevents civil liability attaching to a person, the liability attaches instead to the State.

(4) In this section—

owner, of a dam, includes—

- (a) the operator of the dam; or
- (b) a director of the owner or operator of the dam; or
- (c) an employee of the owner or operator of the dam; or
- (d) an agent of the owner or operator of the dam.

Toni Lake

From: Peter Borrows
Sent: Sunday, 16 January 2011 4:28 PM
To: 'bob.reilly'; Rob Drury; Duty Sec; 'john.bradley';
'barry.dennier'; 'daniel.spiller';
Cc: 'michael.lyons'; Mike Foster; 'Elaina Smouna';
'peter.allen';
Subject: Cabinet in confidence - Ministerial brief outline
Attachments: Ministerial brief - contents outline.docx; Ministerial Briefing Note January 17 2011 Final Draft for distribution.docx; Jan 2011 Flood Event_Ver 1_draft for distribution.docx

Please see attached draft with attachment.

In relation to the draft contents outline sent yesterday, the following is a cross reference FYI.

The attached Ministerial Briefing Note addresses the questions contained in the Ministerial Information Request as follows:

- 1) Design of Dam – Storages/Spillway upgrade

Refer Section 1

- 2) "The Flood Event" – Q&A

- a. Chronology - High level time step of events and significant decision making/changes – more detailed time step information for Tuesday afternoon (i.e. what was the BOM forecast at the time, narrow peak etc.)

Refer Section 2.5

- b. How does Wivenhoe Dam work as a flood mitigator?

Refer Sections 2.1, 2.3 and 3.1

- c. What are the factors being balanced when making decisions about the amount of dam releases? To what extent does information from the Bureau of Meteorology/rain gauges influence decisions? How reliable is this information?

Refer Sections 3.1 and 3.2

- d. Statistics on how much did Wivenhoe Dam knock off the flood peak.

Refer Section 2.1

- e. What would have happened if Wivenhoe Dam had not been built and we only had Somerset Dam? What damage would have been caused compared to what has currently been experienced (damage statistics)?

Refer Sections 2.1 and 2.2

- f. If we have undertaken pre-emptive dam releases to bring Wivenhoe Dam's full supply level down to lower than what we had maintained (i.e. 60%), what would have been the river height for the period that this flood event occurred?

Refer Section 2.4

- g. If pre-emptive dam releases would not have made a difference, why? (i.e. why did we not release earlier?)

Refer Section 2.4

- h. Why was Wivenhoe Dam only allowed to rise up to 191% and not 230%?

Refer Section 2.2

- i. What is the fuse plug and why did it need to be maintained?

Refer Section 2.3

- j. What damage or town isolation occurred during the Wivenhoe Dam releases that occurred since October 2010?

Refer Section 2.4

- k. Did Seqwater have time to reduce the dam level between the 5 events? If so, would it have made a difference to this flood event?

Refer Section 2.4

3) The Flood Mitigation Manual

Refer Section 3.1

- a. Describe the decision making framework - Four strategies

Refer Section 3.2

- b. How is the Manual designed to work?

Refer Section 3.2

- c. History of Flood Mitigation Manual updates and peer review – who was on the panels, studies that fed into previous versions of the Manual and who was involved in these studies?

Refer Section 3.1

- 4) Regulatory context - *Water Supply (Safety and Reliability) Act 2008* (Information provider: Peter Allen - DERM)

Refer Section 4

Regards, Peter.

Peter Borrows

Chief Executive Officer

Queensland Bulk Water Supply Authority *trading as* Seqwater



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Website | www.seqwater.com.au



From: Elaina Smouha [REDACTED]
Sent: Saturday, 15 January 2011 5:03 PM
To: Mike Foster; peter.allen [REDACTED] bob.reilly [REDACTED] Peter Borrows; Rob Drury; Duty Seq
Cc: john.bradley [REDACTED] barry.dennier [REDACTED] daniel.spiller [REDACTED]
michael.lyon [REDACTED] Elaina Smouha
Subject: Cabinet in confidence - Ministerial brief outline

Dear All

To assist, attached is a Ministerial brief outline as per our recent teleconference, for Monday's Emergency Cabinet meeting. It also records those who will be providing information for the Background and Flood Mitigation Manual report process.

As discussed, the brief needs to be provided to Minister Robertson tomorrow (Sunday, 16 January 2011).

Regards

Elaina

Elaina Smouha

Director, Governance and Regulatory Compliance

SEQ Water Grid Manager

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Ministerial brief outline

What is the objective?

- a) Ensuring public transparency
- b) To answer the State's questions on the performance of Wivenhoe Dam operations
- c) Preparation for a public inquiry
- d) Normal and logical course of conduct after the occurrence of a major flood event – Review requirement under the Flood Mitigation Manual

Background (focus on Brisbane River flooding issues)

- 1) Design of Dam – Storages/Spillway upgrade (*Information provider: Seqwater and Peter Allen - DERM*) [1/3 to ½ a page]
- 2) "The Flood Event" – Q&A (*Information provider: Seqwater*) [2 ½ pages]
 - a. Chronology - High level time step of events and significant decision making/changes – more detailed time step information for Tuesday afternoon (i.e. what was the BOM forecast at the time, narrow peak etc.)
 - b. How does Wivenhoe Dam work as a flood mitigator?
 - c. What are the factors being balanced when making decisions about the amount of dam releases? To what extent does information from the Bureau of Meteorology/rain gauges influence decisions? How reliable is this information?
 - d. Statistics on how much did Wivenhoe Dam knock off the flood peak.
 - e. What would have happened if Wivenhoe Dam had not been built and we only had Somerset Dam? What damage would have been caused compared to what has currently been experienced (damage statistics)?
 - f. If we have undertaken pre-emptive dam releases to bring Wivenhoe Dam's full supply level down to lower than what we had maintained (i.e. 60%), what would have been the river height for the period that this flood event occurred?
 - g. If pre-emptive dam releases would not have made a difference, why? (i.e. why did we not release earlier?)
 - h. Why was Wivenhoe Dam only allowed to rise up to 191% and not 230%?
 - i. What is the fuse plug and why did it need to be maintained?
 - j. What damage or town isolation occurred during the Wivenhoe Dam releases that occurred since October 2010?
 - k. Did Seqwater have time to reduce the dam level between the 5 events? If so, would it have made a difference to this flood event?

- 3) The Flood Mitigation Manual (*Information Provider: Seqwater/DERM*) [½ to 1 page]
 - a. Describe the decision making framework - Four strategies
 - b. How is the Manual designed to work?
 - c. History of Flood Mitigation Manual updates and peer review – who was on the panels, studies that fed into previous versions of the Manual and who was involved in these studies?
 - d. **Attach** Minister Robertson's request for advice on pre-emptive release and our response (*Information provider: SEQ Water Grid Manager*)
- 4) Regulatory context - *Water Supply (Safety and Reliability) Act 2008* (*Information provider: Peter Allen - DERM*)
 - a. Flood Mitigation Manual approval
 - b. Formal reporting process under the Flood Mitigation Manual – **attach** report resulting from the February 1999 flood event
 - c. Decision making process under the Flood Mitigation Manual –
 - i. Who makes the flood release decisions under the Manual?
 - ii. who is informed/consulted?
 - iii. effect of the recent Flood Communication Protocol?
- 5) Brian Cooper Flood Mitigation Manual compliance review (*Responsible: SEQ Water Grid Manager*)

Seqwater report

(*Information provider: Seqwater, Peter Allen and Bob Reilly*)

Seqwater, in consultation with Peter Allen and Bob Reilly, to set out how Seqwater's Flood Mitigation Manual Report to the Chief Executive on the effectiveness of the operational procedures will be undertaken.

- **Attach** table of contents of the 1999 Flood Mitigation Manual report
- Reflect Brian Cooper's compliance review
- Peer review – establishment of an expert panel – who will be on it? Peter Allen and Bob Reilly may provide some input.
- Communication Protocol and incorporation into the Flood Mitigation Manual (revisit in the next fortnight?)

Timeframes on the development of the report – consider urgency due to anticipated further rainfall during this summer.

Ministerial Briefing Note
17 January 2010
Flood Event January 2011

1. BACKGROUND INFORMATION ON WIVENHOE DAM

2. WIVENHOE DAM FLOOD MITIGATION AND FLOOD OPERATIONS

- 2.1 What were the benefits provided by Wivenhoe Dam during the current event?
- 2.2 Why was Wivenhoe Dam only allowed to rise up to 191% and not 230%?
- 2.3 What is the role of the erodible fuse plug embankments?
- 2.4 Why weren't pre-emptive releases undertaken prior to the start of the flood event?
- 2.5 Is there a detailed record of the events associated with the current flood?

3. THE MANUAL OF OPERATIONAL PROCEDURES FOR FLOOD MITIGATION AT WIVENHOE DAM AND SOMERSET DAM

- 3.1 What is the Manual of Flood Mitigation and how was it developed?
- 3.2 What is contained in the Manual?

4. REGULATORY CONTEXT

5. COMPLIANCE WITH MANUAL

6. SEQWATER REPORT

1 BACKGROUND INFORMATION ON WIVENHOE DAM

Wivenhoe Dam was completed in 1984 and has two main functions;

- A 1,165,000 ML storage providing an urban water supply for Brisbane;
- Flood mitigation in the Brisbane River by providing a dedicated flood storage volume of 1,450,000 ML (this flood storage was increased in 2005 to 1,966,000 ML with the dam at the point of failure).

In accordance with the Queensland Regulatory program for dam spillway upgrades, a further upgrade of Wivenhoe Dam is scheduled to occur prior to 2035.

Wivenhoe Dam is in excellent condition with four Comprehensive Dam Safety reviews undertaken in the last 14 years, the latest in 2010.

2 WIVENHOE DAM FLOOD MITIGATION AND FLOOD OPERATIONS

2.1 What were the benefits provided by Wivenhoe Dam during the current event?

The following graphs demonstrate the significant benefits of Wivenhoe Dam in mitigating the current flood event, with reductions in flood peak of up to 2.5 metres in the City area and up to 5.5 metres in the Moggill area further upstream.

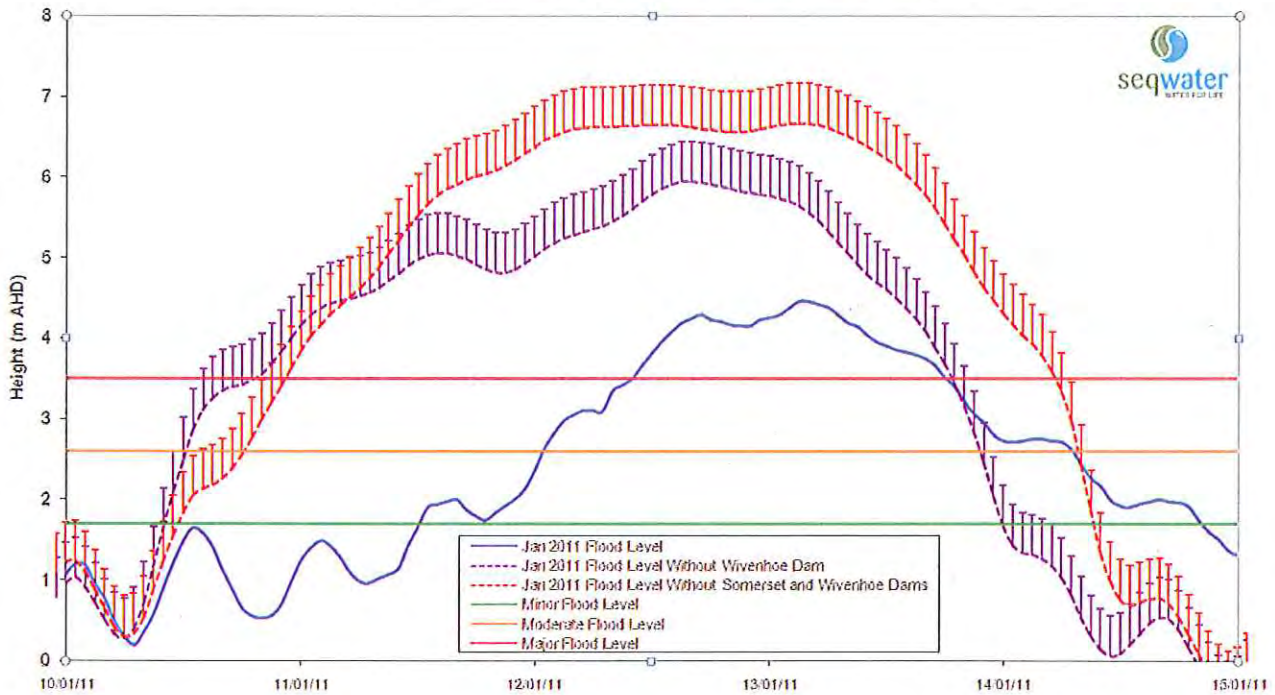
This equates to significant reduction in the potential for loss of life as well as saving in damages in the order of up to \$1.6 billion based on current damage curves. Up to 13,000 more properties would have been impacted by the event without the Dam. (Source: Flood Damage Tables provided to Seqwater by the Brisbane City Council).

The time at which flood levels remained elevated above major levels has also been reduced by up to 3 days by the dam. This has significant benefits to impact on the population of the city, property damage and the recovery operation.

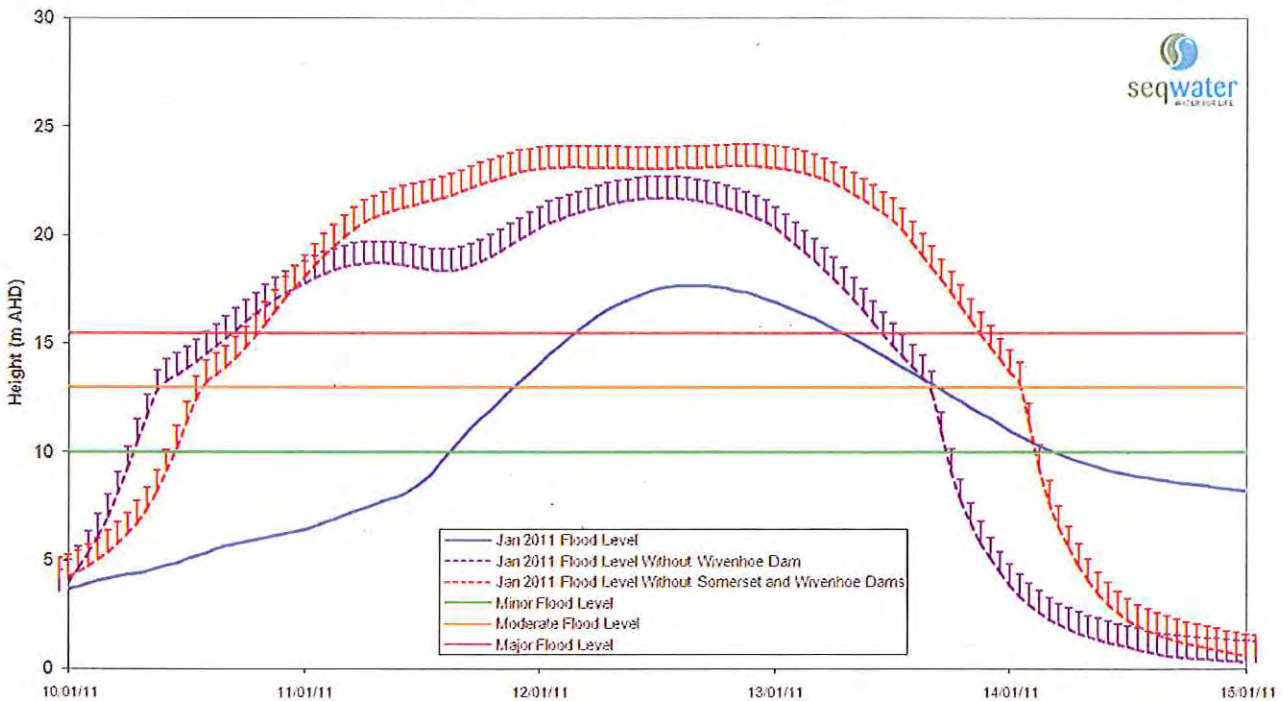
Depending on the nature of the event, the presence of Wivenhoe Dam could also potentially increase flood warning times to impacted areas. How these times may have been increased during the current event is presently difficult to quantify, but discussions will be held with BOM on this issue at a later date.

In addition, the strategy adopted to quickly close off releases once the peak in the dam had been reached and rain stopped falling certainly reduced the predicted flood peak by at least one metre in the lower Brisbane River area.

JANUARY 2011 BRISBANE FLOOD Assessment of Flood Levels at Brisbane City



JANUARY 2011 BRISBANE FLOOD Assessment of Flood Levels at Moggill



2.2 Why was Wivenhoe Dam only allowed to rise up to 191% and not 230%?

Wivenhoe Dam mitigates downstream flooding by storing incoming flood water during a rainfall event and releasing these waters at a reduced flow rate downstream to reduce flood impacts. The timing of the releases is also manipulated so that the aim is for outflows from the dams to impact on downstream areas only after the peak inflows from the downstream major tributaries have passed. However this aim cannot always be achieved in practice. This is because some large floods, such as the one currently being experienced, have the potential to overflow the dam's flood storage compartment. **Should this occur, the dam would fail and the resulting damage and loss of life would be at least 100 to 1000 times greater than that currently being experienced.**

Therefore the basis of all flood operation decision making is to ensure the dam never fails. This is the reason that the dam's flood storage compartment would never be intentionally fully filled as any additional inflows after this point would result in a dam failure. At any one time, there will always be uncertainty about what rain is going to occur. Hence, we cannot use all of the flood capacity as we would not be able to release sufficient water to cater for large inflows.

2.3 What is the role of the erodible fuse plug embankments?

Another factor that impacts on flood release decision making in large events are the levels at which the erodible fuse plugs are triggered. The fuse plugs act as a safety valve to rapidly increase dam outflows if the structural safety of the dam is in danger. Loss of one or more fuse plugs severely limits the ability of the dam to mitigate the effects of future flood events that may occur prior to the fuse plug or plugs being reinstated. Reinstatement of a fuse plug following an event would take a minimum of 4 to 6 months and would require an extended period of relatively dry weather.

2.4 Why weren't pre-emptive releases undertaken prior to the start of the flood event?

In the 25 days leading up to the current event, three flood events impacting on Wivenhoe Dam were experienced, with gate releases being made on all but five of those days. The total outflow from these events was around 700,000ML.

During these events, requests were received from Councils and residents impacted by bridge closures downstream of the dam to curtail releases as soon and as quickly as possible. Additionally the 2 January end date of the flood event prior to the current event meant that significant drain down of the dam prior to the onset of the current event that commenced on 6 January 2011, was not possible without major bridge inundation downstream of the dam and without exceeding minor flood levels in the lower Brisbane River.

Additionally, a flood event was also experienced in October 2010 that resulted in a release of 750,000ML from the dam. Accordingly drain down below the dam full supply level prior to the start of the first December event would not have been possible without significant bridge inundation and without exceeding minor flood levels (as defined by BOM and BCC) in the lower Brisbane River.

Regardless, significant drain down prior to the current event would have had little impact on the peak level in Wivenhoe Dam as shown in the table below. The reason for this is that this total event inflow volume of 2,600,000 ML is well in excess of the useable flood storage combined with the available water supply storages shown in the table.

The specific impact on the Lower Brisbane River of these reduced dam levels requires the use of a complex hydraulic model. The results of this modelling would still contain a degree of uncertainty as illustrated by the difficulties in estimating the final flood peak in Brisbane during the event. This is because the rapid closure of the gates after peak inflow was achieved resulted in significant water level reductions downstream and this is difficult to model accurately.

JANUARY 2011 FLOOD			
Starting Level		Peak Height	Capacity
%	m AHD	m AHD	%
100	67.0	74.97	191
95	66.5	74.93	191
90	65.8	74.88	190
75	64.0	74.63	187
50	60.0	74.11	180

It should be noted that the possible reductions shown above are based up a unique dual peaked flood hydrograph with a volume of about 2,600,000 ML which occurred during this event. A hydrograph with the same volume but a different distribution could result in a significantly lower reduction in peak water levels.

Flood operations at the dam are also highly dependent upon the flood inflow volume and a slight variation in the flood volume could significantly reduce the benefits associated with draining down the dam prior to a flood event.

2.5 Is there a detailed record of the events associated with the current flood?

A preliminary report has been prepared and is attached to this briefing.

3 THE MANUAL OF FLOOD MITIGATION AT WIVENHOE DAM AND SOMERSET DAM

3.1 What is the Manual of Flood Mitigation and how was it developed?

The Manual of Flood Mitigation for Wivenhoe and Somerset dams in its current form was developed in 1992 during an extensive hydrological study of the Brisbane and Pine Rivers catchments by DPI, Water Resources. The final reports were subject to extensive internal review by the Water Resources Group before being reviewed by an independent review panel comprising Professor Colin Apelt, Head of Department, Department of Civil Engineering, University of Queensland and Mr Eric Lesleighter, Principal Hydraulic Engineer and Chief Engineer Water Resources, Snowy Mountains Engineering Corporation. Subsequently, the Manual was extensively reviewed during the Brisbane Valley Flood Damages Minimisation Study in 2006, with the latest comprehensive review of the Manual undertaken in 2009. Both of these reviews have included expert review panels comprising key stakeholders, with the most recent review involving representatives from DERM, BOM, BCC and SunWater.

The Manual of Flood Mitigation is prepared by Seqwater as the owner of the dam and approved and gazetted by the Chief Executive of DERM in accordance with the Water Supply Act 2008. The manual defines flood objectives procedures; roles and responsibilities; and staffing and operational requirements for flood events impacting on Wivenhoe and Somerset dams.

3.2 What is contained in the Manual?

The primary objectives of the procedures contained in the Manual are, in order of importance:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers primarily, this involves minimising inundation of the seven bridges below the dam upstream of Moggill);
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.

- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

During an event, the operation of the dam transitions between the following four operating strategies depending of the circumstances at the time. These procedures associated with these strategies are explained in detail in the Manual.

- **Strategy W1** – Primary consideration is given to Minimising Disruption to Downstream Rural Life.
- **Strategy W2** – Transition Phase moving from Minimising Disruption to Protecting Downstream Urban Areas.
- **Strategy W3** – Primary consideration is to Protect of Urban Areas from Inundation.
- **Strategy W4** – Primary consideration is to protecting the structural safety of the Dam.

In addition to these strategies, historical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane River system within a short time of each other. Accordingly for each flood event, the aim is always to empty stored floodwaters within seven days after the flood peak has passed through the dams.

4 REGULATORY CONTEXT (Provided by Peter Allen and unedited)

These are contained in the Flood Mitigation Manual (manual) approved under sections 370 to 374 of the *Water Supply (Safety and Reliability) Act 2008*. The Chief Executive Officer (CEO) of DERM (or his delegate) approves the manual, and the approval is notified in the Queensland Government Gazette. Approval can be for a period of up to five years, after which the approval needs to be renewed. There are no decision-making criteria specified in the Act for the CEO to take into account when approving the manual.

The manual for the dams requires, amongst other matters:

1. Flood operations to be conducted in accordance with manual's provisions. (There is an approval process specified in the manual, if Seqwater considers a different flood release strategy is desirable to deal with a particular flood event. This was not used in the January 2011 flood event)
2. Flood operations to be under the control of CEO-approved engineers (who are highly qualified and experienced)
3. Annual reporting on the preparedness and status of the flood control system for flood operations, and the training of the personnel who manage the flood events.
4. Reporting on the flood operations during flood events.
5. Reviews after flood events such as the January 2011 event. For this flood event, the Queensland Government engaged Mr Brian Cooper, an independent consulting engineer, to review compliance with the manual. Mr Cooper concluded (Attachment??): "...The strategies in the Flood Mitigation Manual have been followed, allowing for the discretion given to make variations in order to maximise flood mitigation effects. The actions taken and decisions made during the Flood Event appear to have been prudent and appropriate in the context of the available knowledge available to these responsible for flood operations and the way events unfolded..." (p.3 of the final report or other appropriate reference??)

The manual is separate from a draft communication protocol (Insert name) between the Local, State and Commonwealth government agencies that are affected by the dams' flood operations. This protocol is not binding on the parties to it is not subject to regulatory approval/review.

Some DERM staff, because of their specialist skills, work in the Flood Operations Centre that Seqwater activates to manage such events. None of them are involved in any of the regulatory decisions concerning the dams or are members of the work unit (Office of the Water Supply Regulator) which undertakes the CEO's regulatory functions.

5 COMPLIANCE WITH THE MANUAL

(To be provided)

6 SEQWATER REPORT

It is recommended that the process and content for reports required for this event be:

- In the short term, utilise this report attached to this briefing note as the basis for communications and discussion.
- Prepare any Interim Reports as agreed to provide information and input as required.
- Seqwater prepare a Comprehensive Report as per the existing regulatory requirements of the Act and the gazetted manual and any requirements of the Dam Safety Regulator. This would be done within 6 weeks of the closure of the current event as per the manual. This timeframe is subject to any new mobilisation of the Flood Operations Centre. The Table of Contents would include:
 - Introduction
 - Flood Event Summary
 - Mobilisation and Staffing
 - Event Rainfall
 - Inflow and Release Details
 - Data Collection System Performance
 - Data Analysis Performance
 - Communication
 - Flood Management Strategies and Manual Compliance
 - Improvements in data collection systems, practices and processes.
 - improvements by interacting agencies
 - Review of factors impacting on the protection of urban areas
 - Recommendations & Conclusions
- The report would then be reviewed by the Dam Safety Regulator in conjunction with any peer review they require. The review should cover:
 - Were the provisions of the manual complied with?
 - What improvements to either facilities e.g. stream gauges, or work practices, are desirable to improve Seqwater's ability to predict inflows into the dams.
 - Are improvements to either Seqwater's facilities or work practices desirable to improve Seqwater's ability to manage events? For example, investigations to raise the dam to improve its flood storage capacity, If so, what are they and their implications

- Are changes to the facilities or work practices of other organisations desirable to improve Seqwater's abilities to manage these events? If so, what are they and their implications? (For example, would it be worth funding Brisbane River crossing upgrades so that floodwater could be released faster, while not adversely affecting access to properties--or maybe alternative strategies e.g. resupply operations could be put in place to achieve similar outcomes?)
- Given the manual's order of priorities i.e. protection of the dam etc, are any changes in the flood release strategies for either dam desirable? If so, what are they, and their implications
- Based on this review, a review of the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam would occur utilising an expert panel of review including representatives of DERM, Seqwater, BoM, affected Local Governments and other stakeholders as necessary.



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**JANUARY 2011 FLOOD
EVENT**

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1 INTRODUCTION

Wivenhoe Dam was constructed by the Queensland Government between 1977 and 1984. The dam is a 56 m AHD high and 2.3 kilometre long earth and rock embankment separated into two parts by a concrete gravity spillway. The spillway is controlled by 5 radial gates, each 12.0 metres wide by 16.0 m AHD high. Two saddle dam embankments are located on the left side of the reservoir.

The dam spillway capacity was upgraded in 2005. This was done primarily through the construction of a 164 metre wide secondary spillway through the right abutment of the existing dam. This spillway contains three erodible earth fill fuse plug embankments that are initiated at different dam levels in excess of EL 75.6.

The dam has two main functions by providing:

- A 1,165,000 ML storage at full supply level (FSL EL 67.0) providing an urban water supply for Brisbane and surrounding areas;
- Flood mitigation in the Brisbane River by providing a dedicated flood storage volume of 1,450,000 ML up to EL77 (this flood level was increased as part the 2005 upgrade to allow a water level of EL80m and a temporary flood storage volume of 1,966,000 ML with all fuse plugs initiated and the dam at the point of failure).

The dam has an EXTREME hazard classification under ANCOLD guidelines because of the significant development downstream in the Brisbane and Ipswich metropolitan areas, with the population at risk in the event of a dam failure numbering in the hundreds of thousands.

In accordance with the Queensland Regulatory program for dam spillway upgrades, a further upgrade of Wivenhoe Dam is scheduled to occur prior to 2035 to enable the dam to safely pass the Probable Maximum Flood. This work will involve the reconstruction of Saddle Dam 2 as a fuse plug spillway.

Wivenhoe Dam is in excellent condition. Comprehensive Dam Safety reviews undertaken in accordance with ANCOLD guidelines have been undertaken in 1997 (Gutteridge, Haskins & Davey Pty Ltd), 2003 (Wivenhoe Alliance), 2006 (NSW Department of Commerce), 2009 (GHD) and September 2010 (Seqwater). The reports concluded that the design of the dam is in accordance with modern day standards and that there are no significant outstanding design or construction issues that require investigation.

2 WIVENHOE DAM FLOOD MITIGATION AND FLOOD OPERATIONS

2.1 Flood Mitigation

The Brisbane River catchment covers an area of approximately 14,000 square kilometres of which about half is below Wivenhoe Dam. Maximum overall flood mitigation effect is achieved by operating Wivenhoe Dam in conjunction with Somerset Dam. Although Somerset and Wivenhoe Dam reduce flooding in Brisbane City, major flooding can still occur. The Lockyer-Laidley Valley drains into the Brisbane River through Lockyer Creek that enters the Brisbane River just downstream of Wivenhoe Dam near Lowood. Another major tributary, the Bremer River, flows into the Brisbane River at Moggill. Wivenhoe Dam has no control over inflows into the Brisbane River from both these major tributaries.

Wivenhoe Dam mitigates downstream flooding by storing incoming flood water during a rainfall event and releasing these waters at a reduced flow rate downstream to minimise flood impacts. The timing of the releases is also manipulated so that the aim is for outflows from the dams to impact on downstream areas only after the peak inflows from the downstream major tributaries have passed. However, this aim cannot always be achieved in practice. This is because some large floods, such as the one currently being experienced, have the potential to overflow the dam's flood storage compartment. **Should this occur, the dam would fail and the resulting damage and loss of life would be at least 100 to 1000 times greater than that currently being experienced.**

Therefore the basis of all flood operation decision making is to ensure the dam never fails. This is the reason that the dam's flood storage compartment would never be intentionally fully filled as additional inflows after this point would result in a dam failure. Similarly, there will be uncertainty on future rainfall that could occur which could not be releases if there was insufficient flood storage which could not be stored or released.

Another factor that impacts on flood release decision making in large events are the levels at which the erodible fuse plugs are triggered. Loss of one or more fuse plugs severely limits the ability of the dam to mitigate the effects of future flood events that may occur prior to the fuse plug or plugs being reinstated. Reinstatement of a fuse plug following an event would take a minimum of 4 to 6 months and would require an extended period of relatively dry weather.

2.2 Flood Operations

A real time flood monitoring and forecasting system has been established in the Wivenhoe and Somerset Dam catchments. This system employs radio telemetry to collect, transmit and receive rainfall and stream flow information. The system consists of around 230 field stations that automatically record rainfall and/or river heights at selected locations in the dam catchments. Most of these field stations are owned by Seqwater with the remainder belonging to other agencies.

The rainfall and river height data is transmitted to Seqwater's Flood Operations Centre in real time. Once received in the Flood Operations Centre, the data is processed using a Real Time Flood Model (RTFM) to estimate likely dam inflows and evaluate a range of possible inflow scenarios based on forecast and recorded rainfall in the dam catchments. The RTFM is a suite of hydrologic computer programs that utilise the real time data to assist in the operation of the dams during flood events.

Seqwater engineers use the RTFM for flood monitoring and forecasting during flood events to operate the dams in accordance with a Manual of Flood Mitigation (the origin of and objectives and procedures contained in the Manual of Flood Mitigation are explained in the following section of this document). Releases of water from the dams are optimised to minimise the impacts of flooding in accordance with the objectives and procedures contained in a Manual of Flood Mitigation.

The RTFM and data collection network performed well During the January 2011 event, with no failures experienced that compromised the ability of Seqwater to operate the dam.

3 MANUAL OF FLOOD MITIGATION FOR WIVENHOE AND SOMERSET DAMS

The Manual of Flood Mitigation for Wivenhoe and Somerset Dams, in its current form, was developed in 1992 during an extensive hydrological study of the Brisbane and Pine Rivers catchments by DPI, Water Resources. The final reports were subject to extensive internal review by the Water Resources Group before being reviewed by an independent review panel comprising Professor Colin Apelt, Head of Department, Department of Civil Engineering, University of Queensland and Mr Eric Lesleighter, Principal Hydraulic Engineer and Chief Engineer Water Resources, Snowy Mountains Engineering Corporation.

Subsequently, the Manual was extensively reviewed during the Brisbane Valley Flood Damages Minimisation Study in 2006, with the latest comprehensive review of the Manual undertaken in 2009. Both of these reviews have included expert review panels comprising key stakeholders, with the most recent review involving representatives from DERM, BOM, BCC and SunWater.

The Manual of Flood Mitigation is prepared by Seqwater as the owner of the dam and approved and gazetted by the Chief Executive of DERM in accordance with the Water Supply Act 2008. The manual defines flood objectives procedures; roles and responsibilities; and staffing and operational requirements for flood events impacting on Wivenhoe and Somerset dams.

The primary objectives of the procedures contained in the flood manual are, in order of importance:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers primarily, this involves minimising inundation of the seven bridges below the dam upstream of Moggill);
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

During an event, the operation of the dam transitions between the following four operating strategies depending of the circumstances at the time. These procedures associated with these strategies are explained in detail in the Manual.

- **Strategy W1** – Primary consideration is given to Minimising Disruption to Downstream Rural Life. Under this strategy, the predicted water level is below 68.50 m AHD and the maximum release is 1,900m³/s.
- **Strategy W2** – Transition Phase moving from Minimising Disruption to Protecting Downstream Urban Areas. Under this strategy, the water level is predicted to be between 68.5 and 74.0 m AHD and the maximum release is less than 3,500m³/s.
- **Strategy W3** – Primary consideration is to Protect of Urban Areas from Inundation. Under this strategy, the water level is predicted to be between 68.5 and 74.0 m AHD but the maximum release is less than 4,000m³/s.
- **Strategy W4** – Primary consideration is to protecting the structural safety of the Dam. Under this strategy, the water level is predicted to exceed 74.0 m AHD and there is no limit to the maximum release. Consideration is given to managing flood releases to avoid fuse plug initiation if at all possible as this would compromise flood mitigation capacity in the short to medium term.

In addition to these strategies, historical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane River system within a short time of each other. Accordingly for each flood event, the aim is always to empty stored floodwaters within seven days after the flood peak has passed through the dams.

4 JANUARY 2011 FLOOD EVENT

4.1 Background

In the 25 days leading up to the current event, three flood events impacting on Wivenhoe Dam were experienced, with gate releases being made on all but five of those days. The total outflow from these events was around 700,000ML. The details of these events are as follows:

EVENT	EVENT START DATE	EVENT END DATE	VOLUME RELEASED (ML)
1	13/12/2010	16/12/2010	70,000
2	17/12/2010	24/12/2010	150,000
3	26/12/2010	02/01/2011	470,000

During these events, requests were received from Councils and residents impacted by bridge closures downstream of the dam to curtail releases as soon and as quickly as possible.

Additionally the 2 January end date of the flood event prior to the current event meant that significant drain down of the dam prior to the onset of the current event that commenced on 6 January 2011, was not possible without major bridge inundation downstream of the dam and without exceeding minor flood levels in the lower Brisbane River.

Additionally, a flood event was also experienced in October 2010 that resulted in a release of 750,000ML from the dam. Accordingly drain down below the dam full supply level prior to the start of the first December event would not have been possible without significant bridge inundation and without exceeding minor flood levels (as defined by BOM and BCC) in the lower Brisbane River.

Regardless, significant drain down prior to the current event would have had little impact on the peak level in Wivenhoe Dam as shown in the table below. The reason for this is that this total event inflow volume of 2,600,000 ML is well in excess of the useable flood storage combined with the available water supply storages shown in the table.

The specific impact on the Lower Brisbane River of these reduced dam levels requires the use of a complex hydraulic model. The results of this modelling would still contain a degree of uncertainty as illustrated by the difficulties in estimating the final flood peak in Brisbane during the event. This

is because the rapid closure of the gates after peak inflow was achieved resulted in significant water level reductions downstream and this is difficult to model accurately.

JANUARY 2011 FLOOD			
Starting Level		Peak Height	Capacity
%	m AHD	m AHD	%
100	67.0	74.97	191
95	66.5	74.93	191
90	65.8	74.88	190
75	64.0	74.63	187
50	60.0	74.11	180

It should be noted that the possible reductions shown above are based up a unique dual peaked flood hydrograph with a volume of about 2,600,000 ML which occurred during this event. A hydrograph with the same volume but a different distribution could result in a significantly lower reduction in peak water levels.

Flood operations at the dam are also highly dependent upon the flood inflow volume and a slight variation in the flood volume could significantly reduce the benefits associated with draining down the dam prior to a flood event.

4.2 Event Decision Making

The following table contains a summary of the key decisions points associated with the current event. As at 16 January 2011, the event remains in progress.

DATE AND TIME	FLOOD EVENT MILESTONE
07:00 06/01/2011 (Thursday)	Rainfall is experienced in the dam catchments that will result in flood releases, however Wivenhoe releases are delayed for 24 hours to allow Lockyer Creek flood flows to pass downstream and prevent the isolation of the community dependent of Burtons Bridge. The forecast is for 150mm over the next 24 hours.
15:00 07/01/2011 (Friday)	Wivenhoe releases commence, with operational strategy W1 in use. Rainfall for the next four days is estimated to be between 140mm and 300mm, with a forecast for rain easing on Tuesday 11 January 2011. All bridges downstream of the dam with the exception of Fernvale Bridge and Mt Crosby Weir Bridge are expected to be inundated for a number of days.

06:00 09/01/2011 (Sunday)	Moderate to heavy rain periods forecast until Tuesday, but both Wivenhoe and Somerset dam levels were falling slowly, with Somerset at 1.27 m AHD above FSL and Wivenhoe 1.58 m AHD above FSL.
15:30 09/01/2011 (Sunday)	Following significant rain during the day a meeting of Duty Engineers is held. The QPF issued at 16:00 indicates 50mm to 80mm over the next 24 hours. Based on this forecast, it is anticipated that dam levels can be held to a maximum of 3.50 m AHD above FSL in Somerset and 5.5 m AHD above FSL in Wivenhoe. However, by 19:00 it was apparent that both Fernvale Bridge and Mt Crosby Weir Bridge would be inundated by the combined dam releases and Lockyer Creek flows and that the operational strategy had progressed to W2.
06:30 10/01/2011 (Monday)	Rainfall continued during the night and based on rainfall on the ground it was apparent the operational strategy had progressed to W3.
06:30 10/01/2011 (Monday)	Rainfall continued during the day but based on rainfall on the ground, operational strategy W3 remained in use. However it was apparent that any further heavy rain would result in progression of the operational strategy to W4.
08:00 11/01/2011 (Tuesday)	Rainfall continued during the night with isolated heavy falls in the Wivenhoe Dam catchment area and based on rainfall on the ground it was apparent the operational strategy would soon progress to W4 with Wivenhoe Dam exceeding 8.00 m AHD above FSL. The objective now was to limit outflows and subsequent flood damage to urban areas, while ensuring the structural safety of the dam.
11:00 11/01/2011 (Tuesday)	Rapid inflows were experienced in Wivenhoe Dam, with the dam rising almost a metre in eight hours. Releases were increased until the dam level stabilised in accordance with Strategy W4. Computer models were not reflecting actual dam inflows due to intense point rainfalls in the immediate catchment around the dam. Falls are estimated to be similar to those experienced at both Toowoomba and Upper Lockyer the previous day and are falling outside and between existing rain gauges.
21:00 11/01/2011 (Tuesday)	Wivenhoe Dam peaked. Peak release of 7450 cumecs with a level of 0.7 metres below fuse plug trigger.

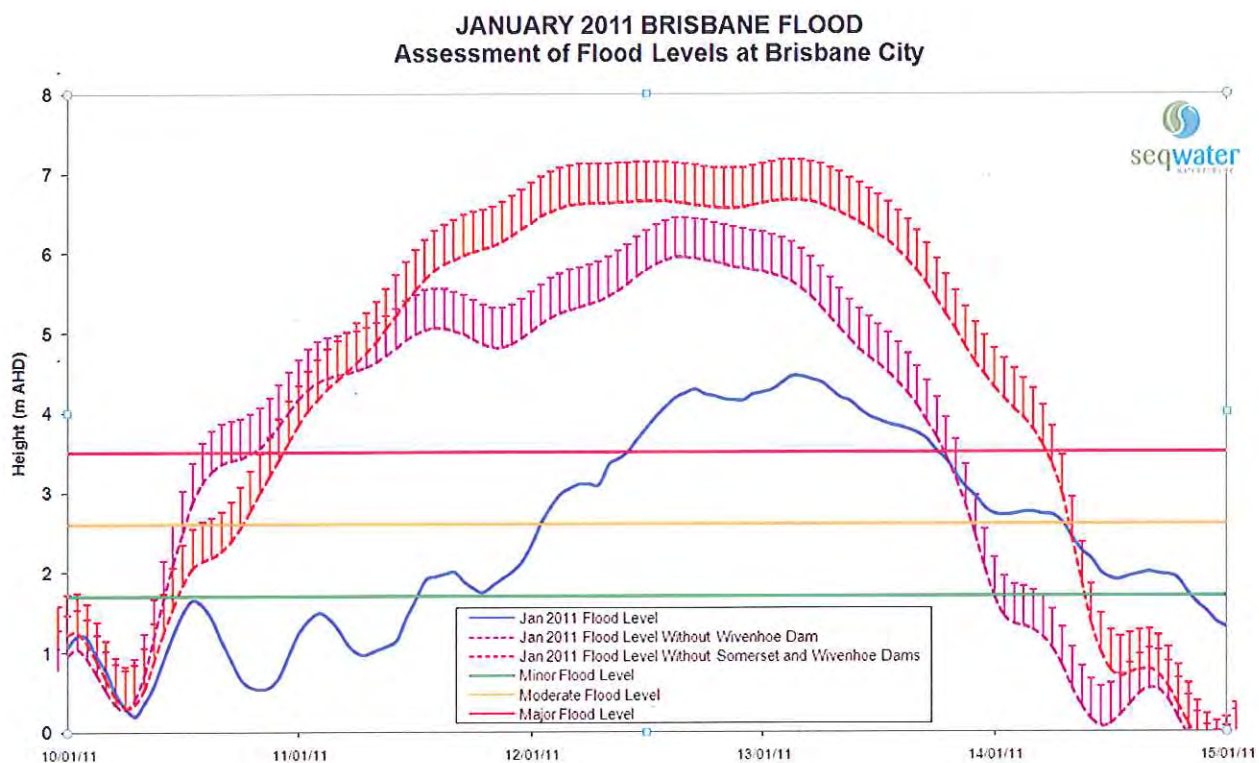
22:00 11/01/2011 (Tuesday)	Wivenhoe Dam releases were closed off as quickly as possible over the next 11 hours, while ensuring water levels in the dam did not rise further and initiate a fuse plug embankment.
08:00 12/01/2011 (Wednesday)	Minimum possible release level reached, with inflows matching outflows. Further reductions in release rate would likely cause the dam level to rise.
21:00 13/01/2011 (Thursday)	The 7 day dam drain down is commenced as Lockyer Creek and Bremer River peaks pass the Lower Brisbane area. Maximum release target is the limit of damaging floods in Brisbane being 3500 cumecs.
09:00 17/01/2011 (Monday)	Drain down continues, with released expected to cease on Wednesday 19 January 2011 unless further rainfall is experienced.

4.3 Flood Mitigation Benefits of Wivenhoe Dam

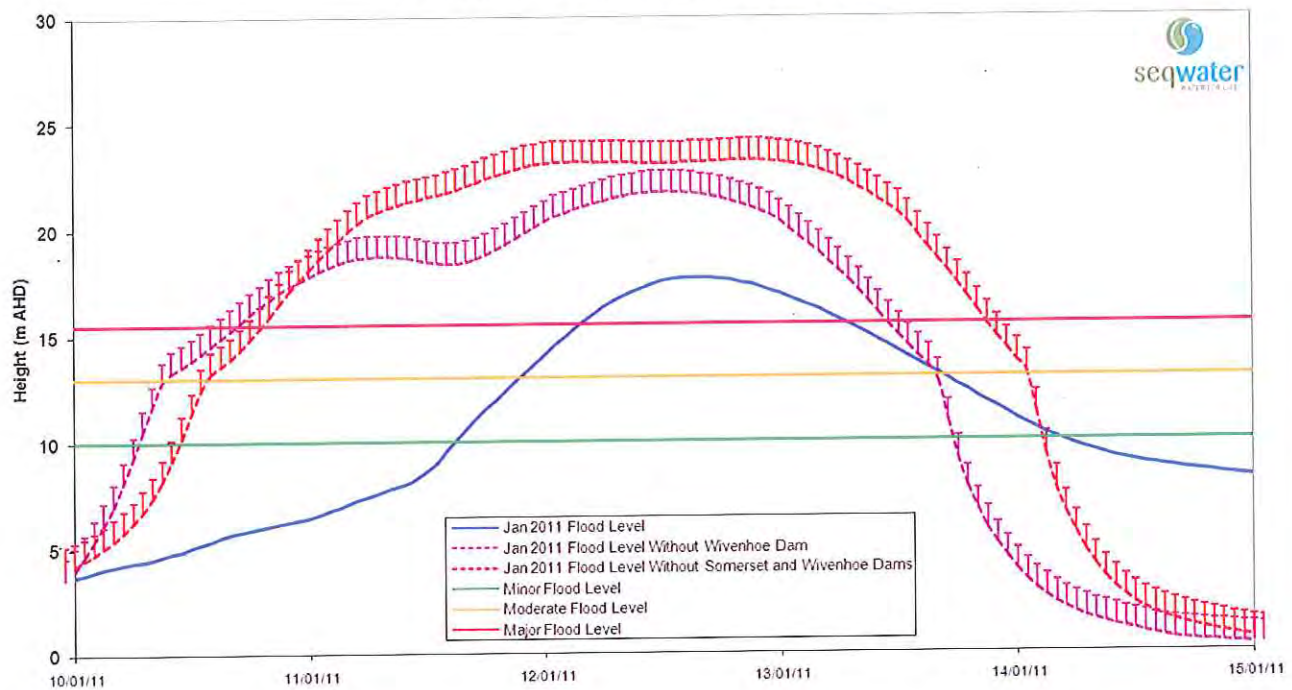
The following graphs demonstrate the significant benefits of Wivenhoe Dam in mitigating the current flood event, with reductions in flood peak of up to 2.5 metres in the City area and up to 5.5 metres in the Moggill area further upstream.

This equates to significant reduction in the potential for loss of life as well as saving in damages in the order of up to \$1.6 billion based on current damage curves. Up to 13,000 more properties would have been impacted by the event without the Dam.

The time at which flood levels remained elevated above major levels has also been reduced by up to 3 days by the dam. This has significant benefits to impact on the population of the city, property damage and the recovery operation.



JANUARY 2011 BRISBANE FLOOD Assessment of Flood Levels at Moggill



The strategy adopted to quickly close off releases once the peak in the dam had been reached and rain stopped falling certainly reduced the predicted flood peak by at least one metre in the lower Brisbane River area. This notion is supported by BOM.

5 EVENT REVIEW

Under the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam that are approved and gazetted by the Department of Environment and Resource Management, there is a regulatory requirement that a report must be prepared as per the below wording:

“Seqwater must prepare a report after each Flood Event. The report must contain details of the procedures used, the reasons therefore and other pertinent information. Seqwater must forward the report to the Chief Executive within six weeks of the completion of the Flood Event.”

Such a report was prepared for the flood events of February and March 2010 and copies are available. A copy of the Table of Contents of that report is included as Appendix 1. For this event, the report would be a comprehensive summary of all procedures, actions, outcomes and processes during the event.

It is recommended that the process and content for reports required for this event be:

- In the short term, utilise this report attached to this briefing note as the basis for communications and discussion.
- Prepare any Interim Reports as agreed to provide information and input as required.
- Seqwater prepare a Comprehensive Report as per the existing regulatory requirements of the Act and the gazetted manual and any requirements of the Dam Safety Regulator. This would be done within 6 weeks of the closure of the current event as per the manual. This timeframe is subject to any new mobilisation of the Flood Operations Centre. The Table of Contents would include:
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 - Flood Management Strategies and Manual Compliance

- Improvements in data collection systems, practices and processes.
 - improvements by interacting agencies
 - Review of factors impacting on the protection of urban areas
 - Recommendations & Conclusions
- The report would then be reviewed by the Dam Safety Regulator in conjunction with any peer review they require. The review should cover:
 - Were the provisions of the manual complied with?
 - What improvements to either facilities e.g. stream gauges, or work practices, are desirable to improve Seqwater's ability to predict inflows into the dams.
 - Are improvements to either Seqwater's facilities or work practices desirable to improve Seqwater's ability to manage events? For example, investigations to raise the dam to improve its flood storage capacity, If so, what are they and their implications.
 - Are changes to the facilities or work practices of other organisations desirable to improve Seqwater's abilities to manage these events? If so, what are they and their implications? (For example, would it be worth funding Brisbane River crossing upgrades so that floodwater could be released faster, while not adversely affecting access to properties--or maybe alternative strategies e.g. resupply operations could be put in place to achieve similar outcomes?)
 - Given the manual's order of priorities i.e. protection of the dam etc, are any changes in the flood release strategies for either dam desirable? If so, what are they, and their implications
 - Based on this review, a review of the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam would occur utilising an expert panel of review including representatives of DERM, Seqwater, BoM, affected Local Governments and other stakeholders as necessary.

Appendix A

FINAL REPORT – FLOOD EVENTS AT WIVENHOE, SOMERSET AND NORTH PINE DAMS FOR FEBRUARY AND MARCH 2010

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"PAH3"



Seqwater Board Meeting - Flood Manual Report

Tuesday 3 March

Outline

- Context of flood event – Wivenhoe and Somerset Dams
- Manual
- Timelines
- Report Preparation Process
- Report Summary and Recommendations
- Legal Position and feedback from Insurers
- Submission to Regulator and Commission
- Communication Plan

Rainfall animation

- Event was almost twice the size of the 74 event
- Dual peak nature of rainfall
- Second peak fell right on Wivenhoe—good for Brisbane!
- Wivenhoe was full and couldn't further mitigate the second peak inflow

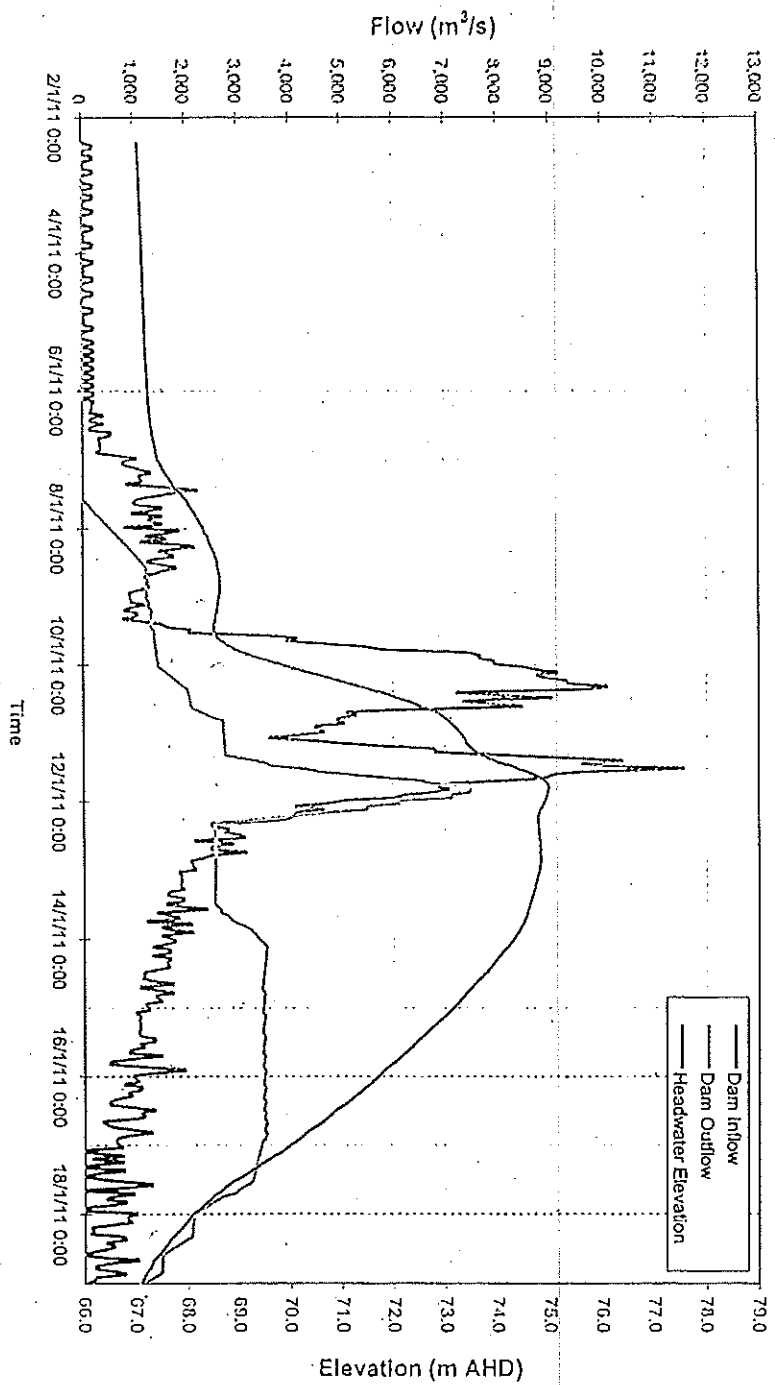
Link to animation:

\\seqwater\shared\January 2011 Flood Event\Comms\Flood Animation\Data\Rainfall animation



January 2011 - Flood Event

Wivenhoe Dam



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January 2011 Flood Manual operations

Operations during the January 2011 flood event (between 6 January 2011 and 19 January 2011) occurred under both of Seqwater's approved flood mitigation manuals –

- a) the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam (November 2009). This Manual was approved by the Chief Executive (of DERM) on 22 December 2009. That approval was gazetted on 22 January 2010 and is for a 5 year period; and
- b) the Manual of Operational Procedures for Flood Mitigation at North Pine Dam (August 2010). This Manual was approved by the Chief Executive (of DERM) on 6 December 2010. That approval was gazetted on 17 December 2010 and is for a 5 year period.

Report timelines

Both Manuals require that a report be prepared and lodged with the Chief Executive within 6 weeks after each flood event.

- There are 7 flood reports to be prepared and submitted in respect of the period since October 2010.
- Focus has been primarily on preparation of the January 2011 flood event report for the Wivenhoe/Somerset due to the large nature of the event, the Ministerial correspondence of 20 January 2011 and the terms of reference of the Commission of Inquiry.
- Given the close consequential nature of those flood events, reports for the events prior to January 2011 have not yet been written as the time usually spent writing reports was spent operating during the subsequent events.
- After discussions with the dam safety regulator, a formal extension request has been made to extend the submission dates for some of the flood event reports.



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Report timelines (cont.)

The report timelines (reflecting requested extensions) are:

Event	Report submission date (or requested submission date)
October 2010 – Wivenhoe/Somerset	31 May 2011
October 2010 – North Pine	31 May 2011
December 2010 – Wivenhoe/Somerset	31 May 2011
December 2010 – North Pine	31 May 2011
January 2011 – Wivenhoe/Somerset	2 March 2011
January 2011 – North Pine	11 March 2011
February 2011 – North Pine	31 May 2011



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Report preparation process - January 2011 flood event report for *Wivenhoe/Somerset*

- Prepared by the 4 Flood Operations Engineers led by John Tibaldi
- Technical report by the flood engineers (reviewed by others)
- Flood engineers comments on reports
- Allen's and Rowlands on board since day 1
- Independent experts (Colin Apelt, Brian Shannon, Greg Roads, Peter Hill, Rory Nathan and Len McDonald)
- Role of external experts
- Discussion on interaction with insurers.

Report Summary

The report:

- confirms and describes the rare and large nature of the January 2011 flood event, putting in into context with prior flood events;
 - describes the operational steps and decisions taken under the flood manual and their timing;
 - concludes that operational decisions were made in accordance with the flood manual;
 - concludes that Wivenhoe and Somerset Dams were operated in accordance with the flood manual during the January 2011 event;
 - identifies the data collection and modelling used in the decision making process and concludes that this data performed well and assisted informed decision making in accordance with the flood manual; and
 - concludes that communications during the event followed the draft inter agency flood communications protocol prepared by the Department of Environment and Resource Management.
- Flood Engineers have no role in setting FSL

Report Summary (cont.)

The report recommendations, which are a requirement under the Manual, are:

- that there should be an examination in conjunction with the Bureau of Meteorology and other relevant agencies on what additional rain gauges should be installed in the Brisbane River basin to improve data recorded during flood events; and
- a review of the flood manual should be undertaken given the large and rare nature of the January 2011 flood event;
- Seqwater should participate with the Bureau of Meteorology and other relevant agencies in a review of the inter agency flood communications protocol.

Legal Position and feedback from insurers

- Overall comments and advice
- Exec summary
- Section 16
- Insurers
- Cover Letter to Regulator

Submission of report to regulator and Commission of Inquiry

- Flood event report will be delivered to Dam Safety Regulator, as the Chief Executive's delegate for the purpose of receiving the flood event reports. Dam Safety Regulator will be asked to provide any comments he may have on the report.
- Report will also be an annexure to Seqwater's submission to the Commission of Inquiry. Provisions of the report to the Commission was confirmed in Seqwater's application for leave to appear before the Commission.
- Submission is being prepared now and is the chance to get other key messages across to Commission.



Communication Plans

- Outline Plan
- Ministerial Briefing request
- After event

Comments from Board

