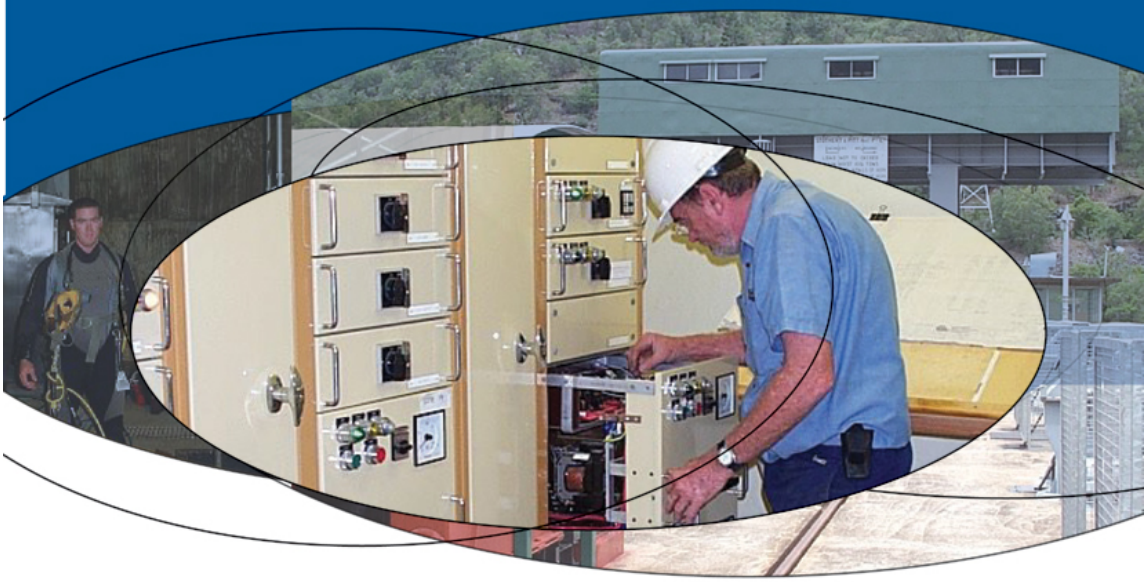
THE DAM SAFETY MANAGEMENT PROGRAM

For

WIVENHOE, SOMERSET, NORTH PINE DAMS



SEQWATER
Wivenhoe, Somerset & North Pine Dams
Quality of water. Quality of life.

INTENTION OF THE DOCUMENT

This document has been prepared to demonstrate SEQWater's compliance with Dam Safety requirements. It should not be used for any other purpose.

Revision No	Date	Description
1	March 2002	Original Issue
2	October 2002	Annual Review
3	December 2003	Annual Review
4	March 2005	Annual Review
5	April 2007`	Annual Review

DAM SAFETY POLICY

POLICY STATEMENT

SEQWater has a Dam Safety Management Program to ensure the continued safe operation of our dams – Wivenhoe, Somerset and North Pine.

BAC OBJECTIVES

Safely operate and maintain our dams in line with best practice.

Operate our dams to mitigate, as far as possible, the effects of flooding.

Ensure that our Dams can safely pass their design flood.

Undertake routine dam safety reviews.

Implement accepted recommendations of the Dam Safety Reviews and Risk Assessments

SEQWATER
Wivenhoe, Somerset & North Pine Dams

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1 EXECUTIVE SUMMARY

1.1 Dam Safety Management Program

A Dam Safety Management Program is a combination of policy, procedures and activities which, when methodically carried out, will ensure that each dam remains safe.

Each activity should be described within a documented procedure which can be reused later. It should also contain self-checking managerial functions which ensure that basic dam safety activities are being carried out and are working correctly.

To demonstrate compliance with dam safety requirements, a documented record of activities associated with these facilities needs to be maintained. The documentation needs to describe the procedure used in the activity and factual outcomes which measure the performance of the procedures, and be recorded in the Corporation's Quality Assurance System.

1.2 Levels of Documentation

A dam safety program consists of six functional levels of documentation, namely:

1. Emergency Action Plan (EAP)
2. Standing Operating Procedures (SOP)
3. Detailed Operating and Maintenance Manuals
4. Inspection and Evaluation Reports
5. Data Books
6. Dam Safety Review/Design Report.

1.3 Management Structure

SEQWater must maintain a suitable management structure to ensure that investigation, design, construction, operation and surveillance meets dam safety requirements.

For high and significant hazard dams, each dam owner must ensure that organisational staffing is sufficient and qualified for the projected workload, and that all programs necessary for the safety of each dam are established, continued and realistically funded throughout the life of the dam.

1.4 Development Permit

The process to satisfy the regulator for dam safety is summarised below:

- Development permits have been issued by Department of Natural Resources and Mines in July 2002.
- Deficiencies identified in Safety Reviews are being rectified by a program of works.

- For deficiencies in relation to Australian design guidelines (ANCOLD Guidelines), a Preliminary Risk Assessment can be undertaken to assess the portfolio of dams and associated risks and consequences of those risks to (amongst other factors) give greater weight to the prioritisation of design deficiency remediation.

1.5 Status for the Corporation's three dams

The status for the Corporation's three dams in relation to the development permit conditions are described in Table 1.

	TABLE 1 – STATUS FOR DAM APRIL 2007			
DEVELOPMENT PERMIT CONDITION	WIVENHOE	SOMERSET	NORTH PINE	REVIEW PERIOD
1. Drawings	All available drawings for the original construction are scanned and stored on CD. Paper copies are archived. The Wivenhoe Upgrade Works from 2004 are available as scanned images with hard copies archived.	All available are scanned and stored on CD. Paper copies are archived.	All available drawings from the original construction are scanned and stored on CD. Paper copies are archived. Upgrade Works carried out in 2000 and 2005 are stored electronically with hard copies archived.	Currently drawing sets are being compiled into controlled sets to include upgrade works – drawings sets to be reviewed annually.
2. Design Report	Produced 1995	Not available *	Not available.*	N/A
3. Data Books	Completed as much as is available.	Completed as much as is available.	Completed as much as is available.	N/A
4. Construction Report	Produced 1995	Not available *	Not available *	N/A
5. Standard Operating Procedures	Exist. Control document status.	Exist. Control document status.	Exist. Control document status.	Annual
6. Operation & Maintenance Manuals	Exist. Control document status.	Exist. Control document status.	Exist. Control document status.	Currently undergoing a complete revision to be completed mid 2008.
7. Dam Safety & Inspection Reports.	Operations data recorded in MAINSAVER; Surveillance data recorded in files;	Operations data recorded in MAINSAVER; Surveillance data recorded in files;	Operations data recorded in MAINSAVER; Surveillance data recorded in files;	Currently implementing a new asset management system to replace Mainsaver (comp 2007).

	TABLE 1 – STATUS FOR DAM APRIL 2007			
DEVELOPMENT PERMIT CONDITION	WIVENHOE	SOMERSET	NORTH PINE	REVIEW PERIOD
	Inspections undertaken: • Routinely under O&M Contract by Sunwater personnel and by OM. • SEQWater Operations Engineer Review of Data. • Annual periodic inspections had not been formally recorded until 1998. • Comprehensive inspections every five years have been undertaken (last one in 2006).	Inspections undertaken: • Routinely under O&M Contract by Sunwater personnel and by OM. • SEQWater Operations Engineer Review of Data. • Annual periodic inspections had not been formally recorded until 1998. • Comprehensive inspections every five years have been undertaken (last one in 2006).	Inspections undertaken: • Routinely under O&M Contract by Sunwater personnel and by OM. • SEQWater Operations Engineer Review of Data. • Annual periodic inspections had not been formally recorded until 1998. • Comprehensive inspections every five years have been undertaken (last one in 2006).	Twice Weekly Monthly Annually 5 Yearly As per development permits, due by 1/10/2005
8. Dam Safety Review	Undertaken 1997.	Undertaken 1995.	Undertaken 1995.	20 Yearly
9. Eliminate Deficiencies from Dam Safety Review & Risk Assessment	Current status detailed in Appendices B,C,D of Dam Safety Management Program	Current status detailed in Appendices B,C,D of Dam Safety Management Program	Current status detailed in Appendices B,C,D of Dam Safety Management Program	As agreed with Dept Natural Resources and Water
10. Emergency Action Plans	Exist. Control document status.	Exist. Control document status.	Exist. Control document status.	Annual

* Unavailable due to loss of records but superseded by more recent dam safety reviews.

2 OBJECTIVE OF THE DAM SAFETY MANAGEMENT PROGRAM

The primary objective of dam safety management is to ensure that each dam is operated and maintained in a safe manner and to minimise the risks associated with a dam failure. The Corporation aims to achieve this objective through its Dam Safety Management Program.

The failure of a dam is essentially a low probability, high consequence occurrence. A dam failure would have significant impacts including loss of life, direct financial losses to the dam owner and downstream property owners, indirect financial losses associated with the loss of supply, and personal liability.

The Corporation's commitment to dam safety is realised through the provision of adequate funding and resources essential to carry out the programs which ensure dam safety.

3 RESPONSIBILITY AND ACCOUNTABILITY

Dam Safety Legislation is contained within the Water Act 2000. The legislation defines an objective of protecting life and property and gives broad discretionary powers to the Chief Executive of the Department of Natural Resources and Water (NRW) who is responsible for dam safety in Queensland.

Requirements are now prescribed in Queensland Safety Management Guidelines for Referable Dams (2001). In addition, NRW have released the Guidelines on Acceptable Flood Capacity for Dams in February 2007. These guidelines have implications for the upgrade program of the dams owned by SEQWater.

Dam owners may be responsible for any damage to life or property arising from failure of their dam. Consequently, dam owners need to be committed to dam safety and have an effective dam safety management program. A dam safety management program is intended to minimise the risk of dams failing and to protect life and property from the effects of such a failure should one occur.

Previously the Australian National Committee on Large Dams (ANCOLD) "Guidelines on Dam Safety Management" (1993) and the Queensland Dam Safety Guidelines (1994) defined the requirements for dam safety. A TMP that incorporates our 3 dams is a requirement under the Water Act 2000. We are meeting our obligations in accordance with the Act with respect to the TMP.

4 REQUIREMENTS FOR DEVELOPMENT PERMIT

Dam safety management guidelines produced by Department of Natural Resources and Water Safety Group require that dam owners have the following documentation:

- Emergency Action Plan. This is a short document that details procedures to be followed in the event of problems developing at a dam.

- Standing Operating Procedures. This document details procedures to be followed in the operation of the dam especially during periods of flooding or high risk operation. It should contain sufficient information to enable all safety equipment at the dam to be operated.

- Detailed Operating and Maintenance manuals. This documentation should contain general information detailing operating, maintenance and over haul instructions for all equipment at the dam and the maintenance procedures.

- Inspection and Evaluation Reports. This document records details of operations, surveillance data and the findings of Inspection Engineers.

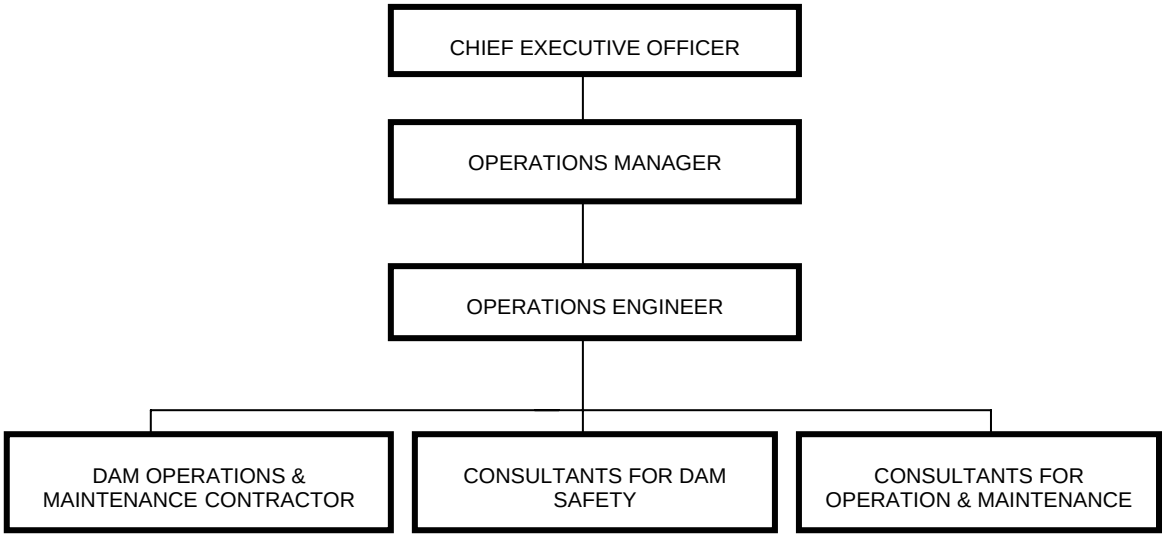
- Data Books. A data book is an abbreviated, convenient source of information summarising all the pertinent records and history related to the safety of the dam. It will contain a complete set of as constructed plans of the dam. It may actually be a large set of documentation.

- Dam Safety Review / Design Reports, Investigation Reports etc. This collection of documents should detail all the technical information on the investigation, design and construction of a dam. They should include the basis for all design and operating criteria and be in sufficient detail that no further investigations are necessary to resolve any technical issues which may arise. In the absence of a design report, the dam safety review should cover those areas not adequately documented.

The Corporation has produced all the above-mentioned documentation in QA format and operates and maintains its dams in accordance with the requirements of the documentation. The documentation is also periodically reviewed and updated as required.

5 MANAGEMENT STRUCTURE OF THE CORPORATION TO ENSURE DAM SAFETY

The Corporation's Operations Section manages the operation of the Corporation's dams. The relevant section of the organisational structure is shown below:



The principal responsibilities for dam safety are allocated as follows:

OPERATIONS MANAGER

- To implement this Dam Safety Management Program;
- To communicate with the Dam Safety Regulator (Department of Natural Resources and Water) should a deficiency arise or a requirement to operate a dam outside of the approved Standing Operating Procedure.

OPERATIONS ENGINEER

- To manage the operation and maintenance of the dams;
- To supervise contractors, staff and consultants utilised in the management of the dams;
- Implement upgrade programs as required to minimise risk;
- Review surveillance data submitted by the Operations and Maintenance Contractor.

OPERATIONS AND MAINTENANCE CONTRACTOR

- To operate the dam in accordance with the Standing Operating Procedures.
- To maintain the dam infrastructure in accordance with the Operation and Maintenance Manuals.
- To undertake other functions as described in Contract No T5-00/01 – Operation and Maintenance of Wivenhoe, Somerset and North Pine Dams from 2001 to 2009.

SEQWater has a term contract with Sunwater for the provision of these services.

6 THE CORPORATION'S DAM SAFETY MANAGEMENT PROGRAM

The Corporation's Dam Safety Management Program is designed to provide assurance for the Corporation and also the community that its dams are indeed safe and that a works program is in place to provide this level of assurance. The Program ensures that:

- adequate resources are committed to dam safety;
- only relevant prevailing technology is used; and
- sound management is in place.

6.1 Hazard Classification

The assigned consequences category and relevant PAR for each of the corporation's three dams is listed in Table 1. The consequences category is based on the recommendations of the ANCOLD Guidelines on Assessment of the Consequences of Dam Failure (ANCOLD 2000). The Population at Risk estimates is taken from the Preliminary Risk Assessment carried out by SKM in 2000 using the inundation mapping from the Brisbane River Flood Studies carried out by the Queensland Department of Water Resources in the early 1990's.

Table 1 – SEQWater Dams Consequences Category

Dam	Sunny Day Failure PAR	PMF Failure PAR	Sunny Day Consequences Category	PMF Hazard Category
Wivenhoe	57000	244000	Extreme	Extreme
Somerset	0	72	Significant	High B
North Pine				
• Saddle Dam 1	3	838	High C	High A
• Saddle Dam 2	66	787	High B	High A
• Saddle Dam 3	21	714	High C	High A
• Right Abutment	0	658	Significant	High A
• Left Abutment	0	658	Significant	High A
• Concrete Monolith	0	778	Significant	High A

6.2 Procedures related to Dam safety

The Corporation has in place numerous operational procedures related to Dam safety. The procedures address the following areas:

- Operational and maintenance aspects which affect dam safety and related equipment maintenance;
- Routine monitoring and surveillance;
- Specific inspections;
- Dam safety reviews;
- Flood operations; and
- Seismic monitoring.

6.2.1 Operational and maintenance aspects which affect dam safety and related equipment maintenance

The objectives for operation and maintenance are to ensure that the dam is used to maximum effect while maintaining an adequate standard of safety and preparedness for continuing operation. To meet these objectives all operations and maintenance is undertaken by contract to the following documentation. These documents are incorporated in our QA system.

a). Manuals of Standing Operating Procedures

These manuals detail procedures to be followed in both the normal operation of the dam, and during periods of flooding or high risk operation. They contain a continuum of procedures that encompass specific critical tasks associated with the operations of the dams. These include:

- routine operations;
- inspections, evaluations and reviews;
- routine and non-routine maintenance;
- flood operations including the ALERT system and the Real Time Flood Model; and
- Dam surveillance.

The procedures also define what is contained in other dam safety compliance documentation, with one folder for each dam with 19 procedures each. A detailed review of the procedures is to be carried out by 2008.

b). Detailed Operation and Maintenance Manuals

The operation and maintenance manuals contain general information; detailed operating, maintenance and overhaul instructions for all equipment at each dam; and maintenance procedures. A major purpose of the manual is to implement a well-designed and recorded maintenance program to reduce equipment failures, increase reliability, extend asset lives and reduce overall operating costs.

Separate Operation and Maintenance Manuals have been prepared for:

Wivenhoe Dam	17 Volumes
Somerset Dam	16 Volumes
North Pine Dam	18 Volumes

These manuals are currently undergoing a complete revision as part of the ongoing management of the dams. The revision will provide data on key components, update supplier information, capture procedure developed by the Operations and Maintenance Contractor and ensure that all necessary data is recorded for the operation of the storages. The manuals will be simplified to reflect the key activities required for the operation of the dam. Additional information which is only rarely required will be capture electronically and included in the revised Asset Management System being implemented by SEQWater.

Additionally, the Corporation develops an annual Planned Maintenance Program based on the Corporation's Total Asset Management Plans and a five-year rolling program of maintenance. The

foundation for the five year rolling program is the Corporation's Total Asset Management Plans for the dams. SEQWater is currently moving to a new software platform and reviewing all aspects of the Asset Management System.

6.2.2 Routine Monitoring and Surveillance

Monitoring and inspections are a fundamental part of the dam safety process. These range from routine daily observations to special safety review inspections.

a). Routine Monitoring and Surveillance

For confirmation of satisfactory behaviour and identification of deficiencies, the Operation and Maintenance Contractor's dam supervisors undertake routine inspections and instrument readings as part of their normal duties at each dam. Inspections are in accordance with the requirements of the relevant Standing Operating Procedures and Operation and Maintenance Manuals including maintaining records of all surveillance in the operating log and in the dam data books instrument recording folders.

The dam supervisors ensure that all instruments are regularly maintained and tested at intervals not exceeding those recommended by the manufacturers of the instruments to ensure reliability of measurements carried out.

Instruments read include:

Wivenhoe Dam:

- V-notch weirs in lower gallery of spillway for seepage
- Seepage measuring points in right and left embankment drainage system
- Piezometers – right embankment for piezometric pressure and primary concrete spillway for uplift pressure
- Inclinometers (right embankment) for movement
- Survey points on concrete and embankment for deformation measurement

Somerset Dam:

- Piezometers in upper and lower galleries for uplift pressure
- Crack measurement for crack in upper gallery and construction joint in deck
- Water depth in foundation drains
- Survey points on concrete structure for deformation measurement

North Pine Dam:

- V-notch weirs in lower gallery for seepage
- Uplift pressure gauges in lower gallery
- Seepage measuring points in Main Dam Right Embankment drainage system

- Standpipe piezometers in Main Dam Right Embankment for water depth
- Standpipe piezometers downstream of Main Dam concrete gravity section on right abutment for water depth
- Standpipe piezometers downstream of Main Dam concrete gravity section on left abutment for water depth
- Survey points on concrete structure for deformation measurement

b). Unplanned or Emergency Inspections

Where ongoing dam surveillance or unusual flood or earthquake events indicate abnormal behaviour, the dam supervisors undertake an unplanned inspection at the direction of the Operations Manager. Follow-up inspections by the Operations Manager and possibly dam specialist consultants may be required.

c). Specific Inspections

This inspection involves the confirmation of satisfactory behaviour or identification of deficiencies by a thorough on-site inspection; by evaluating data; and by applying current criteria and state-of the-art knowledge. All equipment is test operated to identify any deficiencies. Condition monitoring is undertaken on selected mechanical and electrical equipment every 6 months and recorded in the dam data books.

d). Annual Dam Inspection

Periodic (Annual) Dam Inspections are performed by the Corporation's Operations Engineer in conjunction with specialist dams engineers by visual examination of the dams and review of surveillance data against prevailing knowledge.

The annual inspections require the review of maintenance records of equipment which is considered important for Dam Safety. This includes but is not limited to spillway and sluice gates and emergency generating equipment.

e). Comprehensive Dam Inspection

A comprehensive dam inspection is preformed every five years by an external inspection team made of up of experienced dam designers and dam surveillance engineers. The comprehensive inspection involves:

- A physical inspection of all dam components by the inspection team;
- A review of all monitoring data and surveillance records;
- A review of investigations and remedial works carried out on the dam since the previous inspection;
- A review of all dam safety documentation;
- A review of the status of the dam in relation to current standards; and
- A report detailing the outcomes from the review.

f). Dam Safety Reviews

A Dam Safety Review is a procedure for systematically assessing a dam's safety. It usually incorporates:

- A current hazard assessment;
- An audit of existing documentation on the dam;
- A detailed review of structural, hydraulic, hydrologic, and geotechnical design aspects;
- A review of historical operational records; and
- A review of surveillance reports.

The Safety Review provides the knowledge that demonstrates a dam is known to be safe. Safety Reviews are not normally carried out on a regular basis, but the existing condition of the dam should be reflected in the last Safety Review undertaken, ie. if conditions change a Safety Review should be carried out. Queensland Dam Safety Procedures state that "Because of frequency of changes in standards, it is recommended that all dams with potential to damage life or property should have a minimum of one safety review every twenty years."

The following Table summarises the different types of inspections undertaken as part of the Corporation's Dam Safety Management Program.

	Continuous Surveillance	**Unplanned or Emergency Inspections**	**Periodic (Annual) Dam Inspections**	**5 Yearly Surveillance Inspection**	**Specific Inspections**	**Dam Safety Reviews**
Dam Supervisors	1	↓	↓			
Consultant / Reviewers		2a ↓	2a ↓	2a ↓	2a ↓	↓
Operations Engineer	1	2a	2a	2	2a	2a
Regulator						2a

1 Safety Check

2 Safety Assessment

a Decision upon measures to improve safety

↓ Flow of information

g). Flood Operations

The operations of each dam during flood is in accordance with manuals, one for the Wivenhoe/Somerset system and one for North Pine, developed in conjunction with the Corporation, Department of Natural Resources and Mines and Bureau of Meteorology. These manuals are reviewed after every flood event and these changes must be authorised by the Minister for Natural Resources and Water. Variation in flood operations from these manuals must be approved by the Chief Executive of Natural Resources and Water and the Chairman of SEQWater.

h). Seismic Monitoring

The Corporation has six stations throughout the three dam catchments with seismometers which measure seismic activity in x, y and z directions in real time. This data is transmitted via radio telemetry to the Wivenhoe Office where the information is analysed. Six accelerometers are to be installed, two at each dam, one at the crest and one at the base of each dam, to measure the actual dam movement during earthquakes.

7 PERSONNEL AND TRAINING

7.1 General

The Corporation's philosophy on Dam Safety is that safe management is a frame of mind. It involves all the people concerned – from the Corporation itself, to the General Manager, the relevant staff of the Operations Section and the Operation and Maintenance contractor and his dam supervisors and Flood Control Centre Team.

The Corporation also relies on "expert" advice from a range of consultants on a range of matters related to the safe management of the dams, and ways to improve management practices and/or the structures themselves.

Education and training is developed and delivered along the lines of developing awareness of the need for ongoing vigilance, surveillance and maintenance in addition to giving/reviewing instructions of the relevant and desirable procedures.

7.2 Operations Section Staff Training

Education and training for the relevant Operations Section staff is gained through experience and formal education; experience with the current management of the dams (eg use of, and enhancement of the O&M Manuals, the Standard Operating Procedures, the Emergency Action Plans, analysis of surveillance data, etc); and relevant "formal" seminars, etc. eg ANCOLD Conferences. Operations Section staff at Lake Wivenhoe Information Centre undertake Incident Response training for dissemination of information during a flood.

7.3 Contractor Training – Dam Operations

The contract for the Operation and Maintenance of the dams contains a requirement for training of the contractor's personnel. The requirement is specified in Standard Operating Procedures for the dams and also for flood operations. In summary, the Contractor's Manager is responsible for

establishing an approved training program and the dam supervisors must ensure all personnel involved in operation and maintenance activities at the dam receive proper training before they undertake relevant activities and also ensure such training, including refresher courses, is carried out at least annually.

Standby operators who may be required to operate the dam in an emergency are also required to receive organised training to ensure they are familiar and confident with the Operation Procedures. Such training includes:

- Familiarisation with the dam, the equipment, and the location of controls, tools, keys etc. required to operate the equipment;
- Instruction on the Standard Operating Procedures;
- Instruction on the Operation and Maintenance Manuals;
- Supervision by an experienced operator during initial operations;
- Regular involvement in testing of equipment to maintain familiarity; and
- Testing to ensure training has been satisfactorily completed.

The training takes into account the likelihood that operation in an emergency is likely to be in adverse conditions, and that the consequence of failure to operate properly in an emergency can be extremely serious. Crane drivers and crane followers receive in addition to operator training as described above, the required training for operation of a runway crane, and are required to be licensed or accredited by applicable legislation or regulations.

7.4 Contractor Training – Flood Operations

The O&M contract also contains specific requirements for training of operators, both at the dams and also in the Flood Control Centre, in flood operations. The Contractor is required to be prepared to competently deal with flood events in accordance with the requirements of the Standard Operating Procedures, the Emergency Action Plans and the Manuals of Operational Procedures for Flood Release from the Dams. The contractor must prepare a program for approval prior to 31 July each year which sets out the training schedule for all flood response team members. The flood response team includes all the Contractor's operators and flood control centre staff and other staff required to respond to flood events at any of the dams. This program also states the names and contact details of all staff proposed at each dam and at the flood control centre and the names and contact details of any backup flood response team members.

Training of all flood response team members occurs prior to 30 September each year. No flood response team members are permitted to provide services at a dam or flood control centre during a flood event if this training has not been satisfactorily completed. Training includes simulation of real past events and events up to and including the probable maximum flood with all staff operating at their designated work stations during the training. Prior to 30 September each year the Contractor submits a formal Statement of Preparedness. This statement includes:

- An outline of the training given to the flood response team members;
- The names of all flood response team members who have satisfactorily completed training;
- An assurance to the Corporation that the Contractor is prepared to deal with any flood event; and

- An assurance that all management and communication channels to be used in a flood event are unambiguous and effective and have been recently tested and found to be satisfactory.

7.5 Proficiencies Required of Personnel

The following Table summarises the proficiencies required for personnel involved in the Dam Safety Management Program.

GROUP	PRINCIPAL AREAS OF PROFICIENCY
Corporation Directors Chief Executive Officer	Awareness of environmental, regulatory and financial responsibilities relating to dam safety. Understanding of the significance of hazard and risk.
Operations Manager Operations Engineer	Geotechnical principles Design principles including structural, geotechnical, hydrologic and hydraulic Construction techniques Operation and maintenance procedures Surveillance processes Emergency planning Emergency response
Contractor's operation and maintenance personnel	Safe operating procedures Maintenance practices Surveillance principles, including monitoring Emergency responses including alerting others Need for vigilance
Consultants	Expert advice on: Geotechnical principles Design principles including structural, geotechnical, hydrologic and hydraulic Construction techniques Operation and maintenance procedures Surveillance processes

8 DAM SAFETY MANAGEMENT PROJECTS

As discussed above, the Corporation's Dam Safety Management Program is a multi-faceted approach to ensuring safe operations and maintenance of its dams. In addition to the above-mentioned activities related to operation and maintenance, surveillance and training, four specific 'project activities' occur to ensure this goal. These are:

- Flood Studies

- Dam Safety Reviews
- Planned Maintenance Program
- Other Safety Projects

8.1 Flood Studies

In August 1990, the Corporation commissioned the Department of Primary Industries, Water Resources Business Group to undertake the Brisbane River and Pine River Flood Study. The need for the study 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.

The Executive Summary Report was tabled in draft in December 1994, and in final copy version in 1997. The report detailed numerous conclusions and recommendations that have been prioritised for action (or no action).

In 2000, SKM and Hydro Tasmania carried out a preliminary portfolio risk assessment of the three dams owned by SEQWater. One of the key risks identified by this assessment was flood risk for Wivenhoe Dam. The Wivenhoe Alliance was formed and consequently carried out an upgrade of Wivenhoe Dam to reduce flood risk. Detailed assessments were made of flooding for the upgrading works. The 5 yearly report in 2006 also recommended that flood study for North Pine be updated to assess changes in hydrological methods.

A comprehensive Table listing the recommendations, prioritisation and status is contained within Appendix E. It is intended that this Table will be updated at the end of every financial year.

8.2 Dam Safety Reviews

The actions undertaken in relation to dam safety and licensing of the dams are summarised below:

In 1994, the Dam Safety Manager of DNR advised that DNR will not licence a dam with known deficiencies. Full Dam Safety Reviews had not been undertaken for the Corporation's dams at that time.

In 1995, Safety Reviews of North Pine Dam and Somerset Dam were carried out by Gutteridge Haskins & Davey and the Hydro Electric Commission Enterprise Corporation. Both dams were rated "Conditionally Poor" using the USBR Safety Evaluation of Existing Dams (SEED) methodology.

This rating means "a potential dam safety deficiency is recognised for unusual loading conditions which may realistically occur during the expected life of the structure. CONDITIONALLY POOR may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency; further investigations and studies are necessary." The Reviews highlighted areas of concern, and made a substantial number of recommendations, including the need for obtaining construction material parameters.

The Safety Reviews were peer reviewed by R Russo Consultants who reported some disagreements with the GH&D/HECEC methodology and noted that, in his opinion, in the cases where the original consultants deemed the structure not to comply with ANCOLD guidelines that they in fact did, or were “probably safe”.

The recommendations of GH&D/HECEC have been tabulated and prioritised for action, and are included in Appendix B of this document. Note that in some cases, it has been decided not to accept the recommendation. The prioritisation process was based on a feeling of an assessment of the criticality of the recommendation and the cost of the recommendation ie a pseudo risk assessment.

A program of works was developed and every budget since 1995/96 has contained items of work from the program.

In 1997, a Safety Review of Wivenhoe Dam was undertaken and similar steps to those outlined above were taken.

In 1999, a Preliminary Risk Assessment consultancy was awarded to Sinclair Knight Merz in conjunction with the Hydro Electric Commission Enterprise Corporation to assess the portfolio of dams and associated risks and consequences of those risks to (amongst other reasons) give greater weight to the prioritisation process. The report detailed numerous conclusions and recommendations, which have been prioritised for action (or no action). A comprehensive Table listing the recommendations, prioritisation and status is contained within Appendix C. It is intended that this Table will be updated at the end of each financial year.

Detailed Risk Assessments of the recommendations of the above report have being undertaken. As these reports are done, the recommendations and actions are included in Appendix D.

Between 2002 and 2004, SMEC completed a detailed risk assessment for Somerset Dam

As per the Dam Development Permit Conditions, the dates for the next Dam Safety Reviews are as follows:

Wivenhoe Dam – October 2017

North Pine Dam – October 2015

Somerset Dam – October 2015

8.3 Planned Maintenance Program

The O peration and Maintenance Contract has a requirement for the Contractor to prepare, in conjunction with the Corporation, each March during the period of the Contract an Annual Report on Planned Maintenance. The Report identifies for each dam observations of deteriorating condition or performance of various components or scope for enhancements to improve efficiency, economy or safety of operations.

The Report covers all aspects including civil works, electrical and mechanical works such as painting, plant refurbishment, plant replacement, automation or upgrades and instrumentation.

The Report makes recommendations for planned maintenance activities in the coming year with cost estimates together with proposed methods of implementing the work including details of any proposed sub-contracts. Indicative timing for carrying out such work are also provided.

When agreement is reached on the scope of works, the Planned Maintenance is approved for implementation.

A rolling plan for longer term maintenance for a period up to 2010 has been prepared.

Another significant feature of the O&M contract is that the Corporation is not bound to use the Contractor in any role for any planned maintenance and reserves the right to make other arrangements to carry out planned maintenance at its sole discretion. This feature is used for discrete projects.

8.4 Other Safety Projects

As noted in (c) above, the Corporation reserves the right to undertake dam maintenance/safety projects outside of the O&M contract. This feature allows flexibility for the Corporation in its operations. Typical projects that have been undertaken this way are the refurbishment of the 70 tonne gantry crane at North Pine Dam and the reconstruction of the right embankment and two saddle dams at North Pine Dam.

8.5 Current Safety Projects

In 2006, a comprehensive dam safety inspection of the three dams owned by SEQWater was carried out by representatives from the NSW Department of Commerce and NSW State Water. Key recommendations from this inspection are presented in Appendix F.

Key projects to come out of this inspection include:

- Updating of the risk assessments for the three dams; and
- Updating the hydrology for North Pine Dam.

Appendix A. Reports and Investigations

North Pine Dam

In respect to the Dam design and construction the following reports and investigations have been undertaken. The classification number is the reference number in SEQWater Records Section.

Classification No	Title	Author
Flood Studies		
FM015	Brisbane River and Pine Rivers Flood Study North Pine Dam Post Dam Flood Frequency Analysis Report No 5 – December 1991	DPI
FM027-V1	Brisbane River & Pine River Flood Studies Pine River System Hydraulic Model: Interim Report on North Pine Dam Break Analysis Volume 1 April 1993	DPI
FM027-V2	Brisbane River & Pine River Flood Studies Pine River System Hydraulic Model: Interim Report on North Pine Dam Break Analysis Volume 2 April 1993	DPI
FM027-V3	Brisbane River & Pine River Flood Studies Pine River System Hydraulic Model: Interim Report on North Pine Dam Break Analysis Volume 3 April 1993	DPI
FM028	Brisbane River and Pine River Flood Studies Report No 10 North Pine Dam: Rating of Spillway Gates. April 1993	DPI
FM055	Sth East Qld Water Corporation Report on Data Collection Network at Somerset Dam, Wivenhoe Dam and North Pine Dam – April 2001. Project: E-01299(1). Contract T5-95/96	DPI
FM057-V2	Brisbane River and Pine River Flood Study: Report No 4b. Pine River Hydrology Report Design Flood Estimation Volume 2 August 1991	DPI
FM059-V1	Brisbane River and Pine River Flood Studies Report No 11a. Pine Rivers System Hydraulic Model Report – North Pine Dam Dambreak Analysis Volume 1 June 1993	DPI
FM061-V1	Brisbane River and Pine River Flood Studies Report No 14a. Pine Rivers System Hydraulic Model Report – Sideling Creek Dam Dambreak Analysis	DPI

	Volume 1 October 1993	

Dam Studies		
WS153	Geotechnical Investigations – North Pine Dam Factual Report on Geotechnical Investigations December 1997	GHD
WS154	Geotechnical Investigations – North Pine Dam – Report on Additional Geotechnical Investigations on the Dispersiveness of the Embankment Materials – April 1998	GHD
WS158	Geotechnical Investigations – North Pine Dam – Factual Report on Geotechnical Investigations – December 1997	GHD
WS162	Safety Review – North Pine Dam September 1995	GHD
WS187	Report – Radial Gate Piers Structural Adequacy Assessment North Pine Dam – September 1999	DNR
WS195	Report on the Piping Potential of North Pine Dam Saddle Dam No 1 – October 1999	HECEC
WS208	Preliminary Risk Assessment Wivenhoe, Somerset and North Pine Dams Final Report March 2000	SKM/HEC
WS219	North Pine Dam – Remedial Works on Embankments Factual Report on Construction Works – May 2000	GHD
WS239	North Pine Dam – Factual Report on Geotechnical Information North Pine Saddle Dam No 1 August 1999	GHD
WS256	Gate Reliability Assessment – North Pine Dam Final Report June 2001	AWT
?	Report for North Pine Dam – Dam Monoliths Structural Adequacy Assessment – July 2002	Sunwater
?	Geotechnical Investigation for the Earthfill Embankments of the North Pine Dam Abutments and Saddle Dams – June 2002	Qld Gov – Dept. Main Roads
WS 274	Report on North Pine Dam Embankments and Saddle Dams – Further investigation of Piping Potential and Preliminary Design for Piping Protection – September 2002	Sunwater

Somerset Dam

In respect to the Dam design and construction the following reports and investigations have been undertaken. The classification number is the reference number in SEQWater Records Section.

Classification No	Title	Author
Flood Studies		
FM021-V1	Hydrology Report for Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam. Volume 1 – Report January 1985	DPI
FM023-V1	Brisbane River and Pine River Flood Study: Report No 17a. Brisbane River System Hydraulic Model Report – Somerset Dam – Wivenhoe Dam Hydraulic Model Calibration. Volume 1 May 1994	DPI
FM032	Brisbane River and Pine River Flood Studies. Brisbane River Flood Hydrology: Final Draft Report on Somerset Dam – Dam Failure Models June 1994	DPI
FM033-V1	Brisbane River and Pine River Flood Study: Report No 21a. Brisbane River System Hydraulic Model Report – Somerset Dam – Dam Failure Analysis Volume 1 June 1994	DPI
FM045	Hydrology Report for Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam – January 1985.	DPI
FM062	Brisbane River and Pine River Flood Study: Report No 20, Brisbane River System Hydraulic Model Report – Somerset Dam – Dam Failure Modes Volume 1 June 1994	DPI
Dam Studies		
WS163	Safety Review – Somerset Dam September 1995	GHD
WS208	Preliminary Risk Assessment Wivenhoe,	

	Somerset and North Pine Dams Final Report – March 2000	SKM/HEC
TS311	1996 Somerset Dam Safety Review 5th August 1996 Comments by R Russo	R. Russo
WS 19/7/3	Geotechnical Investigations and Recommended Piezometer Locations	GHD
	Somerset Dam – Detailed Risk Assessment Stage 1 – 5th February 2003	SMEC
	Somerset Dam – Detailed Risk Assessment Stage 2 – August 2004	SMEC

Wivenhoe Dam

In respect to the Dam design and construction the following reports and investigations have been undertaken.

Classification No	Title	Author
Flood Studies		
FM020	Brisbane River and Pine River Flood Studies. Report on Warragamba Dam EIS Flood Study. Report No 6. April 1992	
FM021-V1	Hydrology Report for Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam. Volume 2 – Appendices. January 1985.	
FM022-V1	Brisbane River and Pine River Flood Studies. Brisbane River Flood Hydrology Report: Interim Report on Design Flood Estimation. Volume 1. March 1993.	
FM022-V3	Brisbane River and Pine River Flood Studies. Brisbane River Flood Hydrology Report: Interim Report on Design Flood Estimation. Volume 3 March 1993.	
FM022-V4	Brisbane River and Pine River Flood Studies. Brisbane River Flood Hydrology Report: Interim Report on Design Flood Estimation. Volume 1. March 1993.	
FM023-V1	Brisbane River and Pine River Flood Study: Report No 17a. Brisbane River System Hydraulic Model Report – Somerset Dam – Wivenhoe Dam Hydraulic Model Calibration. Volume 1 – May 1994	
FM034	Brisbane River & Pine River Flood Studies Brisbane River System Wivenhoe dam – Moreton Bay Hydraulic Model: Final Draft Report on Wivenhoe Dam Failure Modes. Report No 22. July 1994 Report on North Pine Dam Break Analysis Volume 3 April 1993	
FM035-V1	Brisbane River and Pine River Flood Study Brisbane River System Wivenhoe Dam – Moreton Bay Hydraulic Model: Final Draft Report on Wivenhoe Dam Failure Analysis. Volume 1 October 1994.	

Classification No	Title	Author
	Spillway Gates. April 1993	
FM036-V2	Brisbane River and Pine River Flood Study Brisbane River System Wivenhoe Dam – Moreton Bay Hydraulic Model: Final Draft Report on Wivenhoe Dam Model Calibration. Volume 2 October 1994.	
FM036-V3	Brisbane River and Pine River Flood Study: Report No 23c. Brisbane River System Hydraulic Model Report – Derivation of Wivenhoe Dam Discharges. Volume 3 October 1994	
FM036-V4	Brisbane River Flood Study Brisbane River System Wivenhoe Dam – Moreton Bay Hydraulic Models: Final Draft Report on Wivenhoe Dam Model Calibration. Volume 4 October 1994	
FM036-V5	Brisbane River Flood Study. Brisbane River System Wivenhoe Dam – Moreton Bay Hydraulic Models: Final Draft Report on Wivenhoe Dam Model Calibration. Volume 5 October 1994.	
Dam Studies		
WS013	Progress Report to Premier's Department State Government of Queensland for Phase 2 of the Wivenhoe Dam Seismic Surveillance Project Report WDSSP-4. August 1983.	
WS015	Interim Report to Premier's Department State Government of Queensland for Post-Impounding Stage of the Wivenhoe Dam Seismic Surveillance Project July-October 1984. Report WDSSP-7.	
WS016	Interim Report to Premier's Department State Government of Queensland for Post-Impounding Stage of the Wivenhoe Dam Seismic Surveillance Project Jan – Jun 1984. Report WDSSP-6.	
WS017	Interim Report to Premier's Department State Government of Queensland for Post-Impounding Stage of the Wivenhoe Dam Seismic Surveillance Project Mar 1997 to April 1991 Report WDSSP-3.	
WS062-C1	A Comprehensive Evaluation of the Proposed Wivenhoe Dam on the Brisbane River	
WS082	Post-construction Report on Wivenhoe Dam. September 1995.	

Classification No	Title	Author
WS094	Wivenhoe Dam Design Report Volume 1 – Text	
WS094-V2	Wivenhoe Dam Design Report –Volume 2 – Drawings	
WS138	Report on the Feasibility Study of a Hydroelectric Scheme at Wivenhoe Dam September 1997	
WS174	Wivenhoe Dam Seismic Surveillance Network Operational Report to June 1994.	
WS222-C1	Report on Seismic Assessment of the Radial Gates, Piers and Bridges – Wivenhoe Dam	
WS231-V1	Engineering Feasibility Study into Augmentation of the Flood Passing Capacity of Wivenhoe Dam Volume 1 – Phase Two Report	
WS231-V2	Engineering Feasibility Study into Augmentation of the Flood Passing Capacity of Wivenhoe Dam Volume 1 – Phase One Report	
WS242	Report on Embankment Foundation Soils and Sources of Construction Materials for Wivenhoe Dam Queensland Co-Ordinator General's Department – August 1977.	
WS243	Report on Sources of Construction Materials for Third Stage Construction of Wivenhoe Dam Queensland Co-ordinator General's Department Reprinted June 1979	
WS244	The Geology of Wivenhoe Dam Site Report and Logs of Drill Holes Queensland Co-ordinator General's Department Part 1 of 3 (December 1976)	
WS245	The Geology of Wivenhoe Dam Site Report on Logs of Drill Holes Queensland Co-ordinator General's Department Part 2 of 3 (December 1976)	
WS246	The Geology of Wivenhoe Dam Site Report and Logs of Drill Holes Queensland Co-ordinator General's Department Part 3 of 3 (December 1976)	
WS254	Wivenhoe Saddle Dam Geotechnical Investigation Factual Geotechnical Report May 2001.	
WS163A	Safety Review – Wivenhoe Dam April 1997	GHD
WS208	Preliminary Risk Assessment Wivenhoe, Somerset and North Pine Dams – Final Report March 2000	

Classification No	Title	Author
		SKM/HEC
	Engineering Feasibility Study into Augmentation of the Flood Passing Capacity of Wivenhoe Dam – Report on Volume One – Phase Two Report – February 2001	GHD
WD	Detailed Stability Check of Spillway Retaining Wall Monoliths at Wivenhoe Dam – Final Report – June 2001.	Sunwater
WD	Summary of Available Test Data Wivenhoe Dam September 2001.	GHD
WD	Review of Soil Testing at Wivenhoe Dam, Review of Reports – July 2001.	Sunwater
WD	Review of GHD Report Report on Wivenhoe Saddle Dam Geotechnical Investigation. July 2001	Sunwater
WD	Review of Record Testing of Zone 1A Material During Construction of Wivenhoe Dam – Final Report – September 2001.	Sunwater

Appendix B. Dam Safety Reviews

Classification No	Title	Author
NPD DS	Safety Review – North Pine Dam – September 1995	GHD
SOM DS	Safety Review – Somerset Dam – September 1995	GHD
WIV DS	Safety Review – Wivenhoe Dam – April 1997	GHD

NORTH PINE DAM SAFETY REVIEW – *STATUS AT April 2007*				
No	Recommendation	Priority	Date Complete	Comments
1.	If the missing design and construction records are not found then investigations be undertaken to determine the actual properties of the materials in the dam and its foundation. These investigations would include.			
1a.	Concrete dam: - Drilling not less than three holes through the dam and at least 20 m into the foundation with core recovery. The core should be at least 100mm diameter. - Undertake laboratory testing on the core to determine the density of the concrete and rock, and the strength of the concrete and rock. - Undertake borehole camera inspections down the holes. - Install plumb-bob tilt meters and additional piezometers in the holes when drilling is completed.	M	1999	Completed 1999 Completed Not considered necessary Not considered necessary
1b.	Rolled fill dams: - Selection of representative sites and determine the gradation of the rip rap on the dams. - Undertake investigations to determine the properties of the rolled fill and foundations. This will require at least three boreholes in each abutment and one borehole in each saddle dam. Insitu permeability tests may be undertaken in the boreholes. - Undertake laboratory testing to define the properties of the rolled fill and foundation. This testing may include: - Atterberg limits, Emerson crumb, pinhole, insitu density and moisture content, particle size, grading including hydrometer, shear strength and permeability.	M	1998 1998 1998 1998	Completed 1998 Completed 1998 Completed 1998 Completed 1998

	- Install piezometers in the left and right rolled fill abutments in at least two cross sections in each abutment and at the maximum section in the saddle dams. At least three piezometers would be installed at each cross section.			Pending outcome of risk assessment. Bore holes already installed.
2.	Calibrate the Bourdon gauges in the gallery and where defective gauges are found replace them. Determine whether flow is occurring into the uplift cell installations by monitoring the flow occurring when the gauges are removed.		1998	Completed
3a.	When the properties of the dam are known and the uplift behaviour is known the structural analysis should be repeated with the known piezometric levels and potential variations, and actual design parameters for the dam.	L		Undertake in comprehensive inspection in 2005
3b.	Undertake detailed structural analysis of the gate piers to assess the behaviour of the piers under various degrees of loss of prestress and under earthquake and normal reservoir loading.	M	1999	Completed 1999. Piers OK
4.	Determine the structural adequacy of the gates under earthquake loading and the requirements to ensure that they meet current practice standards.	L		Not an outcome of preliminary risk assessment. Review with comprehensive inspection 2005.
5.	Inspect the spillway bucket & rip rap after pumping out the bucket.	L		Include in next dam safety inspection 2015
6.	Every monolith joint should be identified in the gallery by the monolith no on each side.		1996	Completed 1996
7.	The trees on the left and right abutments and saddle dams should be removed.		1996	Completed 1996
8.	The sump pumps should be calibrated to ensure that they have a combined capacity of at least 1200 l/minute.	M		Combined capacity is 398l/m. No further action.
9a.	Uplift monitoring be undertaken at monthly intervals.		Ongoing	Commenced 1997
9b.	The behaviour of the uplift gauges be reviewed again 12 months after the gauges have been calibrated.		Yes	Data reviewed annually and in next comprehensive inspection in 2005
10.	Cavitation damage in the spillway chute should be repaired.	L		Repairs done when highlighted by annual inspections

11.	Undertake deflection / deformation surveys of the dam crest including saddle dams and within the galleries.		Yes	Yearly deformation surveys have been reintroduced from 1998
12.	Ultrasonic thickness surveys be undertaken on the outlet pipe to assess whether there has been any reduction in steel thickness due to corrosion and a core of the mortar lining be taken to assess whether the lining is still alkaline and protecting the steel.		1998	Pipe inspected in 1998

The priority in the Table was assigned prior to a risk assessment being undertaken and given as either low (L), medium (M) or high (H).The 1998 annual safety inspection highlighted the possibility of loss of material on the downstream side of the right embankment, and this material was found to be dispersive. A filter layer was placed on the downstream side of these embankments, with this work being completed in late 1999.

SOMERSET DAM SAFETY REVIEW – *STATUS AT APRIL 2007*				
No.	Recommendation	Priority	Date Complete	Comments
1.	In order to assess the extent of the deterioration it is recommended that:			
1a.	Measurements of pH, dissolved gases, water temperature and sulphate be undertaken in the reservoir water at various depths and times of the year at the dam. In addition the saturation index or Longellier Index should be calculated. Cores be taken from the concrete in the upstream face of the dam to test for deterioration or loss of cement.	M		Undertake in comprehensive inspection in 2005.
1b.	Cores be taken from the gate pier concrete for testing to assess whether alkali aggregate reaction is occurring.	M		Undertake in comprehensive inspection in 2005.
1c.	The joint opening between Monoliths L/M be monitored at the deck level, upper gallery level, and lower deck level. If movement is not continuing over a 1 or 2 year period the joint should be repaired and the water stop reinstated.	M		Review during annual inspections
1d.	The caps on the drilled foundation drainage holes should be removed and replaced with 90º elbows and the rate of seepage from each drain monitored.	H	Dec1998	Drain flushing only necessary
1e.	The emergency coaster gate be repaired or replaced to provide a gate that can be safely placed in flowing water.	M		Design check & field test in 2001. Gate is safe
2.	In order to “prove” the stability model assumptions about drainage, uplift, rock joint strength, cracking, concrete strength and density it is recommended that investigations be undertaken. These investigations should involve drilling and recovery of core with a diameter of not less than 100mm. This drilling will include:			
2a.	At least five holes through the dam with some holes extending about 20m into the foundation.	M		Completed 2000
2b.	At least 3 boreholes in the left and right abutment near the toe of the dam to a depth of about 10m and at least two sub-horizontal holes drilled into the dam from the dam abutments to inspect cracking and the quality of the concrete foundation interface.	M		Completed 2000

SOMERSET DAM SAFETY REVIEW – *STATUS AT APRIL 2007*				
No.	Recommendation	Priority	Date Complete	Comments
2c.	Bore hole camera inspection of the holes in the dam and abutment to define cracking, joint orientation and opening.	M		Not considered necessary
2d.	6 holes in the left and right dissipator retaining walls to determine the properties & depth of the backfill and monitor water levels.	M		Not considered necessary
2e.	Inspection of the floor of the dissipator to assess its current condition and if practical undertake drilling in the floor to assess the quality of the concrete/rock interface, and install piezometers to determine uplift pressures beneath the dissipator floor.	M		Inspection completed 1997
2f.	Inspect the drain/weep holes in the floor of the dissipator and assess whether they are working and whether high velocity flow could enter the holes. Map the position of the holes.	M		Inspection completed 1997
3a.	It is recommended that a crack survey be undertaken to locate the position and extent of all visible cracks in the dam. This survey should be in sufficient detail to enable new cracks to be identified in the future.	M		Completed 1999
3b.	It is recommended that the frequency of the current crack monitoring in the upper gallery be undertaken at one month intervals rather than weekly.		1996	Complete
4.	To prevent entry of water into the gallery it is recommended that:			
4a.	A bulkhead gate be designed, supplied and installed at the access door to the upstream regulator/trashrack platform.	M	2002	Completed in 2001
4b.	The importance of the bulkhead gate be fully understood by all staff at the dam and that it should be installed & removed as part of the regular safety inspection.	H	1996	Included in Operator training
4c.	The reflux valve on the sump pump outlet pipe be regularly inspected and maintained.		1996	Included in Routine Maintenance
5.	It is recommended that the following instrumentation be installed to allow effective monitoring of the structural performance of the dam:			
5a.	Piezometer at 5 sections in the dam. These should be located at the following points in the dam:	M		Completed 1999

SOMERSET DAM SAFETY REVIEW – *STATUS AT APRIL 2007*				
No.	Recommendation	Priority	Date Complete	Comments
	- Upstream of the grout curtain, about 5 m upstream of the grout curtain and about 1 m below the "cut-off" level. - Between the grout curtain and drilled drainage holes. - Between the upstream foundation drain and upstream foundation tunnel. - At the downstream toe of the dam.			
5b.	It is recommended that thermometers be installed in the dam to measure the change in response of temperature with depth into the concrete. This should be compared with deformation monitored using plumb bobs and precise survey of the crest.	L		Temperature recorded by Piezometers therefore complete.
5c.	Piezometers in each of the six boreholes drilled behind the dissipator retaining walls.	L		Review in next Dam Safety Review in 2015
5d.	Piezometers in the floor of the dissipator to monitor uplift.	L		Review in next Dam Safety Review in 2015
5e.	Carry out a precise survey at the location surveyed in the early 1980's, and then at six monthly intervals in the winter and summer.	M		Completed in 1999 & surveyed annually
5f.	Install plumb bob monitoring in the drill holes installed from the crest of the dam and intersecting the lower gallery.	L		Review in next Dam Safety Review in 2015
5g.	Install surface movement points on the crest of the dam and along the downstream toe of the dam.	M		Crest points installed 1999
5h.	Install a water meter on the sump pump system to monitor the quantity of water seeping into the under drains and take water samples at six monthly intervals and undertake certain analyses to assess deterioration of the grout curtain.	L		Completed in July 2001
6.	About 12 months after installing the monitoring system review the data collected and reassess the stability of the dam. It is recommended that a study be undertaken of the flood limits likely to access to the site during extreme flood events, this study would also result in an improved knowledge of the tailwater levels likely to exist at the dam.	L		Review in next Dam Safety Review in 2015
7.	Until detailed investigation and		1996	Complete

SOMERSET DAM SAFETY REVIEW – *STATUS AT APRIL 2007*				
No.	Recommendation	Priority	Date Complete	Comments
	analyses are completed it is recommended that the imminent failure flood level be adopted as RL 105.7 if the radial gates are closed and RL 109.1 if the radial gates are open.			

WIVENHOE DAM SAFETY REVIEW – *STATUS AS AT APRIL 2007* – CAPITAL WORKS				
No.	Recommendation	Priority	Date Complete	Comments
1.	**Mechanical/Electrical**			
a.	The feasibility of converting the gates to automatic operation be investigated.			Automatic operation not considered economical
b.	That consideration be given to refurbishing the control system to provide condition monitoring.	H	1996	Completed 1996
c.	That means of improving the security of the hydraulic pipework be investigated.	M	2000	Completed 2000
d.	That a system of valving and quick connect oil pressure fittings be provided at each winch and thereby permit the connection of an emergency oil supply system.	M	2000	Completed 2000
e.	That the diesel hydraulic unit be re-located to the surface/or be converted to a mobile unit.	M	2000	Completed 2000
f.	That consideration be given to re-locating the main hydraulic unit and control panels to a higher level in the building.	M	July 1999	The room containing this equipment has been waterproofed – no further action.
g.	That consideration be given to providing a sheltered control station or control room near the present control complex.			Not considered necessary
h.	That consideration be given to providing on-line alternative oil supplies, and improved drainage system including an oil separator.	M		Included with 1b, c, d.
k.	That the fuel system be upgraded to be more accessible, and to reduce the fire risk from leaks.	H	July 1999	Completed
l.	That the adequacy of the system be reviewed by a fire detection and control expert.	H	July 1999	Completed
m.	That consideration be given to upgrading the ventilation provisions of the underground control complex and running the system continuously.	M		Fire safety equipment upgraded in 2000.
n.	That consideration be given to improving the system for delivering fuel to the diesel operated oil pump.	M	1996	Completed 1996
o.	That the adequacy of the intruder detection system be reviewed and that the alarms be interconnected to a	M		Security system with dial out completed in 2001

WIVENHOE DAM SAFETY REVIEW – *STATUS AS AT APRIL 2007* – CAPITAL WORKS				
No.	Recommendation	Priority	Date Complete	Comments
	paging system which will alert operators, a security firm or the police.			
p.	That operators be equipped with hand held radios for use while operating the spillway gates.	H	1997	Completed 1997
q.	That gate position indicators be investigated.	L		Installed 2000
r.	That tests be conducted to determine whether a single hoist would be capable of moving a gate safely under emergency conditions.	H	July 1999	Discussions held with DNR design staff – one winch will hold gate – no further action.
s.	Consideration be given to ensuring the duplicate hydraulic pumps be made flood proof.	H	August 1999	Included with 1b, c, d.
t.	That consideration be given to improving the fail safe nature of the Main Switchboard.	M		Inspections done during annual condition monitoring
u.	A review of the load bank size be undertaken.	L		Planned Mntce in plan to 2010.
v.	Review of the location for the outlet works distribution board be undertaken as it is below tailwater level and could be at risk if the dewatering pumps fail.	L		Regular inspection and operation is done on dewatering pumps
w.	A review of the UPS power supply standby time be undertaken to see if it is adequate.	H		Overhauled 2000
x.	The position sensors be installed on each side of each gate.	H		Position indicators connected to flood alert in 2001
2.	**Civil**			
a.	Block numbers are painted on each side of each spillway section block joint allow easy reference to location for all gallery joints, weeping drains or cracks in future inspections.	L	July 2003	
c.	The effectiveness of the spillway flip bucket drainage system be investigated further (section 11.1.1)	M		Review in comprehensive inspection 2005
d.	The radial gates, winches and bridges be checked for seismic loading. Radial gates of this size (16.5m high) have the potential to produce a significant flood wave if they breach (section 12.8.6)	M	Dec 1999	Structurally ok refer Report WS222-C1
e.	Data is obtained for the performance of	Nil	1999	Observed in Feb 99

WIVENHOE DAM SAFETY REVIEW – *STATUS AS AT APRIL 2007* – CAPITAL WORKS				
No.	Recommendation	Priority	Date Complete	Comments
	the spillway, specifically the flows and gate openings with time during the 1991 event and any other data which may be of used such as video or photographs of spill (section 12.9.4).			flood
f.	Vibration monitoring is installed on the radial gates and concrete structure to monitor any vortex formation and gate performance. This should be installed prior to the next spill event (section 12.9.4).	M	1999	Observed in Feb 99 flood. Not considered necessary.
g.	Surveys of the stilling basin before and after flood events are taken to quantify the amount of erosion. These surveys should include the upper level berms. Details on the repairs undertaken (if any) after the 1991 flood should be obtained (section 12.9.5).	M	Dec 1999	Will be resurveyed after each significant flood event.
h.	The flood immunity of the spillway gate control equipment is checked for extreme flood events (section 12.9.6).			As per 1f
i.	The spillway retaining wall monoliths are checked for stability, particularly in light of current earthquake and “at rest” pressure design methods (section 12.9.7).	L		Design check complete in 2001
3.	**Embankment General:**			
a.	Soil properties are confirmed using as placed strength data. This is particularly important for the rolled sandstone fill as the as placed properties will differ from the excavated properties because of particle breakdown (section 12.8.3.2).	L		Not considered necessary.
b.	The alluvium properties are obtained (section 12.8.3.2).	L		Report by GHD Review by Sunwater
c.	Soil properties are obtained for the actual core material used. It is possible	L		Report by GHD

WIVENHOE DAM SAFETY REVIEW – *STATUS AS AT APRIL 2007* – CAPITAL WORKS				
No.	Recommendation	Priority	Date Complete	Comments
	that soil tests relate to borrow area not utilised in construction (section 12.8.2).			Review by Sunwater Strength is adequate.
e.	A review is made of all available soil strength tests and quality control records to determine the actual strength of the embankment as placed (section 12.8.3.6).	L		Report by GHD Review by Sunwater
f.	An investigation into the seepage profile through the embankment is required to determine the actual phreatic surface. This would include a review of the materials used in the downstream shoulder to determine the actual pore pressure profile (section 12.8.3.6).	L	yes	Investigation done Monitor during annual inspections
g.	The embankment is monitored closely following extensive drought periods. This will include monitoring of piezometric levels of the main embankment at least twice weekly during flood and visual inspection of the upstream shoulder (section 12.8.3.6).	L		Piezometric levels read on monthly basis
4.	**Right Bank Section.**			
a.	The reason for the presence of the fine zone in the rip rap on the upstream face approximately halfway between the spillway and the right abutment is investigated further (section 13.8.2).	M	1996	Complete. Material was from access ramp on top of the riprap
d.	The seepage in the right bank of the diversion cut at the foundation contact be monitored with a V notch weir or similar (section 13.8.2).	H	Yes	Review during annual inspection in October each year
f.	The reason for the zone of fine material in the rip rap half way between the right abutment and the spillway on the downstream face be investigated. It is also recommended that this area should be closely watched until appropriate remedial	H	1996	Complete. Material was from access ramp on top of the riprap.

WIVENHOE DAM SAFETY REVIEW – *STATUS AS AT APRIL 2007* – CAPITAL WORKS				
No.	Recommendation	Priority	Date Complete	Comments
	action is taken in the event that the fines have been washed out from the shoulder (section 13.8.2).			
g.	The effectiveness of the drainage system downstream of the core is investigated in light of the increasing pore pressures in the filter at chainage 1800 (section 11.1.2.2).	H	Yes	Review during annual inspection in October each year
5.	**Left Bank Section**			
e.	The concrete manholes installed at regular intervals along the left abutment section toe are investigated further to define where they drain from and whether they should be monitored (section 13.8.3).	H	2002	Complete
6.	**Saddle Dam 1**			
c.	The unusual animal burrows over a large area of the lower part of the downstream shoulder of saddle dam 1 are dug out and recompacted to stop rainfall and runoff from entering the dam structure (section 13.8.4).	M	1998	Complete
d.	The bare patch on the downstream shoulder of saddle dam 1 is recompacted and sowed with grass (section 13.8.4).	M	1998	Complete
e.	Soil testing be undertaken or that the construction testing is investigated to determine whether the soil used for saddle dam 1 is dispersive (section 13.8.4).	M		Complete. Refer Sunwater Reports
f.	Set wheel tracks on the downstream shoulder of saddle dam 1 be repaired so that an erosion gully does not form in them (section 13.8.4).	M	1998	Complete
7.	**Saddle Dam 2**			

WIVENHOE DAM SAFETY REVIEW – *STATUS AS AT APRIL 2007* – CAPITAL WORKS				
No.	Recommendation	Priority	Date Complete	Comments
a.	The long grass on saddle dam 2 (furthest from the main dam) be slashed or mowed to allow easy detection of seepage or erosion (section 13.8.5).	M	1998	Complete and on-going
b.	A zone of 10 meters or so should be cleared of trees on the upstream and downstream toe if saddle dam 2. This includes the large dead tree at the downstream toe (section 13.8.5).	M	1998	Complete
c.	The downstream shoulder and toe of saddle dam 2 is fenced off from vehicles and stock and the track graded in on the left abutment is removed. The original profile of the dam should be re-established and resown with grass (section 13.8.5).	M	1998	Complete
8.	**Outlet Works** It is recommended that a detailed inspection of the corrosion protection of the inside of the penstock be undertaken	M	May 1999	Complete

WIVENHOE DAM SAFETY REVIEW – *STATUS AS AT APRIL 2007* – GENERAL MAINTENANCE				
No.	Recommendation	Priority	Date Complete	Comments
1.	**Mechanical/Electrical**			
i.	Replacement oil be purchased in advance and stored on site as reserve oil for the system.	H	1997	Review during annual inspection in October each year
j.	Consideration be given to providing oil containment and oil clean up materials.	L		As above
2.	**Civil**			
b.	The drain on the stairs of the upper gallery which is still filled with polystyrene foam (possibly from construction) is cleared out (section 13.8.1). The tree at the toe of left side spillway training wall should be removed (section 13.10)	L		As above
j.	Appropriate water safety buoys and	L		As above

WIVENHOE DAM SAFETY REVIEW – *STATUS AS AT APRIL 2007* – GENERAL MAINTENANCE				
No.	Recommendation	Priority	Date Complete	Comments
	booms be placed across the entrance to the spillway.			
3.	**Spillway Section.**			
d.	The rip rap condition be monitored following significant wind storm events. (section 12.8.1)	M	Yes	As above
4.	**Right Bank Section.**			
b.	One or two trees are removed on the downstream shoulder of the right abutment section (section 13.8.2).	M	Yes	As above
c.	The erosion of the far right abutment section above the diversion cut is repaired and monitored after significant rainstorms. In the event that the erosion gets much worse rockfill or concrete drop structures may be required in the formed drain (section 13.8.2).	M	July 1999	Review during annual inspection in October each year
e.	The seepage from the top of the shotcrete protection in the Brisbane River section be closely monitored and that the effect of this on the overall stability of the dam be investigated (section 13.8.2).	M	Yes	Review during annual inspection in October each year
5.	**Left Bank Section**			
a.	Removal of a few trees in a zone 10 metres from the toe of the left embankment section is undertaken (section 13.8.3)	M	1997	As above
b.	The creeper on the upstream face near the left abutment be poisoned so that the performance of the rip rap can be inspected and monitored and the reason for the undersized rip rap determined. Area of insufficient or undersized rip rap in this section will have to be repaired with a cover of suitable rock (section 13.8.3).	M	1997	As Above
c.	The drainage of the seepage at the toe of the highest section in the left abutment section is improved by cleaning out and regrading the drainage bank. The installation of a monitoring weir for this seepage is also required (section 13.8.3).	M	July 1999	Completed and review during annual inspection in October each year
d.	The substantial open drain from the toe of the left abutment section is cleaned out. The inflows into this drain should be investigated and a monitoring weir should be installed if this drain conducts seepage from the dam (section 13.8.3).	M	July 1999	Completed and review during annual inspection in October each year

WIVENHOE DAM SAFETY REVIEW – *STATUS AS AT APRIL 2007* – GENERAL MAINTENANCE				
No.	Recommendation	Priority	Date Complete	Comments
6.	**Saddle Dam 1**			
a.	The long grass on saddle dam 1 (close to the main dam) be slashed or mowed to allow easy detection of seepage or erosion.	H	1997	As above
b.	A zone of 10 metres or so should be cleared of trees on the upstream and downstream toe of saddle dam 1 (section 13.8.4).	H	1997	As above
7.	**Saddle Dam 2**			
d.	The erosion gully forming from the left abutment towards the toe of saddle dam 2 is backfilled and monitored following rain storms (section 13.8.5).	M	1997	As above
e.	The minor runoff erosion on the downstream shoulder of saddle dam 2 be monitored (section 13.8.5).	H	Yes	Completed and review during annual inspection in October each year

The priority in the Table was assigned prior to the risk assessment being undertaken. In this case the priority was given as either low (L), medium (M) or high (H).

Appendix C. Preliminary Risk Assessment

Table of Proposed 'Fixes' with Corporation Comments

Dam	Consultant's Proposed 'Fix'	Estimated Cost	Corporation Comments
North Pine	Downstream filter on Right Embankment and Saddle Dam No 2 & 3 (GHD design)	$0.9m	Work Completed
Wivenhoe	Improve reliability of Spillway Gates (GHD design)	$0.13m	Work Completed
Wivenhoe	Auxiliary Spillway to enable the dam to pass the PMF	$64.2M	Alliance formed and works completed on the Stage 1 upgrade including secondary spillway at the end of 2005
North Pine	Downstream filter on the main dam left embankment and Saddle Dam No 1 and u/s blocking filters.	$0.3M on LHS Abutment	Risk assessment done in 2001/02. Peer review completed in 2002. Left hand abutment works completed by Wivenhoe Alliance. Saddle Dam 1 to be reviewed in 2008 during revision of the risk assessment.
North Pine	Cut off trench downstream of filters.	$2.00m	Risk assessment done in 2001/02. Peer review completed in 2002. Furtehr Geotech Investigations have raised concerns regarding the adequacy of the filters. To be addressed in risk assessment update in 2008.
North Pine	Improve the Spillway Gate reliability.	$0.30m	A detailed risk assessment of gate reliability completed. See Appendix D. Recommendations being implemented.
North Pine	Post-tensioning anchors in dam and gate piers.	$1.25m	Not required – see Sunwater Report.
North Pine	Fuse plug auxiliary Spillway in Right Embankment.	$16.1m	'Fix' not accepted due to low probability of gate failure (see Appendix D).
Somerset	Protective apron at foundation contact.	$1.27m	Detailed Risk Assessment completed between 2002-2004, with Peer Review completed end of 2004. Work not considered as required. To be reassessed during update of risk assessment in 2008.
Somerset	Installing post-tensioning anchors.	$1.50m	Detailed Risk Assessment completed between 2002-2004, with Peer Review completed end of 2004. Work may not be required. To be considered further during the update of the Wivenhoe Somerset Risk Assessment in 2008.
Somerset	Improve Spillway Gate reliability.	$0.30m	Detailed Risk Assessment completed between 2002-2004, with Peer Review completed end of 2004. Work not considered as required. Consider removal of the spillway

Dam	Consultant's Proposed 'Fix'	Estimated Cost	Corporation Comments
			gates.
Downstream of all dams	Develop Emergency Evacuation Plans	$1.50m	Discussions with Local Authorities and SES ongoing. Co-ordinating supply of Dam release information. Evacuation is responsibility of SES and Police.

The above Table has been incorporated into the Strategic Plan for 2001-2004.

Appendix D. Detailed Risk Assessment – North Pine Dam Gate Reliability Assessment

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
1. Recommendations	**Action**
Performance of existing equipment against required standards and Recommendations	
Main Power Supply from Brisbane City Council WTP There are no expected failures of the Brisbane City Council power substation at the Water Treatment Plant that could not be rectified within 1-2 hours by switching over to the standby transformer. The reliability of the normal supply to the dam is subject to the following: There is no alternative supply to the dam. The chance of losing the aerial power lines during a storm to the Brisbane City Council Substation should be considered. Estimated time to repair is 6-8 hours. The failure rates and duration of the failures of supply to the Brisbane City Council should be obtained from Energex's data base. An official agreement should be established with Energex and Brisbane City Council to guarantee restoration of supply within an agreed period of time. This should be in the form of a priority of service agreement, to ensure flood damage to the community downstream is minimised. The response period of time should fit in with the operational requirements of the dam to mitigate a flood event without relying on the diesel generator. How often Brisbane City Council checks and maintains their equipment should be established. If a fire was to break out in the BCC substation and damage the transformers or main switchboard how long before an alternative supply could be arranged for the Dam. This aspect should be investigated and a contingency plan should be put in place. The contingency plan should include actions by Energex, Brisbane City Council, Sun Water and SEQWater.	Separate HV line installed in 2002.
High Voltage Switchroom (At the Dam) The normal power supply should not be relied upon during a flood, as there are some single points of failure within the supply system. These are: The existing mains cable which is old. This cable should be tested every 2 years. A failure would require extensive works and considerable time to replace the cable, especially as there is no alternative supply. The Ring Main Unit taking supply from the Brisbane City Council. Maintenance, cleaning, checking cables and connections should be carried out yearly.	Replaced in 2002
The existing Hazemeyer high voltage fuse panel should be given a high priority. It should be treated as being a high risk, which could	

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
cause significant consequential damage as a result of a fault at this panel. It should also be considered as a significant risk to personnel. The high voltage cable should be provided with mechanical protection and isolation from personnel, and should be securely clamped down. Cable trays and metal covers should be solidly earthed.	Replaced in 2002
The underground routes of the high voltage cables from the Brisbane City Council switchyard in the Treatment Works to the Dam should be clearly marked with a brass marker and/or peg. Where this cable is located inside a wall, the wall should be clearly marked "Danger high voltage cable inside wall".	
It should be noted that to ensure the availability of the back-up transformer, there should be segregation between them. This would contain a fire to one transformer, stop the hot oil from spreading the fire and provide a better survival rate of the second transformer so that mains power to the Dam would remain available.	Both transformers removed due to PCB and replaced by one 11KV and Industry Standard Fire Suppression.
To achieve maximum reliability, the location of cables and terminations should also be considered. The security of power supply from one transformer should be investigated in terms of segregation and isolation between circuits and equipment of the other transformers.	A new transformer and cables were installed in 2002.
Access to the high voltage switchroom should be limited to an electrician with recognised high voltage qualifications, or supervised by an electrician with high voltage qualifications.	O & M Contractor staff are HV qualified.
There should be "Danger High Voltage" signs on all high voltage equipment, and entry to the switchroom	Signs are in place on room. Sunwater to audit.
There should be high voltage switching instructions for the site. Switching should be carried out by a suitably qualified H.V. electrician. All high voltage equipment should be labelled with switch numbers and clearly identified components. Switching instructions should include switch numbers, description of equipment and location and simple dot point procedures.	Complete
The transformers should be checked and tested yearly. This should include the connections, oil leaks, terminations and insulation, as well as the attached cabling. This should also include identifying hot spots. The oil is understood to be tested yearly under current maintenance procedures.	In place.
The existing automatic gas fire extinguishing system should be checked every 6 months along with the normal fire extinguishers, by a suitably qualified company.	Done monthly.
Control Room/Low Voltage Switchboard	
Several aspects are recommended for improvement in relation to the security in operation of the Spillway Gates and also in relation to personnel safety. Recommendations are as follows:	

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
General Segregation of all cables to meet the wiring rules and ensure there is no induced voltages. This includes segregation between high voltage, low voltage and extra low voltage. Also included should be the separation of any communications cable to meet the AUSTEL requirements and ensure personnel safety.	Complete Requirement for annual servicing of the 6.6 kV RMU is no longer required given this system is now obsolete. It has been replaced by the new 11 kV system. The Hazemeyer HV fuse panel hazards have been eliminated by the new 11kV reclosure unit (main switch) on the supply pole. Earthing system has been upgraded with the removal of the old RMU. Spillway Gate motor supplies are now on separate electrical boards. Upgrade included the addition of a spare panel. Hence associated single point of failure risk removed. Switchboards have been labelled with 415v signs. Main switch LV sign is now very visible.
The labelling of gate controls on the main control panel and local control areas should be consistent to avoid confusion, ie. up/down, open/close, stop/off. Fire detection should be installed in the control room. The operational capacity and functionality should be clearly identified. The operations manuals should be updated to suit and equipment altered and relabelled to suit the current functionality. This may require removing connections and equipment or utilising the PLC as a monitoring function only. Components such as limit switches should be checked for wear and protective devices should be tested for correct operation. It is not known how good the earthing system is on site, or how the high voltage earth is connected in relation to the low voltage system, and when it was last tested. It is recommended that this system be fully checked for continuity to ensure safe and reliable operation of protective equipment. This is important in providing a direct path for lightning and surge grounding.	Operation done at local control panel so there is no confusion. In place. Manuals have been updated and PLC to be removed. This is done every 6 months. New earth has been installed in 2001 following yearly inspection by J & P Richardson.

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
MCC - Motor Control Centre The risk to the Spillway Gates is increased by having all the starter equipment located within one panel. The voltage is 240 volt, and a major fault could damage most or all starting equipment, as it is located in the same section. The security of the Spillway Gate starters can be enhanced by placing their starters in separate modules in the MCC with take off directly from the main busbars rather than via a distribution board. This will reduce common failure modes in the form 1 section of the MCC, and also reduce the single points of failure in the distribution board. The location of this critical starting equipment would be safer and more accessible if located at normal operating height. The alarm lights presently located on the side of the MCC would be better placed on the front of an individual MCC module related to the individual gate. A lamp test pushbutton should be fitted on controls where not already existing, such as on the main control panel and the MCC	Work completed by Sunwater in 2002. Replaced
The equipment is fairly old (built in 1976) and it is suspected that the circuit breakers are a distribution type breaker and should be a motor starting circuit breaker. The fault carrying capacity and levels should also be checked to ensure the original equipment is correctly rated and that cascading will occur on fault, thereby limiting the outage to the faulty equipment. It is recommended that one of the Spillway Gate starter's protective devices be fully tested to ascertain whether they will trip correctly, and are calibrated correctly.	
This should include: The circuit breaker The TOL The limit switch settings Phase failure in auto Slack rope switch And Cam switches. If the switchboard is to be upgraded at a later date it is recommended that fuses providing protection for the power supplies be replaced with circuit breakers. This makes it safer and alleviates the need to carry and find replacement fuses, especially during a flood operation. Sufficient battery backed up lighting should be installed to allow for emergency exit and also to find and repair a failure on the	Tested twice yearly. Emergency directions installed.

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
automatic starting system of the diesel generator. It is recommended that battery backed lighting be installed in the office at the dam. It is also recommended that danger notices be placed on the MCC indicating the voltages, especially in areas that are to be used by non-electrical personnel. It is further recommended that non-electrical personnel not open electrical cabinets or operate equipment, which have uncovered terminations or wiring.	Lighting not considered necessary. Rechargeable torches at steps. Sunwater to place signs. All operators are trained for switchboard access.
Have the fuel storage, lines and associated equipment checked by a qualified person such as from a petroleum company to ensure all statutory requirements are being met and the equipment is in good condition. It is recognised that the fuel storage on site is minimal. This check will ensure compliance and also provide expert knowledge of what condition the equipment is in. It is expected that the diesel generator and the mobile unit may well be relied on to open the Spillway Gates during flood as this is the time that an outage of the normal supply is more likely to occur, ie. during stormy weather. With this in mind it is recommended that all electrical spares for the diesel generator and its controls be purchased and kept on site (clearly labelled), in the control room. This will enable the electrician to repair a minor fault quickly, which may otherwise take hours. The pre-flood check for the diesel engines is critical. It is recommended that the following be included in the routine maintenance and, in particular, the pre-flood check: All cable connections. All Switchgear to ensure available power at motors. Sufficient diesel fuel available at the dam site. The diesel engines. Batteries for starting, fully charged. That replaceable spares are available and easy to locate. Similarly all electrical spares for the mobile drive unit should be purchased to ensure minor problems can be dealt with on site, especially if the roads can be cut during a flood event. A pre-flood check of the mobile unit should also include similar checks as listed for the diesel generator above. Spares for this generator are available overnight as indicated by operations personnel. It should be verified what is kept in stock and who keeps it. This should be listed in the flood event manual as a reference. It is suggested that the normal operating ranges be marked on the diesel gauges and control panel meters or on labels beside them. This will allow the operator to foresee a potential problem without	Operations and Maintenance procedures check this. Spare control circuit components not needed to be purchased as they can be readily and promptly obtained. Tested every 6 months Tested Weekly and Pre-flood check list is used Supplier listed in Sunwater procedures. Back up not considered necessary as overnight delivery.

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
reference to a manual. The automatic fire extinguishing system should be checked at the same time as the other fire extinguishing equipment on a regular basis. This is important as a malfunction in the system could cause severe disruption to the operations of the site and possible damage to equipment. Restitution and clean up may take some considerable time and may leave the Dam at risk if a flood event is expected.	Done monthly by Contractor
It should be noted that the fire department may require specific functions of the ventilation system and fans, and availability of controls, at readily accessible locations. All main switches should be clearly identified as main switches so that they can be easily recognised by firemen in order to isolate power totally. There should be a label to this effect at the RMU.	Completed.
Be aware of relevant Environmental agency requirements to guard against accidental damage to the environment due to fuel or oil spillage that may find its way into the waterway via a drain or run-off. Also consider any drainage that may exist that could spread a fire from burning fuel or oil.	Regular environmental audits. Bund to be installed by Sunwater
Telemetry and Monitoring As the existing telephone system is known to have been washed out and also that communication is least dependable during storms some reliance is placed on the radio station to provide security of communication. Hence the radio network should receive adequate maintenance attention and in service testing. It should also be provided with a back-up power supply, preferable non-mains supply such as solar or battery, complete with charging equipment. As indicated above it should also be protected from lightning and surge. It should also have intruder and fire alarms installed as applicable. The following items on the radio station should be alarmed and sent back to the operations centre: Power failure Low power back-up supply Intruder/fire alarm Telemetry signal failure This system could be integrated with a new SCADA system in the future so that data can be polled automatically. It is recommended that the radio equipment at the Dam, Mt. Glorious and receivers be checked and inspected every 3 months as part of the maintenance procedure.	Alert O & M Contractor does regular maintenance.
It is recommended that the EDAC dialler be checked monthly to ensure the unit, alarms and system are operational. It is suggested that a dry run is instigated for a failure of the Control Room in Mineral House during a flood event to ascertain the back-up capacity of the Sunwater Building. This will identify shortcomings in the system, which can then be corrected. It will also identify what problems the Flood Operations Engineer is likely to face and what	Weekly checks done. Flood Manual has operating procedure for loss of communication with Flood Centre.

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
is required to deal with it.	
As there is already a base station in existence, with proven reception, the data could be transmitted via radio as against using a landline to reduce the cost. Sufficient communications back-up systems are already in place to make it an effective system. This system would typically involve VDU screen based operator consoles from which the latest status of the gates can be monitored. The consoles can be placed in any location or as many locations as required. The SCADA system can also integrate local and remote control, monitoring, data archiving and telemetry functions. Critical outstations monitoring river levels and rainfall can also be added to the radio system as required.	Not considered necessary.
It is understood the diesel generator back-up in Mineral House is not under the control of Sunwater and therefore presents some risk. Ideally the generator should be tested monthly and Sunwater should be aware of the test that took place and their results. Sunwater should also ascertain if the Control Room is on the essential services for the building.	New UPS at Flood Centre and diesel generator under maintenance by Q Build.
It is understood the diesel generator back-up in Mineral House is not under the control of Sunwater and therefore presents some risk. Ideally the generator should be tested monthly and Sunwater should be aware of the test that took place and their results. Sunwater should also ascertain if the Control Room is on the essential services for the building.	New UPS at Flood Centre and diesel generator under maintenance by Q Build.
Lightning and Surge Protection There is limited lightning protection installed at the Dam site and nil at the Operations Centre in Mineral House and assumed minimal or none at the Radio Repeater Station. We suggest that lightning protection be implemented as a system at the Dam, the Radio Repeater station, and the Control Centre. This should include: An equipotentially bonded earthing system. Structural protection on the highest points (such as the crane) and structures through the use of finial aerials and /or interceptors. All power incoming and outgoing, including high voltage. All controls and telemetry inputs, cabling and especially electronics equipment. The present protection will not protect the equipment or personnel, as there are several areas where a lightning surge can enter the buildings and structures.	Alert O&M Contractor advised full lightning/surge protection at Repeater Stations and Operations Centre. Sunwater advised adequate lightning/surge protection exists for Dam operation At Dam, Lightning Protection exists: 2 on lift tower, 1 on EDAC 1 on telephone On all power circuits that feed control circuits On Gate Position and Lake Level Indicators Crane operated by remote control and not

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
	used in electrical storm. Current system is to industry standard.
Various lightning and surge equipment is required for different levels of protection from the coarse shunt type at the power sources to the fine series type at the electronics equipment level. All lightning and surge equipment installed should be from the one company to ensure coverage and grading between them. It should be noted that surges are produced by various items of equipment within the site such as motors, switches, fluorescent lighting and UPS systems, all of which will produce spikes capable of damaging electronic equipment.	
The radio Repeater station will be very susceptible to lightning strikes due to its location and the tower. Lightning protection should include: An equi potentially bonded earthing system. Structural protection on the high mast or above it to protect the installation from a direct hit through the use of an interceptor. All power incoming and outgoing. All other incoming and outgoing wiring including communications cable from the radio aerial/tower. The Operations Room in Mineral House should be assessed to be self contained in excluding lightning and surge. This will include protection of all PCs, and communications. Protection should be outside of the device for ease of replacement and integrity.	Alert O&M Contractor advised full lightning and surge protection exists for radio Repeater Stations and Operations Centre
Safety Issues Whilst onsite supervision was very good, formal sign in and out of confined spaces and strategies, as well formal induction was not evident. Equipment and safety systems should be in place and formalised to meet Workcover requirements. Confined space entry and training should also be updated to meet the Australian Standards. Inertia reel fall arrest harnesses are available and utilised on site. It was noted that an attachment wire was connected between handrails across the downstream side of the Spillway Gate. The attachment should be checked by a structural engineer. Provide security for the machinery gallery and entry to this area to protect equipment from vandalism and sabotage. Provide bump caps or helmets when working in the machinery gallery.	A full safety plan is in place Dam operators now trained in LV access. Hazards with access to the starters eliminated with control panel upgrade.
The stairs and platforms from the Spillway road down to the machinery gallery should be checked for compliance with Australian Standards. The risk is considerable the way it is as a trip on the stairs could result in a fall to the bottom of the Dam. All stairways and ladderways should be checked for Australian Standards compliance.	Stairs are in accordance with Australian Standards

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
A warning label(s) should also be placed on the personnel lift-"DO NOT USE IN AN EMERGENCY OR FLOOD EVENT" Additional exit signs should be installed with battery back-up lighting, especially in the machinery gallery. High voltage cabling should be totally segregated and isolated from other equipment and personnel. High voltage equipment should be clearly identified and should be restricted access to qualified personnel. All switches should be clearly identified and switching instructions should be in place and controlled by a high voltage qualified operator. Identify any drains and other outlets that may spread a fire. Re-evaluate the issue of no-electrical personnel operating equipment located within an electrical panel, and also the related issue of the awkward location of the Gate starter equipment. Is there written dispensation from the Department of Natural Resources and Mines for non-electrical personnel to operate this equipment kept with the SEQWCO? If not this may place SEQWCO in a precarious position should an accident occur.	Only a problem if used during mains power failure. Operations procedures require to use additional lighting if working in there in the dark. Completed Completed Not considered an issue. This is in process of being addressed.
Spillway Gate Hoist Motors The motors are tested and inspected regularly. The results are trended and can be utilised to determine wear and tear and to determine when they need to be overhauled. Under these maintenance practices a potential failure should be identified before a fault occurs.	
Assuming the motors are 38 years old and have not been overhauled in their lifetime they should be due for a complete overhaul. It would be worthwhile investigating the cost to increase their insulation rating to class H during the overhaul. It is operational practice to exercise a gate to the first few steps only. This does not give the motor an adequate running time. The gate should be raised to full height whenever possible, water levels permitting. This would fully test the motor to its nameplate rating and allow any moisture in the windings from condensation to evaporate. This will clear the motors of moisture, thereby reducing the possibility of a short in the windings, and enhancing their reliability. Any potential fault is also more likely to appear during a full exercise. This will fully test all associated mechanical and electrical components. A motor should be bench tested to ascertain the heat rise capacity of the windings in relation to the required maximum expected duty. The motors are not expected to have an overheating problem. However this should be confirmed by a heat rise test. This can only be done by factory testing and comparing the results to the expected duty. A spare hoist motor should be available on site to facilitate replacement in event of failure. This will improve the reliability of the	Condition monitoring every 6 months. To be done during 4 monthly checks. Not necessary – mobile unit available Spare available.

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
gate operation.	
Security Alarms The existing intruder alarm could be expanded to keep out vandals and general public by placing monitors near the gate such as movement and infra red detectors which will set off lights and sirens on activation.	Security service – razor wire on site. These monitors are not feasible.
It is assumed that the radio base station has a fire detector and security alarm on it, as this was not inspected. If this is not the case we suggest that they be installed as a local input to the radio repeater station at Mt.Glorious.	No action required, as back-up system on separate tower exists
Smoke Detection/Firefighting Equipment There is currently no fire alarm in the control room, workshops and site office. The cost to install detectors would be small as they could be added to the existing system, even in the interim if a larger system is being considered.	Detectors in control room.
Earth Leakage Protection Earth leakage protection should be provided for all GPO's in the following areas where not already installed: The radio repeater site The Operations centre in Mineral House It is noted that earth Leakage Protection is installed in the Dam Office, Galleries and workshop.	Back up site at Mt Glorious and back up at Flood Centre.
Emergency Lighting Emergency battery lighting should be fitted in the following areas to provide the minimum lighting levels for operations and safe exit during power failure and generator failure: • The machinery gallery. • The control room. • The high voltage room. • The generator room. • The site office. • Back-up lighting should be sufficient to allow for fault finding, location of tools, communications; starting up of the mobile drive unit and repairing a fault in the diesel generator starting sequence. The fittings should be the maintained type which can be used as normal fittings and illuminate when normal supply fails.	Rechargeable torches to be provided.
Mobile Drive Unit It is recommended that the mobile unit be fitted with sufficient power outlets for general 3 phase power supply, 240 volt outlets and the fitting of emergency floodlighting. The limitation of the mobile unit is	Emergency Lighting has been purchased.

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
also the size of the fuel tank. This is due to the unit being built for a specific purpose and not general purpose. Whilst this is not a problem it may be possible to enhance the unit by providing it with additional outlets and a larger fuel tank to cover any emergency. An additional mobile drive unit will allow all gates to be fully raised within 10 hours (approximately 7 hours). However it is likely a third operator would be required. Spare parts for the mobile drive unit need to be available within 2 to 4 hours of requirement.	Not feasible. Noted previously.
Drawings The circuit diagrams for power, control, instrumentation, EDAC and telemetry/radio communications for the site are not known to exist. A full set of Work as Executed drawings should be produced and made available both at the dam and in the SEQWCO Offices. During the site visit it was noted that equipment that is no longer in use remains connected on site. The equipment should be de-commissioned and removed from site and the drawings updated.	Sunwater to issue. Electrical and instrument circuit disgrams currently being updated.
Operations Issues Retain a controlled copy of the O and M Manual in the Brisbane Office. Manuals need to be updated to incorporate current practices e.g the gate control using computer system is no longer in use this needs to be stated in the operation manual. The functional designation of persons needs to reflect the current terminology used on site.	Done
Reliability Data A log should be established at the dam site and operators encouraged to enter any incidences (including 'near misses' or actual events) regarding equipment operation. Eg failure of diesel generator to start, power hydraulic problems, fuse failures etc. Such a log will provide a good statistical basis for future reliability studies.	Daily log used.
Human Factor Issues Human Factors in Maintenance During our visit we were advised that the planned annual maintenance program was well-resourced and included a work order system and monitoring. However, not all maintenance work was checked as a matter of course. When completed, maintenance work was entered into the computer as a record that the work was complete. It is recommended that appropriate checks (e.g., visual or operational testing) of all maintenance work on system critical components be carried out, particularly where this involves removal and replacement (either original or from stock) of components. A 'near miss' reporting system for maintenance is also recommended, to record whether maintenance checks have revealed any	This is available by on-site check sheets.

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
shortcomings in maintenance work.	
Simulations Exercise Given the relatively low probability of serious consequences resulting from a single skills-based error, the most likely disaster scenario is one that results from a combination of two or more simultaneous failures within the system during a flood event. Such human factors failures might include: Inexperience of an operator with responsibility for spillway radial gate operation at a particular time – for example, because the more experienced operator(s) are off sick or unavoidably absent. Fatigue resulting from flood management activity over a period of several days without adequate respite. Stress from the above factors. A maintenance error that remains hidden until revealed by failure in an operational sequence. An accident to an operator during an operational sequence, which draws the only remaining operator to assist – for example, negotiating steep slippery steps while gaining access to or egress from a spillway gate local control panel. It is recommended that the client undertake a simulation exercise that mimics different combinations of the above factors in order to determine the likelihood that the system will respond appropriately (see below for sample scenario). Example scenario for simulation exercise. An experienced operator is working on the third day of a flood event alongside a less experienced operator. Both operators are tired. At 01.00hr instructions are received from FCC to open Gate E (the furthest from the site control room).	Flood operation training done once a year. Flood training accounts for this.
It is raining heavily and the lake is close to over-topping the dam wall. The experienced operator sets off to Gate E and falls down the access steps injuring his back. Though conscious he is effectively immobile. While falling he drops his mobile phone, which falls onto the spillway below. Questions that might be relevant include: How long does it take the inexperienced operator to respond to the non-return of his colleague? What does he do? How long does it take FCC to realise that Gate E has not been opened as per instructions?	
What does FCC do at this point? What if the second operator sets off to find his colleague without contacting FCC; when FCC staff attempt to make contact they are unable to communicate with either operator?	
Periodic Reviews It is recommended that periodic reviews be undertaken of possible	

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
'knock on' effects of decisions implemented centrally within the organisation upon maintenance and operational tasks that impinge upon flood event activities. Two examples from observations made during the North Pine Dam site visit serve to highlight the possibility of improvement in PPE (Personal Protection Equipment). The first was that neither visitors nor operators were required to wear hard hats during a walkabout that included time under the gantry crane. The second is that provision of bump caps during access to spaces within the dam structure would be worth considering as a means of reducing the likelihood of injury. It is recommended that the client organisation undertake a review of PPE requirements, provision, use, monitoring and maintenance on operational sites.	Safety plan in place.
Documentation Brief analysis of the log sheets has revealed that the information recorded in respect of North Pine Dam spillway radial gate opening and closing sequences during the February/March 1999 flood events was incomplete and indicated that on at least some occasions gates were operated out of sequence. It is recommended that, to provide an accurate and up-to-date record of the system state at North Pine Dam during flood events, a simple chart be drawn up on which would be recorded the state of the system in respect of spillway radial gate positions. This information would be simultaneously available to both dam operators and to FCC staff. The information would ideally be obtained automatically from the gate operation control system and displayed appropriately at both local and remote locations.	Not considered necessary.
Organisational Issues From the control room human factor checklist -Ref.- Appendix A Following recommendations emerge: It is recommended that the client organisation determine the range of situations in which it might not be possible to correct actions after an alarm has been raised. Examples of cases where this has occurred could be used to examine possible ways of overcoming any difficulties. These can be incorporated within the Human Reliability Analysis as appropriate. It is recommended that staff training scenarios be reviewed to ensure that as wide a range of problem solving situations as is feasible is incorporated within staff training. It is recommended that the adequacy of guidance for operating in emergencies, particularly documented guidance, and its effective transmission to all operators, be reviewed. It is recommended that the client organisation consider possible effects of its decision making processes upon operational actions during emergencies, taking into account that these could include decisions taken at any time and at any organisational level and not	Flood training is considered adequate. Scenarios are discussed then.

NPD GATE FEASIBILITY	
FINDINGS	**STATUS**
just decisions taken during flood event.	

Appendix E. Flood Studies

1. FLOOD STUDIES

The Executive Summary of the 1994 Brisbane River and Pine River Flood Study contained a list of recommendations.

These are listed in the tables below with their current status.

Brisbane River and Pine River Flood Study Final Report - Executive Summary Recommendations	Status at October 2002
2.2.1 North Pine Dam – Normal Spillway Gate Operation	
1. It is recommended that modifications to the spillway radial gate winch switch gear be considered so as to improve the flood immunity of this equipment, even though there are backup power supplies for the lifting mechanisms for the spillway gates. Such modifications could include moving or waterproofing the switch gear.	Completed. (Backup bridge deck lifting mechanism installed)
2. It is recommended that the relationships between gate settings and discharge presented in the Manual of Operational Procedures for Flood Releases from North Pine Dam (SEQWB, 1992b) be replaced by values derived from physical model testing conducted during the Flood Study.	Completed.
2.2.2 North Pine Dam – One Spillway Gate out of Service Operation	
1. It is recommended that North Pine Dam continue to be operated in accordance with the existing flood operation procedures (refer SEQWB 1992b). Non-compliance with the existing operating procedures could lead to the failure of the dam.	Implemented.
2.2.4 Somerset Dam – Normal Spillway Gate Operation	
1. It is recommended that Somerset Dam continue to be operated in accordance with the existing Manual of	Implemented.

Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam (SEQWB 1992a).	
2.2.6 Wivenhoe Dam – Normal Spillway Gate Operation	
1. It is recommended that investigations continue into possible alternate flood procedures for Wivenhoe Dam during extreme flood events. Where possible this should be based on critical review of operational experiences to date.	Manual of Operating Procedures for Flood Releases will be revised in March 2004 on completion of design of new auxillary spillway.
2. It is recommended that consideration be given to available options to improve the flood immunity of Wivenhoe Dam.	Completed.
3. It is recommended that the Clear Gate Opening (CGO) of the spillway gates of Wivenhoe Dam be measured for the full range of possible gate settings. Measurements should be undertaken during both raising and lowering of the gates so that any hysteresis is noted.	Completed
2.3.1 North Pine Dam	
1. It is recommended that an economic risk analysis be undertaken to assess the viability of lowering the Full Supply Level of North Pine Dam. Such an analysis would be necessary to determine the benefit to downstream communities in increasing the flood mitigation capability of North Pine Dam.	Not considered necessary
2. It is recommended the feasibility of modifying the spillway radial gate switch gear be investigated.	Completed. (Backup operating mechanism)
2.3.2 Somerset Dam & Wivenhoe Dam	
1. It is recommended that an economic risk analysis be undertaken to assess possible methods of improving the flood immunity of Wivenhoe Dam and reducing the risk of flooding of downstream communities.	Analysis completed as part of SKM risk assessment. Options were later considered, with a new auxiliary spillway at Wivenhoe Dam being recommended. New spillway is under construction
2. It is recommended that the real time flood operations model *FLOOD*, be used to refine the existing flood	

operation procedures and comprehensively test alternate operating procedures for the Somerset-Wivenhoe Dam system. Such investigations should not be performed in real time, but rather during training or non-flood operation periods.	**Is in progress – in conjunction with Flood Control Centre Contractor** 

2.4.3 Somerset Dam	
1. It is recommended that the hoist mechanisms for the spillway gates be regularly checked for adequacy and serviceability.	Part of routine maintenance.
2. It is recommended that the existing procedure of fully opening the spillway radial gates of Somerset Dam prior to a flood event be observed whenever possible.	Is a requirement of the Manuals.
3. It is recommended that a structural design check be performed to assess the ability of the spillway radial gates of Somerset Dam to withstand forces exerted by water levels above the non-overflow crest level (EL 107.5m AHD) and above. This check should determine the Imminent Failure Flood Level (IFFL) of the spillway gates so as to confirm assumptions made in regard to potential dam failure modes of Somerset Dam.	Detailed Risk Assessment completed between 2002-2004, with Peer Review completed end of 2004. Work on gates not considered as required
2.5.1 Pine River	
1. It is recommended that emergency preparedness plans for North Pine Dam be established.	Emergency Action Plans completed.
2.5.2 Brisbane River	
1. It is recommended that emergency preparedness plans for Somerset Dam and Wivenhoe Dam be established as a matter of priority.	Emergency Action Plans completed.

2.6.1 Pine River **1.** It is recommended that the flood inundation maps of the Pine River produced as part of the Brisbane River and Pine River Flood Study be distributed to organisations associated with counter disaster planning.	Completed. Distributed to Pine Rivers Shire Council.
2.6.2 Brisbane River 1. It is recommended that flood inundation maps for the Brisbane River produced as part of the Brisbane River and Pine River Flood Study be distributed to organisations associated with counter disaster planning.	Completed. Distributed to Brisbane, Ipswich, Esk and Kilcoy Councils.
2.7.1 Calibration of Runoff-Routing Models 1. It is recommended that the calibration of the runoff-routing models be reviewed when suitable additional data becomes available from the ALERT network.	Checked in February 1999
2.7.3 Concurrent Flooding Estimates 1. It is recommended that developments in the assessment of concurrent flooding estimation be monitored and the analyses updated when appropriate.	Somerset/Wivenhoe concurrent flooding estimates will be completed as part of design of proposed new auxillary spillway for Wivenhoe Dam
2.7.4 Areal Reduction Factors 1. It is recommended that developments in the estimation of areal reduction factors for large catchments and long durations be monitored and the analyses updated when appropriate.	Completed by Bureau of Meteorology, and being used now for design of proposed new auxillary spillway for Wivenhoe Dam.
2.8.2 Calibration of Hydraulic Models 1. It is recommended that the calibrations of the hydraulic models be reviewed after each significant flood event.	Checked in February 1999

2. Whilst the availability of data from the ALERT network should provide sufficient information on which to assess the appropriateness of the calibrations, it is also recommended supplementary flood data be sought from other agencies after significant flood events.	Not required. It is considered that ALERT data is sufficient.
2.8.3 Accuracy of Hydraulic Models	
1. It is recommended that the results of the hydraulic analyses should not be released for the purpose of setting development levels or assessing the impacts of development proposals within the river systems.	Implemented.
2.8.4 Comparison between Hydraulic Routing and Hydrologic Routing	
1. It is recommended that estimates of peak discharge and peak water surface elevation obtained from the hydraulic models be used in preference to the corresponding runoff-routing model estimates.	Implemented.
3.2.1 Radio Telemetry Ground Stations	
1. The installed ALERT network should be regarded as a minimum desirable network and that the performance of the network should be critically assessed after each major flood event so as to identify any inadequacies.	Implemented.
2. Gate movement sensors should be installed on North Pine Dam, Somerset Dam and Wivenhoe Dam and connected to the ALERT network for transmission of the gate settings to the Headworks Operator.	Done 2002.
3. It is recommended that an independent review of the installations of the ALERT network be undertaken by a recognised authority experienced in stream gauging and telemetry systems. Such a review should be undertaken after the first significant flood event to correspond with the de-briefing exercise associated with the operation of the dams and the performance of the real time flood operations model.	Reviewed by O&M contractor – performance more than satisfactory.
3.2.2 Computer Hardware	
1. It is recommended that the hardware platform be periodically reviewed (say every three to five years) and upgraded where necessary to ensure its suitability and appropriateness.	Implemented.

2.	
3.5 Commissioning Process It is recommended that the developers of FLOOD be engaged to provide support to the dam operators in terms of suitably experienced personnel until sufficient Middle Level and High Level operators become available to operate the model.	Implemented.
3.6 Operational Requirements 1. It is recommended that a formalised agreement be made between the SEQWB and the Bureau of Meteorology for the two way transfer of the above information between the Headworks Operators and the Bureau.	Implemented.
3.7 Period Review 1. It is recommended that the real time flood operations model be fully reviewed after each major flood event. This includes a complete review of ALERT data gathering network, hydrologic and hydraulic model calibrations and general system performance. 2. A periodic review of the overall system should also be performed on a regular basis. Such a review could coincide with the review of the flood operation manuals of the storages that occurs every five years.	Implemented. Agreed.
3.8 System Maintenance 1. It is recommended that maintenance of the system lie with the developers (DPI Water Resources) until the system is fully commissioned.	Implemented.

Appendix F. 2006 Comprehensive Surveillance Inspection

North Pine Dam Conclusions and Recommendations

The North Pine Dam Safety Committee, having reviewed the historical data and its performance and inspected the dam, has concluded that:

- The concrete dam is in a satisfactory condition and behaving satisfactorily;
- The spillway is in a satisfactory condition to pass floods up to the original design flood.
- The outlet works are generally in a satisfactory condition.

The Committee made the following recommendations based on the observations and review made on this inspection:

General Issues

1. Review and update the Dam Safety Management Program for Wivenhoe, Somerset, North Pine Dams to address items noted at Section 5.1

Dam Surveillance Issues

2. Review and update the Standard Operating Procedures to address items noted.

3. Review the requirements for routine dam surveillance in the Standard Operating Procedures in the light of the recent release of the ANCOLD Guidelines on Dam Safety Management, August 2003.

4. Ensure time series plots for dam surveillance instrumentation are kept up-to-date, and the full range of plots given for the earlier data (pre June 2001) should be available to allow rapid assessment in the event of an anomaly occurring.

5. Merge the instrumentation data for pre- and post- July 2001 so that long-term plots can be examined for long-term behaviour and previous behaviour under similar storage conditions, as well as looking at short-term and medium-term behaviour.

Comparison of older and newer data is difficult at present, because of presentational differences between available plots for the two sets of data.

6. Prepare a one page checklist for weekly surveillance inspection of the structures at the dam, rather than relying on written-in comments on the (essentially mechanical/electrical) monthly report. This would help to ensure that visual dam surveillance is appreciated as a separate distinct activity with a vital dam safety function, and ensure that all sections of the structures are regularly inspected.

7. Two currently read piezometers, Nos 10 and 16, are not shown on the plots. The apparent inconsistency of 6m in levels of bore P12 between June 2001 and July 2001 appears to be due to an incorrect formula in the later spreadsheet. These should be rectified.

8. The uplift spreadsheet should be corrected to give meaningful plots. Gauge 25 and gauge 31 should be closely monitored for continuing rises. The possible issue of relatively high values in Monoliths 15 and 23 should be checked once reliable uplift level behaviour plots are produced. This reassessment should take account of the higher gauge levels in the gallery and higher foundation levels for Monoliths 15 and 23.

Dam Operations and Maintenance Issues

9. Provide a copy of the annual inspection report to the dam supervisor to supervisor to provide feedback and to ensure that items mentioned are attended to.

10. As a general rule, keep vegetation (other than short grass) at least 5 metres away from dam structures, to ensure effective visual surveillance, and reduce the likelihood of damage through tree roots.

Dam Investigation Studies

11. A detailed review of flood hydrology, downstream flood inundation and potential loss of life estimates be undertaken as a high priority work;

12. Risk assessment studies in general are now dated, and a current risk assessment would be warranted. The need for this would be determined from results of the review recommended at item 11.

13. The dam hazard categories in the SEQWater Dam Safety Management Program of October 2002 should be reviewed to accord with the expanded range of categories in the revised ANCOLD guidelines, as noted in Section 4.5.

Somerset Dam Conclusions and Recommendations

The Somerset Dam Safety Committee, having reviewed the historical data and its performance and inspected the dam, has concluded that:

- The concrete dam is in a satisfactory condition and behaving satisfactorily;
- The spillway is in a satisfactory condition to pass floods up to the original design flood.
- The outlet works are generally in a satisfactory condition.

The Committee made the following recommendations based on the observations and review made on this inspection:

General Issues

1. Review and update the Dam Safety Management Program for Wivenhoe, Somerset, North Pine Dams to address items noted at Section 5.1

Dam Surveillance Issues

2. Monitor and compare storage and seepage water annually

3. Review and update the Standard Operating Procedures to address items noted at Section 5.2;

4. Review the requirements for routine dam surveillance in the Standard Operating Procedures in the light of the recent release of the ANCOLD Guidelines on Dam Safety Management, August 2003.

5. Ensure time series plots for dam surveillance instrumentation are kept up-to-date, and the full range of plots given for the earlier data (pre June 2001) should be available to allow rapid assessment in the event of an anomaly occurring.

6. Merge the instrumentation data for pre- and post- July 2001 so that long-term plots can be examined for long-term behaviour and previous behaviour under similar storage conditions, as well as looking at short-term and medium-term behaviour.

Comparison of older and newer data is difficult at present, because of presentational differences between available plots for the two sets of data.

7. Check the installation level and calibration coefficients used in the plotting spreadsheets for piezometer PJ1.

8. Investigate the reason for lack of drainage at the left spillway training wall

9. Move the air line in the upper gallery sluice section to allow inspection of cracking

10. Prepare a one page checklist for weekly surveillance inspection of thestructures at the dam, rather than relying on written-in comments on the (essentially mechanical/electrical) monthly report. This would help to ensure that visual dam surveillance is appreciated as a separate distinct activity with a vital dam safety function, and ensure that all sections of the structures are regularly inspected.

11. Clarify monolith construction shutdown during World War II – note that this is documented on p15 of 1995 Review

Dam Operations and Maintenance Issues

12. Change the frequency of dam deformation surveys to once every 18 months.

13. Provide a copy of the annual inspection report to the dam supervisor to provide feedback and to ensure that items mentioned are attended to.

14. As a general rule, keep vegetation (other than short grass) at least 5 metres away from dam structures, to ensure effective visual surveillance, and reduce the likelihood of damage through tree roots.

15. The internal drainage system is complicated, particularly at the lower levels of the dam. It is recommended that the drainage system be fully documented, critical drains be monitored and maintenance carried out where necessary.

16. Clean out all drains.

17. Exercise the EAP.

18. Review details of galleries and details associated with them, of charged water supply pipeline within the galleries.

Dam Investigation Studies

19. The dam hazard categories in the SEQWater Dam Safety Management Program of October 2002 should be reviewed to accord with the expanded range of categories in the revised ANCOLD guidelines. as noted in Section 4.8

20. Exploratory drilling be carried out to determine whether cracks exist in the concrete above and below the Upper gallery;

21. Determine whether the WIVOPS flood operation program requires the Somerset spillway gates to be lowered if Wivenhoe Dam is in danger of being overtopped. If this is a requirement, review the associated operational and safety issues and the need for a stability upgrade;

22. Review the dam layout to ensure that galleries remain are not flooded during abutment monolith overtopping; consider need for a watertight door (keeps water in, as well as out – but it would have to be an extreme situation for inflow from cracks to exceed the drain capacity).

23. Review the risk assessment studies for Somerset and Wivenhoe Dams and determine whether more detailed studies are warranted.

24. While the storage level is low, map cracks on the upstream face to augment the crack mapping carried out in 1999, and to allow comparison with other known cracking.

Wivenhoe Dam Conclusions and Recommendations

The Wivenhoe Dam Safety Committee, having reviewed the historical data and its performance and inspected the dam, has concluded that:

- The embankment dams and the two saddle dams are is in a satisfactory condition and behaving satisfactorily;

- The primary spillway is in a satisfactory condition to pass discharges up to its current component of the design flood.

- The secondary spillway is in a satisfactory condition to pass discharges up to its current component of the current design flood.

- The outlet works are generally in a satisfactory condition.

The Committee made the following recommendations based on the observations and review made on this inspection:

General Issues

1. Review and update the Dam Safety Management Program for Wivenhoe, Somerset, North Pine Dams to address items noted.

Dam Surveillance Issues

2. Review and update the Standard Operating Procedures to address items noted. In the SOP for routine instrument surveillance, Appendix B refers to instrumentation which is no longer read, and other details may also be out of date.

3. Review the requirements for routine dam surveillance in the Standard Operating Procedures in the light of the recent release of the ANCOLD Guidelines on Dam Safety Management, August 2003.

4. Ensure time series plots for dam surveillance instrumentation are kept up-to-date, and the full range of plots given for the earlier data (pre June 2001) should be available to allow rapid assessment in the event of an anomaly occurring.

5. Merge the instrumentation data for pre- and post- July 2001 so that long-term plots can be examined for long-term behaviour and previous behaviour under similar storage conditions, as well as looking at short-term and medium-term behaviour.

Comparison of older and newer data is difficult at present, because of presentational differences between available plots for the two sets of data SEQWater Dams.

6. Prepare a one-page checklist for weekly surveillance inspection of the structures at the dam, rather than relying on written-in comments on the (essentially mechanical/electrical) monthly report. This would help to ensure that visual dam surveillance is appreciated as a separate distinct activity with a vital dam safety function, and ensure that all sections of the structures are regularly inspected.

Dam Operations and maintenance Issues

7. Provide a copy of the annual inspection report to the dam supervisor to ensure that items mentioned are attended to.

8. As a general rule, keep vegetation (other than short grass) at least 5 metres away from dam structures, to ensure effective visual surveillance, and reduce the likelihood of damage through tree roots (especially saddle dams and left abutment of left embankment).

9. Remove the ant colonies evident at joints in the wave wall.

10. Clean the grass and debris from joints in the concrete dish drain on the crest adjacent to the wave wall, and clean out the pipe outlets from this drain and ensure that the area around the pipe outlets is clear of vegetation and that the flap valves are operational.

11. Clean out all drains in the concrete dam. They all appear generally satisfactory, but it is 20 years since they have been cleaned and some would have been affected by the spillway upgrade works.

Dam Investigation Studies

12. The dam hazard categories in the SEQWater Dam Safety Management Program of October 2002 should be reviewed to accord with the expanded range of categories in the revised ANCOLD guidelines.

13. Review the risk assessment studies for Somerset and Wivenhoe Dams and determine whether more detailed studies are warranted.

Appendix G. Plans

- LOCALITY PLAN

- GENERAL ARRANGEMENT

  NORTH PINE DAM

- GENERAL ARRANGEMENT

  SOMERSET DAM

- GENERAL ARRANGEMENT

  WIVENHOE DAM