seqwater
WATER FOR LIFE

MANUAL

OF

OPERATIONAL PROCEDURES

FOR

FLOOD MITIGATION

AT

WIVENHOE DAM

AND

SOMERSET DAM

Uncontrolled Copy

Revision 7
November 2009

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0	27 October 1968	Original Issue
1	6 October 1992	Complete revision and re-issue
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3	24 August 1998	Change to page 23
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6	20 December 2004	Miscellaneous amendments and re-issue
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1 INTRODUCTION

1.1 Preface

Given their potential significant impact on downstream populations, it is imperative that Wivenhoe and Somerset Dams be operated during flood events in accordance with clearly defined procedures to minimise impacts to life and property. This manual outlines these procedures and is an approved Flood Mitigation Manual under Water Supply Act 2008.

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

The primary objectives of the procedures contained in this Manual are essentially the same as those contained in previous Manual versions. These objectives in order of importance are:

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

In meeting these objectives, the dams must be operated to account for the potential effects of closely spaced Flood Events. Accordingly, normal procedures require stored floodwaters to be emptied from the dams within seven days of the flood event peak passing through the dams.

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

1.2 Meaning of Terms

In this Manual, save where a contrary definition appears -

"Act" means the *Water Supply (Safety and Reliability) Act 2008*;

"AEP" means annual exceedance probability, the probability of a specified event being exceeded in any year.

"Agency" includes a person, a local government and a department of state government within the meaning of the Acts Interpretation Act 1954;

"AHD" means Australian Height Datum;

"Chairperson" means the Chairperson of Seqwater;

"Chief Executive" means the Director General of the Department of Environment and Resource Management or nominated delegate;

"Controlled Document" means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

"Dams" means dams to which this Manual applies, that is Wivenhoe Dam and Somerset Dam;

"Dam Supervisor" means the senior on-site officer at Wivenhoe or Somerset Dam as the case may be;

"Duty.Flood Operations Engineer" means the Senior Flood Operations Engineer or Flood Operations Engineer rostered on duty to be in charge of Flood Operations at the dams;

"EL" means elevation in metres Australian Height Datum;

"Flood Event" is a situation where the Duty Flood Operations Engineer expects the water level in either of the Dams to exceed the Full Supply Level;

"Flood Operations Centre" means the Centre used during by Flood Operations Engineers to manage Flood Events;

"Flood Operations Engineer" means a person designated to direct flood operations at the dams in accordance with Section 2.4 of this Manual;

"FSL" or "Full Supply Level" means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

"Gauge" when referred to in (m) means river level referenced to AHD, and when referred to in (m^3/s) means flow rate in cubic metres per second;

"Manual" or "Manual of Operational Procedures for Flood Events at Wivenhoe Dam and Somerset Dam" means the current version of this Manual;

"Power Station" means the Wivenhoe pumped storage hydro-electric power station associated with Wivenhoe Dam and Split-Yard Creek Dam;

"Senior Flood Operations Engineer" means a person designated in accordance with Section 2.3 of this Manual under whose general direction the procedures in this Manual must be carried out;

"Seqwater" means the Queensland Bulk Water Supply Authority trading as Seqwater.

1.3 Purpose of Manual

The purpose of this Manual is to define procedures for the operation of Wivenhoe Dam and Somerset Dam to reduce, so far as practicable, the effects of flooding associated with the dams. This is achieved by the proper control and regulation in time of the flood release infrastructure at the dams, with due regard to the safety of the dam structures.

The procedures in this Manual have been developed on the basis that the community is to be protected to the maximum extent practical against flood hazards recognising the limitations on being able to:

- Obtain accurate forecasts of rainfall during flood events;
- Accurately estimate flood run-off within the dam catchments;
- Identify all potential flood hazards and their likelihood;
- Remove or reduce community vulnerability to flood hazards;
- Effectively respond to flooding;
- Provide resources in a cost effective manner.

1.4 Legal Authority

This manual has been prepared as a Flood Mitigation Manual in accordance with Chapter 4 Part 2 of the Act.

1.5 Application and Effect

The procedures in this Manual apply to the operation of Wivenhoe Dam and Somerset Dam for the purpose of flood mitigation, and operation in accordance with the manual shall give the protection from liability provided by Section 374 of the Act.

1.6 Date of Effect

The procedures in this Manual shall have effect on and from the date on which this version of the Manual is approved by gazette notice.

The Manual shall remain in force for the period of approval as determined by the Chief Executive. This approval may be for a period of up to five years.

Before the approval of the Manual expires, Seqwater must review and if necessary update the Manual and submit a copy to the chief executive for approval.

1.7 Observance of Manual

This Manual contains the operational procedures for Wivenhoe Dam and Somerset Dam for the purposes of flood mitigation and must be used for the operation of the dams during flood events.

1.8 Provision for Variations to Manual

If Seqwater is of the opinion that this Manual should be amended, altered or varied, it must submit for approval as soon as practical, an appropriate request to the Chief Executive, setting out the circumstances and the exact nature of the amendment, alteration or variation sought. The Chief Executive may accept, reject or modify the request prior to approval.

1.9 Distribution of Manual

Seqwater must regard the manual as a Controlled Document and ensure that only controlled manuals are used in the direction of flood mitigation activities. Agencies having copies of controlled hardcopies of the Manual are listed in Appendix A. Seqwater must maintain a Register of Contact Persons for issued controlled hardcopies of the Manual and must ensure that each issued document is updated whenever amendments or changes are approved.

2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

Pursuant to the provisions of the Act, Seqwater is responsible for operating and maintaining the dams in accordance with this Manual in order to retain the protection from liability afforded by the Act. Operators, employees, agents, and contractors working for Seqwater must also comply with this Manual to obtain the protection of the Act.

2.2 Operational Arrangements

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

- Sufficient numbers of suitably qualified personnel are available to operate the dams if a Flood Event occurs.
- Sufficient numbers of suitably qualified personnel are available to operate the Flood Operations Centre if a Flood Event occurs
- A Duty Flood Operations Engineer is on call at all times. The Duty Flood Operations Engineer must constantly review weather forecasts and catchment rainfall and must declare a Flood Event if the water level of either Wivenhoe or Somerset Dam is expected to exceed Full Supply Level as a result of prevailing or predicted weather conditions.
- A Senior Flood Operations Engineer is designated to be in the charge of Flood Operations at all times during a Flood Event.
- Release of water at the dams during Flood Events is carried out under the direction of the Duty Flood Operations Engineer.
- All practical attempts are made to liaise with the Chairperson and the Chief Executive if the release of water from the Dams during a Flood Event is likely to endanger life or property.

2.3 Designation and Responsibilities of Senior Flood Operations Engineer

Seqwater must nominate one or more suitably qualified and experienced persons to undertake the role of Senior Flood Operations Engineer. If approved by the Chief Executive, these persons can be authorised in the Schedule of Authorities (see Section 2.6). When rostered on duty during a Flood Event, the responsibilities of the Senior Flood Engineer are as follows:

- Set the overall strategy for management of the Flood Event in accordance with the objectives of this Manual.
- Provide instructions to site staff to make releases of water from the Dams during Flood Events that are in accordance with this Manual.
- Apply reasonable discretion in managing a Flood Event as described in Section 2.8.

Seqwater must ensure that an adequate number of Senior Flood Operations Engineers are available to manage all Flood Events.

2.4 Designation and Responsibilities of Flood Operations Engineer

Seqwater must nominate one or more suitably qualified and experienced persons to undertake the role of Flood Operations Engineer. If approved by the Chief Executive, these persons can be authorised in the Schedule of Authorities (see Section 2.6). When rostered on duty during a Flood Event, the responsibilities of the Flood Engineer are as follows:

- Direct the operation of the dams during a flood event in accordance with the general strategy determined by the Senior Flood Operations Engineer.
- Follow any direction from the Senior Flood Operations Engineer in relation to applying reasonable discretion in managing a Flood Event as described in Section 2.8. Unless otherwise directed, a Flood Operations Engineer is to follow this Manual in managing Flood Events and is not to apply reasonable discretion unless directed by the Senior Flood Operations Engineer or the Chief Executive.
- Provide instructions to site staff to make releases of water from the Dams during Flood Events that are in accordance with this Manual.

Seqwater must ensure that an adequate number of Flood Operations Engineers are available to manage all Flood Events. Seqwater must also ensure that an adequate number of suitably qualified and experienced persons are available to assist the Flood Operations Engineers during all Floods Events.

2.5 Qualifications and Experience of Engineers

Qualifications

All engineers referred to in Sections 2.3 and 2.4 must hold a Certificate of Registration as a Registered Professional Engineer of Queensland and must hold appropriate engineering qualifications to the satisfaction of the Chief Executive.

Experience

All engineers referred to in Sections 2.3 and 2.4 must, to the satisfaction of the Chief Executive, have:

(1) Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and

(2) At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:

- Investigation, design or construction of major dams;
- Operation and maintenance of major dams;
- Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;
- Applied hydrology with particular reference to flood forecasting and/or flood forecasting systems.

2.6 Schedule of Authorities

Seqwater must maintain a Schedule of Authorities containing a list of the Senior Flood Operations Engineers and Flood Operations Engineers approved by the Chief Executive to direct flood operations at the dams during floods. A copy of the Schedule of Authority must be provided to the Chief Executive by 30 September of each year.

Seqwater shall nominate suitably qualified and experienced engineers for registration in the Schedule of Authorities as the need arises. Each new nomination must include a validated statement of qualifications and experience as required by the Chief Executive. Seqwater must obtain the approval for all nominations from the Chief Executive prior to their inclusion in the Schedule of Authorities.

If, in the event of unforseen and emergency situations, no Senior Flood Operations Engineer or no Flood Operations Engineer is available from the Schedule of Authorities to manage a Flood Event, Seqwater must temporarily appoint a suitable person or persons and immediately seek ratification from the Chief Executive.

2.7 Training

Seqwater must ensure that operational personnel required for flood operations activities receive adequate training in the various activities involved in flood control operation as required by the Chief Executive.

2.8 Reasonable Discretion

If in the opinion of the Senior Flood Operations Engineer, it is necessary to depart from the procedures set out in this Manual to meet the flood mitigation objectives set out in Section 3, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary subject to the following:

- Before exercising discretion under this Section of the Manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must make a reasonable attempt to consult with both the Chairperson and Chief Executive.

- The Chief Executive would normally authorise any departures from the Manual. However if the Chief Executive cannot be contacted within a reasonable time, departures from the Manual can be authorised by the Chairperson.

- If both the Chairperson and the Chief Executive cannot be contacted within a reasonable time, the Senior Flood Operations Engineer may proceed with the procedures considered necessary and report such action at the earliest opportunity to the Chairperson and Chief Executive.

2.9 Report

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

3 FLOOD MITIGATION OBJECTIVES

3.1 General

To meet the purpose of the flood operational procedures in this Manual, the following objectives, listed in descending order of importance, are as follows:

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

In meeting these objectives, the dams must be operated to account for the potential effects of closely spaced Flood Events. Accordingly, normal procedures require stored floodwaters to be emptied from the dams within seven days of the flood event peak passing through the dams.

Additionally, the auxiliary spillway constructed at Wivenhoe Dam in 2005 incorporates fuse plugs. Triggering of a fuse plug will increase floods levels downstream. Where possible, gate operations at both Wivenhoe and Somerset dams should be formulated to prevent operation of the fuse plug. This potential scenario is possible only when the forecast peak water level for Wivenhoe Dam just exceeds the trigger level for the fuse plug and sufficient time is available to alter releases.

3.2 Structural Safety of Dams

The structural safety of the dams must be the first consideration in the operation of the dams for the purpose of flood mitigation.

Wivenhoe Dam

The structural safety of Wivenhoe Dam is of paramount importance. Structural failure of Wivenhoe Dam would have catastrophic consequences. Wivenhoe Dam is predominantly a central core rockfill dam. Such dams are not resistant to overtopping and are susceptible to breaching should such an event occur. Overtopping is considered a major threat to the security of Wivenhoe Dam. Wivenhoe Dam is overtopped by an event with a 1 in 100,000 AEP.

Somerset Dam

The structural safety of Somerset Dam also is of paramount importance. Failure of Somerset Dam could have catastrophic consequences. Whilst Wivenhoe Dam has the capacity to mitigate the flood effects of such a failure in the absence of any other flooding, if the failure were to occur during major flooding, Wivenhoe Dam could be overtopped and destroyed also.

Somerset Dam is a mass concrete dam. Such dams can withstand limited overtopping without damage. Failure of such structures is rare but when they do occur, they occur suddenly without warning, creating very severe and destructive flood waves. Although Somerset Dam is overtopped by an event with a 1 in 5,000 AEP, it is expected that the dam could withstand at least 2.2 metres of overtopping without failure, provided all radial gates are fully open. This equates to an event centred on the Somerset Dam catchment with a 1 in 20,000 AEP.

Extreme Floods and Closely Spaced Large Floods

As indicated in the previous section, techniques for estimating extreme floods show that floods are possible which would overtop both dams. In the case of Wivenhoe Dam such an overtopping would most likely result in the destruction of the dam. Such events however require several days of intense rainfall to produce the necessary runoff.

Historical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane River system within a short time of each other. Therefore, unless determined otherwise by the Senior Flood Operations Engineer in accordance with Section 2.8, the aim during a Flood Event should be to empty stored floodwaters within seven days after the flood peak has passed through the dams. In a very large flood, this time frame may not be achievable because of downstream flood conditions and it may be necessary to extend the emptying period by several days.

The discharges from the dams should be regulated so as to have little impact on the urban reaches of the Brisbane River, taking into account inflows into the river downstream of the dams. However the seven day drainage requirement may result in submergence of some bridges. Regardless, the level of flooding as a result of emptying stored floodwaters after the peak has passed is to be less than the flood peak unless accelerated release is necessary to reduce the risk of overtopping.

3.3 Inundation of Urban Areas

The prime purpose of incorporating flood mitigation measures into Wivenhoe Dam and Somerset Dam is to reduce flooding in the urban areas of the flood plains below Wivenhoe Dam. The peak flows of floods emanating from the upper catchments of Brisbane and Stanley Rivers can be reduced by controlling flood releases from the dams, while taking into account flooding derived from the lower Brisbane River catchments.

3.4 Disruption to Rural Areas

While the dams are being used for flood mitigation purposes, bridges and areas upstream of the dams may be temporarily inundated. Downstream of the dam, bridges and lower river terraces will be submerged. The operation of the dams should not prolong this inundation unnecessarily.

Disruption to navigation in the Brisbane River can also be taken into account when considering disruption to rural areas downstream of the dam. Generally, this consideration is secondary to considerations associated with reducing bridge inundation.

3.5 Retain the storage at Full Supply Level at the Conclusion of the Flood Event

As the dams are the primary urban water supply for South East Queensland, it is important that all opportunities to fill the dams are taken. There should be no reason why the dams should not be full following a Flood Event.

3.6 Minimising Impacts to Riparian Flora and Fauna

During the drain down phase, consideration is to be given to minimising the impacts on riparian flora and fauna. In particular, strategies aimed at reducing fish deaths in the vicinity of the dam walls are to be instigated, provided such procedures do not adversely impact on other flood mitigation objectives.

Additionally, when determining the time interval between successive gate closures consideration should also be given to reducing potential bank slumping. Rapid draw down of stream levels where banks are saturated should be avoided if this can be managed within the other flood mitigation objectives.

4 FLOOD CLASSIFICATION

For the reference purposes of this Manual, four magnitudes of flooding are classified as follows:

Minor Flooding

Causes inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.

Moderate Flooding

In addition to the impacts experienced during Minor Flooding, the evacuation of some houses may be required. Main traffic routes may be impacted. The area of inundation is substantial in rural areas requiring the removal of stock.

Major Flooding

In addition to the impacts experienced during Moderate Flooding, extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required. The 1974 flood that impacted on the Ipswich and Brisbane areas is classified as a major flood.

Extreme Flooding

This causes flooding impacts equal to or in excess of levels previously experienced. In addition to the impacts experienced during Major Floods, the general evacuation of people from significant populated areas is likely to be required.

It should be noted that a flood may not cause the same category of flooding along its entire length and the relevant agencies shall have regard to this when flooding is predicted. The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia.

The current classifications for key reference gauges in the Brisbane River are given in Appendix B.

5 FLOOD MONITORING AND FORECASTING SYSTEM

5.1 General

A real time flood monitoring and forecasting system has been established in the dam catchments. This system employs radio telemetry to collect, transmit and receive rainfall and stream flow information. The system consists of more than 100 field stations that automatically record rainfall and/or river heights at selected locations in the dam catchments. Some of the field stations are owned by Seqwater with the remainder belonging to other agencies.

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

5.2 Operation

The Senior Flood Operations and Flood Operations Engineers use the RTFM for flood monitoring and forecasting during flood events to operate the dams in accordance with this Manual. This is done by optimising releases of water from the dams to minimise the impacts of flooding in accordance with the objectives and procedures contained in this Manual.

Seqwater is responsible for improving the operation of the RTFM over time by using the following processes:

- Implementing improvements based on Flood Event audits and reviews.
- Improving RTFM calibration as further data becomes available.
- Updating software in line with modern day standards.
- Improving the coverage and reliability of the data collection network to optimise data availability during Flood Events.
- Recommendations by Senior Flood Operations Engineers.

A regular process of internal audit and management review must be maintained by Seqwater to achieve these improvements.

Seqwater must also maintain a log of the performance of the data collection network. The log must include all revised field calibrations and changes to the number, type and locations of gauges. Senior Flood Operations and Flood Operations Engineers are to be notified of all significant changes to the Log.

Seqwater must also maintain a log of the performance of the RTFM. Any faults to the computer hardware or software are to be noted and promptly and appropriately attend to.

5.3 Storage of Documentation

The performance of any flood monitoring and forecasting system is reliant on accurate historical data over a long period of time. Seqwater must ensure that all available data and other documentation is appropriately collected and catalogued for future use.

5.4 Key Reference Gauges

Key field station locations have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to relocate field stations from these locations or vary flood classification levels, agreement must first be obtained between Seqwater, Bureau of Meteorology and the Local Government within whose boundaries the locations are situated.

Gauge boards that can be read manually must be maintained by Seqwater as part of the equipment of each key field station. Where possible and practical during Flood events, Seqwater is to have procedures in place for manual reading of these gauge boards in the event of failure of field stations.

5.5 Reference Gauge Values

Other agencies such as the Bureau of Meteorology, Brisbane City Council and Ipswich City Council have direct access to the information from field stations for flood assessment purposes. The consultation between agencies is a very important part of the assessment and prediction of flood flows and heights.

Seqwater must ensure that information relevant to the calibration of its field stations is shared with these agencies.

6 COMMUNICATIONS

6.1 Communications between Staff

Seqwater is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Seqwater Flood Operations Centre and site staff at Wivenhoe and Somerset Dams.

6.2 Dissemination of Information

Agencies other than Seqwater have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public associated with Flood Events. Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public. Agency information requirements are generally as shown in the table below.

The Senior Flood Operations and Flood Operations Engineers must supply information to each of these agencies during Flood Events. The contact information for these Agencies and communication procedures is contained in the Emergency Action Plans for the dams and each agency is to receive updated controlled copies of these documents.

Seqwater must liaise and consult with these agencies with a view to ensuring all information relative to the flood event is consistent and used in accordance with agreed responsibilities.

AGENCY INFORMATION REQUIREMENTS

Agency	Activity	Information Required from Flood Operations Centre	Trigger
Bureau of Meteorology	Issue of flood warnings for Brisbane River basin	Actual and projected discharges from Wivenhoe Dam Actual and projected discharges from Somerset Dam	Initial gate operations and thereafter at intervals to suit forecasting requirements
Department of Environment and Resource Management	Review of flood operations and discretionary powers	Actual and predicted lake levels and discharges	
Somerset Regional Council	Flood level information upstream of Somerset Dam and upstream and downstream of Wivenhoe Dam	Actual and predicted lake levels, Somerset Dam and actual and predicted lake levels and discharges, Wivenhoe Dam	Somerset Dam water level predicted to exceed EL 102 m AHD and initial Wivenhoe Dam gate operation
Ipswich City Council	Flood level information for Ipswich City area	Nil (information obtained from BOM)	
Brisbane City Council	Flood level information for Brisbane City area	Nil (information obtained from BOM)	

6.3 Release of Information to the Public

Seqwater is responsible for the issue of information regarding storage conditions and current and proposed releases from the dams to the public and the media.

The Bureau of Meteorology has responsibility for issuing flood warnings.

The Emergency Services Response Authorities, under the Disaster Management Act 2003, have responsibility for the preparation of a local counter disaster plan and the interpretation of flood forecast information for inclusion in their local flood warnings prepared under the flood sub plan of the counter disaster plan.

7 REVIEW

7.1 Introduction

With the passage of time neither the technical assumptions nor the physical conditions on which this Manual is based may remain unchanged. It is also recognised that the relevance of the Manual may change with changing circumstances. It is important therefore, that the Manual contain operational procedures which cause the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

This process must involve all personnel involved in the management of Flood Events, to ensure that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based. Variations to the Manual may be made in accordance with provisions in Section 1.8.

7.2 Personnel Training

Seqwater must report to the Chief Executive by 30 September each year on the training and state of preparedness of operations personnel.

7.3 Monitoring and Forecasting System and Communication Networks

Seqwater must provide a report to the Chief Executive by 30 September each year on the state of the Flood Monitoring and Forecasting System and Communication Networks. The report must assess following in terms of hardware, software and personnel:

- Adequacy of the communication and data gathering facilities.
- Reliability of the system over the previous period.
- Reliability of the system under prolonged flood conditions.
- Accuracy of forecasting flood flows and heights.
- The overall state of preparedness of the system.

Seqwater must take any action considered necessary for the proper functioning and improvement of this system.

7.4 Operational Review

After each significant flood event, Seqwater must report to the Chief Executive on the effectiveness of the operational procedures contained in this manual. This report must be submitted within six weeks of any flood event that requires mobilisation of the Flood Operations Centre.

7.5 Five Yearly Review

Prior to the expiry of the approval period, Seqwater must review the Manual pursuant to provisions of the Act. The review is to take into account the continued suitability of the communication network and the flood monitoring and forecasting system, as well as hydrological and hydraulic engineering assessments of the operational procedures.

8 WIVENHOE DAM FLOOD OPERATIONS

8.1 Introduction

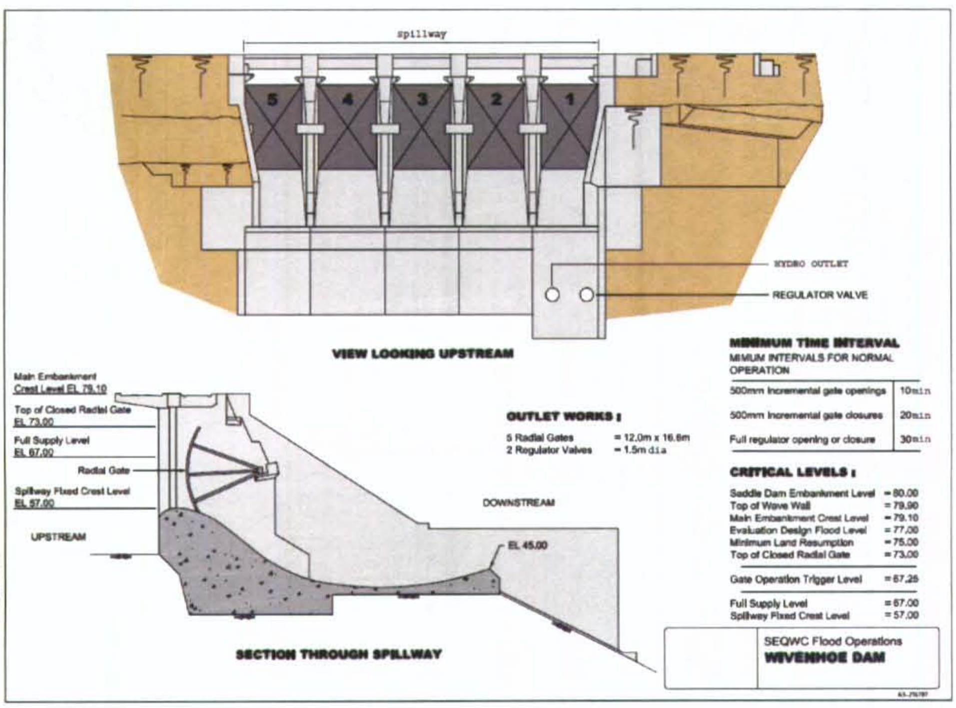
Wivenhoe Dam is capable of being operated in a number of ways to reduce flooding in the Brisbane River downstream of the dam, depending on the origin, magnitude and spatial extent of the flood. Maximum overall flood mitigation effect will be achieved by operating Wivenhoe Dam in conjunction with Somerset Dam.

The reservoir volume above FSL of EL 67.0 is available as temporary flood storage. How much of the available flood storage compartment is utilised, will depend on the initial reservoir level below FSL, the magnitude of the flood being regulated and the procedures adopted.

Splityard Creek Dam is part of the overall Wivenhoe Area Project and it forms the upper pumped storage for hydro power generation. Splityard Creek Dam impounds a volume of 28,700 ML at FSL (EL 166.5). This volume can be emptied into Lake Wivenhoe within 12 hours and this water can affect the level in Wivenhoe Dam by up to 300mm when Wivenhoe Dam is close to FSL. Operation of the power station and release of water from Splityard Creek Dam to Lake Wivenhoe is outside the control of Seqwater, but should be considered when assessing the various trigger levels of Wivenhoe Dam.

8.2 Flood Release Infrastructure

Radial Gates and an Auxiliary Spillway are the primary infrastructure used to release water during flood events at Wivenhoe Dam. The arrangement of the Radial Gates is shown in the diagram below:



In addition to the five radial gates, the auxiliary spillway was constructed in 2005 as part of an upgrade to improve flood adequacy of this storage. The auxiliary spillway consists of a three bay fuse plug spillway at the right abutment. In association with other works constructed at the dam, this gives the dam crest flood an AEP of approximately 1 in 100,000. Another one bay fuse plug spillway may be constructed at Saddle Dam Two in the future.

Pertinent information about the auxiliary spillway, including the initiation level for the specific bays is given in the following table.

AUXILIARY SPILLWAY - FUSE PLUG DETAILS

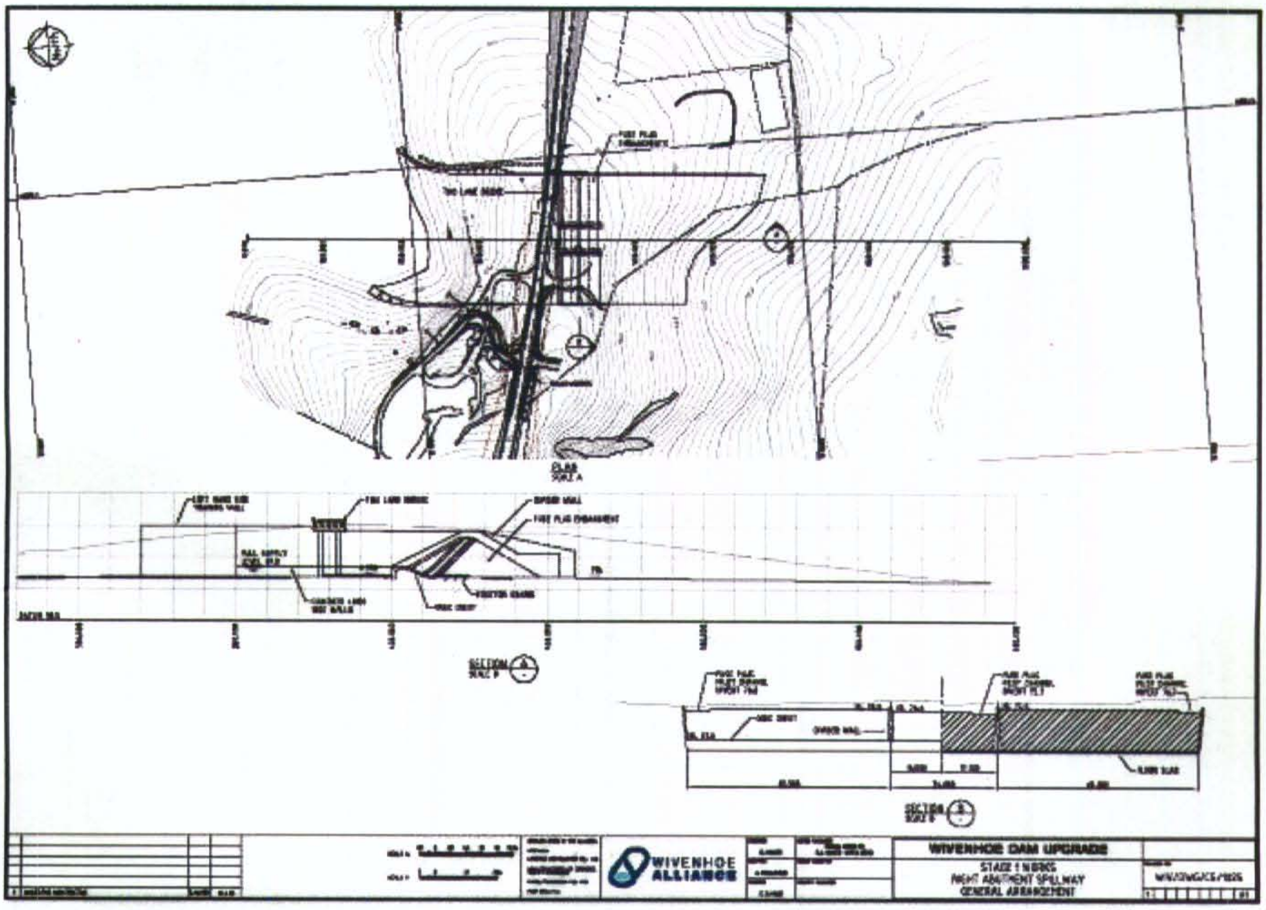
Auxiliary Spillway Component	Spillway Type	Spillway Width	Spillway Crest Level	Fuse Plug Pilot Channel Invert Level	Storage Level corresponding to Fuse Plug Pilot Channel Invert Level*
		m	m AHD	m AHD	m AHD
Central Bay	Ogee	34.0	67	75.7	75.7
Right Side Bay	Ogee	64.5	67	76.2	76.23+
Left Side Bay	Ogee	65.5	67	76.7	76.78++

* Storage Level is as per that measured at the Headwater Gauge. Initiation of Fuse Plug is expected to occur when the Lake Water Level exceeds the Lake Level at Fuse Plug Pilot Channel by 0.10 - 0.15 m.

+ Includes 0.03m of drawdown from the Fuse Plug Pilot Channel Invert to the Lake Water Level

++ Includes 0.08m of drawdown from the Fuse Plug Pilot Channel Invert to the Lake Water Level

The arrangement of the Auxiliary Spillway is shown in the diagram below.



8.3 Initial Flood Control Action

Once a Flood Event is declared, an assessment is to be made of the magnitude of the Flood Event, including:

- A prediction of the maximum storage levels in Wivenhoe and Somerset Dams.
- A prediction of the peak flow rate at the Lowood Gauge excluding Wivenhoe Dam releases.
- A prediction of the peak flow rate at the Moggill Gauge excluding Wivenhoe Dam releases.

The spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding EL 67.25.

8.4 Flood Operations Strategies

There are four strategies (W1 to W4) used when operating Wivenhoe Dam during a flood event as outlined below. These strategies are based on the Flood Objectives of this manual. As outlined in Section 3, the objectives, listed in descending order of importance, are as follows:

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

Within any strategy, consideration is always given to these objectives in this order, when making decisions on dam releases.

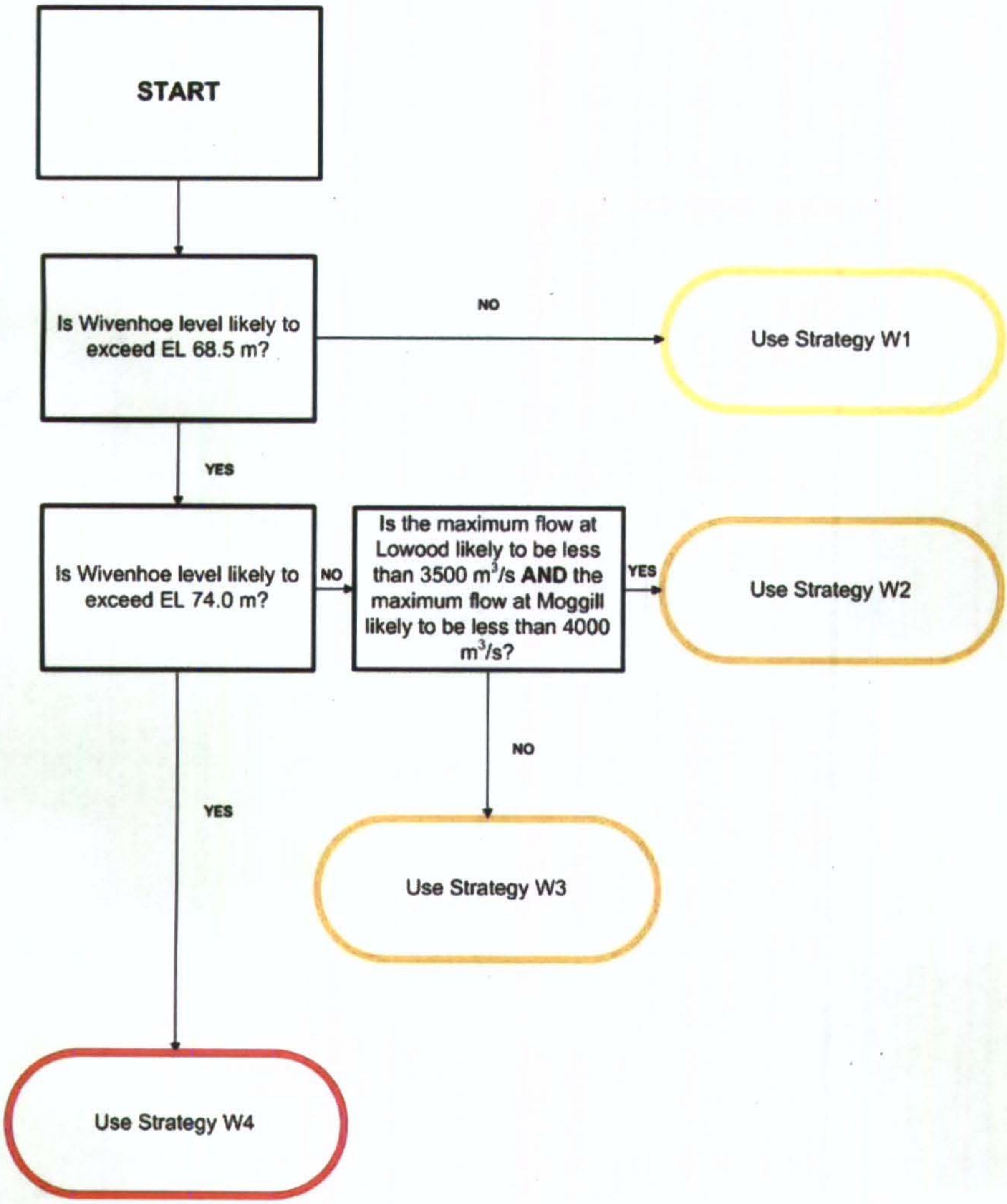
The strategy chosen at any point in time will depend on the actual levels in the dams and the following predictions, which are to be made using the best forecast rainfall and stream flow information available at the time:

- Maximum storage levels in Wivenhoe and Somerset Dams.
- Peak flow rate at the Lowood Gauge (excluding Wivenhoe Dam releases).
- Peak flow rate at the Moggill Gauge (excluding Wivenhoe Dam releases).

Strategies are likely to change during a flood event as forecasts change and rain is received in the catchments. It is not possible to predict the range of strategies that will be used during the course of a flood event at the commencement of the event. Strategies are changed in response to changing rainfall forecasts and stream flow conditions to maximise the flood mitigation benefits of the dams.

When determining dam outflows within all strategies, peak outflow should generally not exceed peak inflow. A flowchart showing how best to select the appropriate strategy to use at any point in time is shown below:

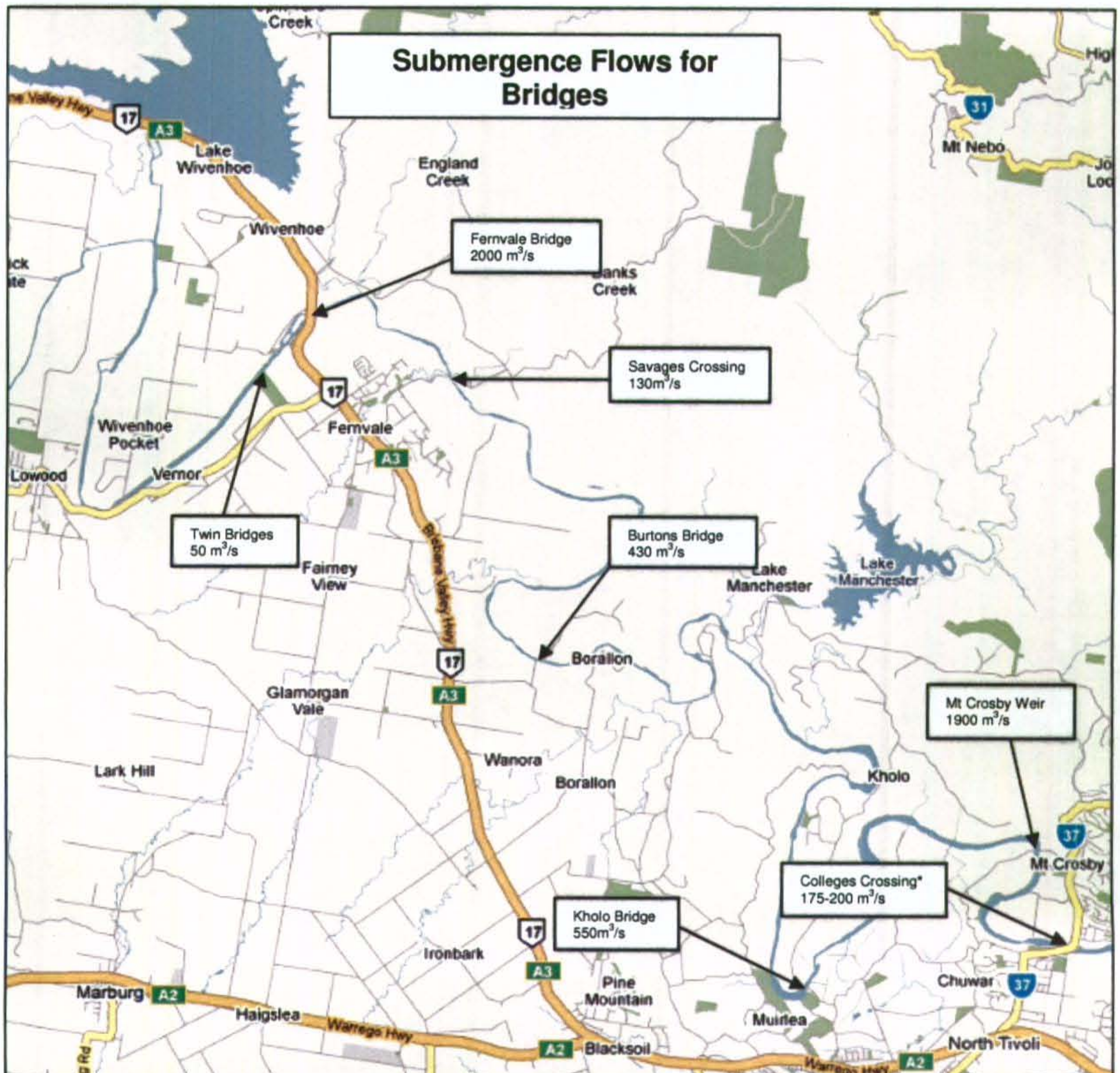
WIVENHOE FLOOD STRATEGY FLOW CHART



Strategy W1 - The Primary Consideration is Minimising Disruption to Downstream Rural Life

Conditions	• **Wivenhoe Storage Level predicted to be less than 68.50 m AHD** • **Maximum release predicted to be less than 1,900 m^3/s** • **The primary consideration is minimising disruption to downstream rural life**

The intent of Strategy W1 is to not to submerge the bridges downstream of the dam prematurely (see Appendix I). The limiting condition for Strategy W1 is the submergence of Mt Crosby Weir Bridge that occurs at approximately 1,900 m^3/s.



* Note: Colleges Crossing is affected by tides

For situations where flood rains are occurring on the catchment upstream of Wivenhoe Dam and only minor rainfall is occurring downstream of the dam, releases are to be regulated to limit, as much as appropriate in the circumstances, downstream flooding.

The following strategies require a great deal of control over releases and knowledge of discharges from Lockyer Creek. In general, the releases from Wivenhoe Dam are controlled such that the combined flow from Lockyer Creek and Wivenhoe Dam is less than the limiting values to delay the submergence of particular bridges. The diagram above shows the location of the impacted bridges and the approximate river flow rate at which they are closed to traffic.

Strategy W1A Twin Bridges, Savages Crossing and Colleges Crossing

Lake Level greater than 67.25 m AHD
[Maximum Release 110 m^3/s]

Firstly, endeavour to maintain Twin Bridges trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 50 m^3/s.

Once Twin Bridges is closed to traffic, endeavour to maintain Savages Crossing trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 110 m^3/s.

Once Savages Crossing is closed to traffic, endeavour to maintain College's Crossing trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 175 m^3/s. Note that College's Crossing can be impacted by tidal influences.

When the flood event subsides, all gates are to be closed when the dam achieves FSL in accordance with Section 8.5.

Strategy W1B College's Crossing and Burtons Bridge

Lake Level greater than 67.50 m AHD
[Maximum Release 380 m^3/s]

No consideration is given to maintaining Twin Bridges or Savages Crossing open.

Endeavour to maintain College's Crossing trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 175 m^3/s.

Once College's Crossing is closed to traffic, endeavour to maintain Burtons Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 430 m^3/s.

Strategy W1C Burtons Bridge and Kholo Bridge

Lake Level greater than 67.75 m AHD
[Maximum Release 500 m^3/s]

No consideration is given to maintaining College's Crossing open.

Endeavour to maintain Burtons Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 430 m^3/s.

Once Burtons Bridge is closed to traffic, endeavour to maintain Kholo Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 550 m^3/s.

Strategy W1D Kholo Bridge and Mt Crosby Weir Bridge

Lake Level greater than 68.00 m AHD
[Maximum Release 1900 m^3/s]

No consideration is given to maintaining Burtons Bridge open.

Endeavour to maintain Kholo Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 550 m^3/s.

Once Kholo Bridge is closed to traffic, endeavour to maintain Mt Crosby Weir Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 1900 m^3/s.

Strategy W1E Mt Crosby Weir Bridge and Fernvale Bridge

Lake Level greater than 68.25 m AHD
[Maximum Release 1900 m^3/s]

No consideration is given to maintaining Kholo Bridge open.

Endeavour to maintain Mt Crosby Weir Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 1900 m^3/s.

Once Mt Crosby Weir Bridge is closed to traffic, endeavour to maintain Fernvale Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 2000 m^3/s.

If the level reaches EL 68.5 m AHD in Wivenhoe Dam, switch to Strategy W2 or W3 as appropriate.

Strategy W2 - Strategy W2 is a Transition Strategy where the primary consideration changes from Minimising Impact to Downstream Rural Life to Protecting Urban Areas from Inundation.

Conditions	• **Wivenhoe Storage Level predicted to be between 68.50 and 74.00 m AHD** • **Maximum Release predicted to be less than 3,500 m^3/s** • **This is a transition strategy in which the primary consideration changes from minimising disruption to downstream rural life to protecting urban areas from inundation** • **Lower level objectives are still considered when making decisions on water releases. Objectives are always considered in order of importance**

The intent of Strategy W2 is limit the flow in the Brisbane River to less than the naturally occurring peaks at Lowood and Moggill, while remaining within the upper limit of non-damaging floods at Lowood (3,500 m^3/s). In these instances, the combined peak river flows should not exceed those shown in the following table:

LOCATION	TARGET MAXIMUM FLOW IN THE BRISBANE RIVER
Lowood	The lesser of: • the natural peak flow at Lowood excluding Wivenhoe Dam releases, and; • 3,500m^3/s.
Moggill	The lesser of: • the natural peak flow at Moggill excluding Wivenhoe Dam releases, and; • 4,000m^3/s.

Strategy W3 – The primary consideration is Protecting Urban Areas from Inundation

Conditions	• **Wivenhoe Storage Level predicted to be between 68.50 and 74.00 m AHD** • **Maximum Release should not exceed 4,000 m^3/s** • **The primary consideration is protecting urban areas from inundation** • **Lower level objectives are still considered when making decisions on water releases. Objectives are always considered in order of importance**

The intent of Strategy W3 is to limit the flow in the Brisbane River at Moggill to less than 4000 m^3/s, noting that 4000 m^3/s at Moggill is the upper limit of non-damaging floods downstream. The combined peak river flow targets for Strategy W3 are shown in the following table. In relation to these targets, it should be noted that depending on natural flows from the Lockyer and Bremer catchments, it may not be possible to limit the flow at Moggill to below 4000 m^3/s. In these instances, the flow at Moggill is to be kept as low as possible.

TIMING	TARGET MAXIMUM FLOW IN THE BRISBANE RIVER
Prior to the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases).	The flow at Moggill is to be minimised.
After the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases).	The flow at Moggill is to be lowered to 4,000m^3/s as soon as possible.

Strategy W4 – The primary consideration is Protecting the Structural Safety of the Dam

Conditions	• **Wivenhoe Storage Level predicted to exceed 74.00m AHD.** • **No limit on Maximum Release rate** • **The primary consideration is protecting the structural safety of the dam** • **Lower level objectives are still considered when making decisions on water releases. Objectives are always considered in order of importance**

The intent of Strategy W4 is to ensure the safety of the dam while limiting downstream impacts as much as possible.

This strategy normally comes into effect when the water level in Wivenhoe Dam reaches 74.0 m AHD. However the Senior Flood Operations Engineer may seek to invoke the discretionary powers of Section 2.8 if earlier commencement is able to prevent triggering of a fuse plug.

Under Strategy W4 the release rate is increased as the safety of the dam becomes the priority. Opening of the gates is to occur generally in accordance with the requirements of Section 8.6, until the storage level of Wivenhoe Dam begins to fall.

There are no restrictions on gate opening increments or gate operating frequency once the storage level exceeds 74.0 AHD, as the safety of the dam is of primary concern at these storage levels. However the impact of rapidly increasing discharge from Wivenhoe Dam on downstream reaches should be considered when determining gate opening sequences.

Strategy W4A – No Fuse Plug Initiation Expected

Lake Level between 74.0 and 75.5 m AHD
[No Maximum Release]

Strategy 4A applies while all indications of the peak flood level in Wivenhoe Dam are that it will be insufficient to trigger operation of the first bay of the fuse plug by reaching 75.5 m AHD.

Gate openings are generally to occur at the minimum intervals and sequences as specified in Section 8.6 until the storage level of Wivenhoe Dam begins to fall. However, to protect the safety of the dam, minimum opening intervals can be reduced and gate opening sequences can be modified.

Strategy W4B – Fuse Plug Initiation Possible

Lake Level greater than 75.5 m AHD
[No Maximum Release]

Strategy W4B applies once indications are the peak flood level in Wivenhoe Dam may exceed EL75.5 and trigger the fuse plug under normal operations. Two scenarios are possible under this strategy. The first scenario is where it may be possible to prevent fuse plug initiation by early opening of the gates. The second scenario is where fuse plug initiation cannot be avoided. The actions associated with these scenarios are contained in the following table:

SCENARIO	ACTION
Potential to keep lake level below EL 75.5 by early opening of the gates and/or varying the operational procedures at Somerset.	The following actions can be used to prevent initiation of the fuse plug provided the safety of the dams is not compromised: • Retain water in Somerset Dam (See Somerset Dam Strategy S3 for guidelines). • Bring the gate operation sequence forward to increase discharge from the dam. In addition to dam safety issues, the impact of rapidly increasing discharge from Wivenhoe Dam on downstream reaches should be considered when determining the rate of gate openings.
Fuse plug initiation cannot be avoided.	PRIOR TO FUSE PLUG INITIATION If possible, the gates are to be raised at a rate to ensure they are out of the water before the initiation of the first fuse plug. The gates should be in the fully open position before the dam water level reaches 75.7 m AHD. FOLLOWING FUSE PLUG INITIATION The impact of rapidly changing discharge from Wivenhoe Dam on downstream reaches should be considered when determining the rate of gate closings in these circumstances. However, once a fuse plug is initiated, the flood storage at the dam is to be drained as quickly as possible within the gate closure sequence.

8.5 Gate Closing Strategies

In general, gate closing commences when the level in Wivenhoe Dam begins to fall and is generally to occur in the reverse order to opening. The final gate closure should occur when the lake level has returned to Full Supply Level. The following requirements must be considered when determining gate closure sequences:

- Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.
- The maximum discharge from the dam during closure should generally be less than the peak inflow into Wivenhoe Dam experienced during the event. The discharge from Wivenhoe Dam includes discharge from triggered fuse plugs, gates, regulator cone dispersion valve and hydro release.
- If, at the time the lake level in Wivenhoe Dam begins to fall, the combined flow at Lowood is in excess of 3,500 m^3/s then the combined flow at Lowood is to be reduced to 3,500 m^3/s as quickly as practicable.
- The aim should always be to empty stored floodwaters stored above EL 67.0m within seven days after the flood peak has passed through the dams. However, provided a favourable weather outlook is available, this requirement can be relaxed for the volume between EL 67.0m and EL 67.5m, to obtain positive environmental outcomes.
- If the flood storage compartments of Wivenhoe Dam and Somerset Dam can be emptied within seven days, the maximum flow in the Brisbane River at Lowood should not exceed 3,500 m^3/s.
- To minimise the stranding of fish downstream of the dam, final closure sequences should consider Seqwater policies relating to fish protection at the dam.

There may be a need to take into account base flow when determining final gate closure. This may mean that the lake level temporarily falls below Full Supply Level to provide for a full dam at the end of the Flood Event.

8.6 Gate Operation Sequences

Radial Gate Opening Operations

When dam outflows are less than 4,000 m^3/s, rapid opening of the radial gates can cause undesirable rapid rises in downstream river levels. Accordingly, when dam outflows are less than 4,000 m^3/s, the aim in opening radial gates is to operate the gates one at a time at intervals that will minimise adverse impacts on the river system. The table below shows the target minimum interval for gate operations in these circumstances. This target interval can be reduced if the gates are at risk of being overtopped or the safety of the dam is at risk.

TARGET MINIMUM INTERVAL FOR RADIAL GATE OPENING (DOWNSTREAM RIVER FLOWS < 4000 m^3/s)

OPERATION	TIME INTERVAL BETWEEN SUCCESSIVE OPENING OF INDIVIDUAL GATES (mins)
Radial Gate opening of 500 mm	10

When dam outflows exceed 4,000 m^3/s, the impact of rapid gate openings on downstream water levels is reduced due to the already elevated river levels. Under these circumstances, the safety of the dam will generally be of primary concern and therefore there are no minimum gate opening intervals in these circumstances.

Under extreme circumstances, the mechanical capability of the radial gate operating system provides the facility to open each radial gate more than five metres within a one hour period. Accordingly, unless a mechanical breakdown is experienced, physical gate opening capability in unlikely to be a constraint in meeting projected outflow targets.

Radial Gate Closing Operations

When dam outflows are less than 4,000 m^3/s, rapid closure of the radial gates can cause adverse impacts to the river system. Accordingly, when dam outflows are less than 4,000 m^3/s, the aim in closing radial gates is to operate the gates one at a time at an interval that will minimise adverse impacts on the river system as outlined in the table below.

TARGET MINIMUM INTERVAL FOR RADIAL GATE CLOSURE

OPERATION	TIME INTERVAL BETWEEN SUCCESSIVE CLOSING OF INDIVIDUAL GATES (mins)
Radial Gate closure of 500 mm	20

When dam outflows exceed 4,000 m^3/s, the impact of rapid gate closings is reduced due to the already elevated river levels. However, given that the safety of the dam is unlikely to be at risk if decisions are made to close radial gates, the target of operating the gates one at a time in accordance with the time interval shown in the above table remains.

Rapid closure of radial gates is permissible however, when there is a requirement to preserve storage or to reduce downstream flooding. When determining gate closure sequences, consideration should also be given to following the calculated natural recession of the flood in the river to aim to ensure that the recession impacts are not greater than those that would have been experienced had the dam not been constructed.

Protection of the Spillway Walls

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete spillway structures and into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions or when Gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool. As these walls have been excavated into erodible sandstone rock, this impingement may cause non-predictable erosion. Upstream migration of this erosion is to be avoided. This can be achieved by operating Gates 1 and 5 to deflect the discharge away from the walls of the plunge pool.

Therefore in operating the spillway, the principles to be observed in order of priority are:

(i) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

(ii) The flow in the spillway is to be symmetrical.

Normal Gate Operation Sequences

Under normal operation, only one gate is to be opened at any one time and the sequences shown in the table below are to be adopted. Generally gates are operated in the order of 3,2,4,1,5. Variations are allowed at any time to protect the structural safety of the dam.

It should also be noted that:

- Gates are numbered 1 to 5 from the left bank looking downstream
- Flow in spillway to be as symmetrical as possible.

RADIAL GATE OPENING SEQUENCES

Gate 1 Opening (m)	Gate 2 Opening (m)	Gate 3 Opening (m)	Gate 4 Opening (m)	Gate 5 Opening (m)	Gate Operated
-	-	-	-	-	-
0.0	0.0	0.0	0.0	0.0	-
0.0	0.0	0.5	0.0	0.0	3
0.0	0.0	1.0	0.0	0.0	3
0.0	0.0	1.5	0.0	0.0	3
0.0	0.0	2.0	0.0	0.0	3
0.0	0.0	2.5	0.0	0.0	3
0.0	0.0	3.0	0.0	0.0	3
0.0	0.0	3.5	0.0	0.0	3
0.0	0.5	3.5	0.0	0.0	2
0.0	0.5	3.5	0.5	0.0	4
0.0	0.5	4.0	0.5	0.0	3
0.0	1.0	4.0	0.5	0.0	2
0.0	1.0	4.0	1.0	0.0	4

Gate 1 Opening (m)	Gate 2 Opening (m)	Gate 3 Opening (m)	Gate 4 Opening (m)	Gate 5 Opening (m)	Gate Operated
0.5	1.0	4.0	1.0	0.0	1
0.5	1.0	4.0	1.0	0.5	5
0.5	1.5	4.0	1.0	0.5	2
0.5	1.5	4.0	1.5	0.5	4
1.0	1.5	4.0	1.5	0.5	1
1.0	1.5	4.0	1.5	1.0	5
1.0	2.0	4.0	1.5	1.0	2
1.0	2.0	4.0	2.0	1.0	4
1.5	2.0	4.0	2.0	1.0	1
1.5	2.0	4.0	2.0	1.5	5
1.5	2.5	4.0	2.0	1.5	2
1.5	2.5	4.0	2.5	1.5	4
1.5	2.5	4.5	2.5	1.5	3
2.0	2.5	4.5	2.5	1.5	1
2.0	2.5	4.5	2.5	2.0	5
2.5	2.5	4.5	2.5	2.0	1
2.5	2.5	4.5	2.5	2.5	5
2.5	3.0	4.5	2.5	2.5	2
2.5	3.0	4.5	3.0	2.5	4
2.5	3.5	4.5	3.0	2.5	2
2.5	3.5	4.5	3.5	2.5	4
3.0	3.5	4.5	3.5	2.5	1
3.0	3.5	4.5	3.5	3.0	5
3.0	4.0	4.5	3.5	3.0	2
3.0	4.0	4.5	4.0	3.0	4
3.0	4.0	5.0	4.0	3.0	3
3.5	4.0	5.0	4.0	3.0	1
3.5	4.0	5.0	4.0	3.5	5
3.5	4.5	5.0	4.0	3.5	2
3.5	4.5	5.0	4.5	3.5	4
4.0	4.5	5.0	4.5	3.5	1
4.0	4.5	5.0	4.5	4.0	5
4.5	4.5	5.0	4.5	4.0	1
4.5	4.5	5.0	4.5	4.5	5
4.5	5.0	5.0	5.0	4.5	2,4
5.0	5.0	5.0	5.0	5.0	1,5
5.0	5.0	5.5	5.0	5.0	3
5.0	5.5	5.5	5.5	5.0	2,4
5.5	5.5	5.5	5.5	5.5	1,5
5.5	5.5	6.0	5.5	5.5	3
5.5	6.0	6.0	6.0	5.5	2,4
6.0	6.0	6.0	6.0	6.0	1,5
6.0	6.0	6.5	6.0	6.0	3
6.0	6.5	6.5	6.5	6.0	2,4
6.5	6.5	6.5	6.5	6.5	1,5
6.5	6.5	7.0	6.5	6.5	3
7.0	7.0	7.0	7.0	7.0	2,4,1,5

Gate 1 Opening (m)	Gate 2 Opening (m)	Gate 3 Opening (m)	Gate 4 Opening (m)	Gate 5 Opening (m)	Gate Operated
7.5	7.5	7.5	7.5	7.5	3,2,4,1,5
8.0	8.0	8.0	8.0	8.0	3,2,4,1,5
8.5	8.5	8.5	8.5	8.5	3,2,4,1,5
9.0	9.0	9.0	9.0	9.0	3,2,4,1,5
9.5	9.5	9.5	9.5	9.5	3,2,4,1,5
10.0	10.0	10.0	10.0	10.0	3,2,4,1,5
11.0	11.0	11.0	11.0	11.0	3,2,4,1,5
12.0	12.0	12.0	12.0	12.0	3,2,4,1,5
13.0	13.0	13.0	13.0	13.0	3,2,4,1,5
14.0	14.0	14.0	14.0	14.0	3,2,4,1,5
15.0	15.0	15.0	15.0	15.0	3,2,4,1,5
17.5	17.5	17.5	17.5	17.5	3,2,4,1,5

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a gate by the immediate opening of a regulator valve (or the reverse operation). This allows for greater control of low flows.

Gate Failure or Malfunction Procedures

Gate operating procedures in the event of equipment failure are contained in Appendix G. If one or more gates are inoperable during the course of the flood event, the gate openings of the remaining gates are to be adjusted to provide the required discharge from the dam. These adjustments should ensure that:

- The impact of the flow on the sidewalls of the plunge pool should be minimised, and
- The flow in the spillway is as symmetrical as practicable.

Radial Gate Turbulence Considerations

Unless in the process of lifting the gates clear of the flow, the bottom edge of the radial gates must always be at least 500 millimetres below the release flow surface. Having the bottom edge of the gates closer to the release flow surface than 500 millimetres may cause unusual turbulence that could adversely impact on the gates. This procedure has never been undertaken in practice and should be observed closely when being undertaken. Variations to the procedure are allowed to protect the structural safety of the dam.

Lowering Radial Gates that have been lifted Clear of the Release Flow

When lowering radial gates that have been lifted clear of the release flow, the bottom edge of the gates must be lowered at least 500 millimetres into the flow. Lowering gates into the release flow less than this amount may cause unusual turbulence that could adversely impact on the gates. This procedure has never been undertaken in practice and should be observed closely when being undertaken. Variations to the procedure are allowed to protect the structural safety of the dam.

8.7 Modification to Flood Operating Procedures if a Fuse Plug Triggers

Where the operation of a fuse plug spillway bay has been triggered, the flood operation procedures are to be modified such that:

- The discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;
- The gates are to be operated, to the extent possible, so that the same discharge restrictions apply as would have if the fuse plug embankment was intact.

8.8 Modification to Flood Operating Procedures if a subsequent flood event occurs prior to the reconstruction of Triggered Fuse Plugs

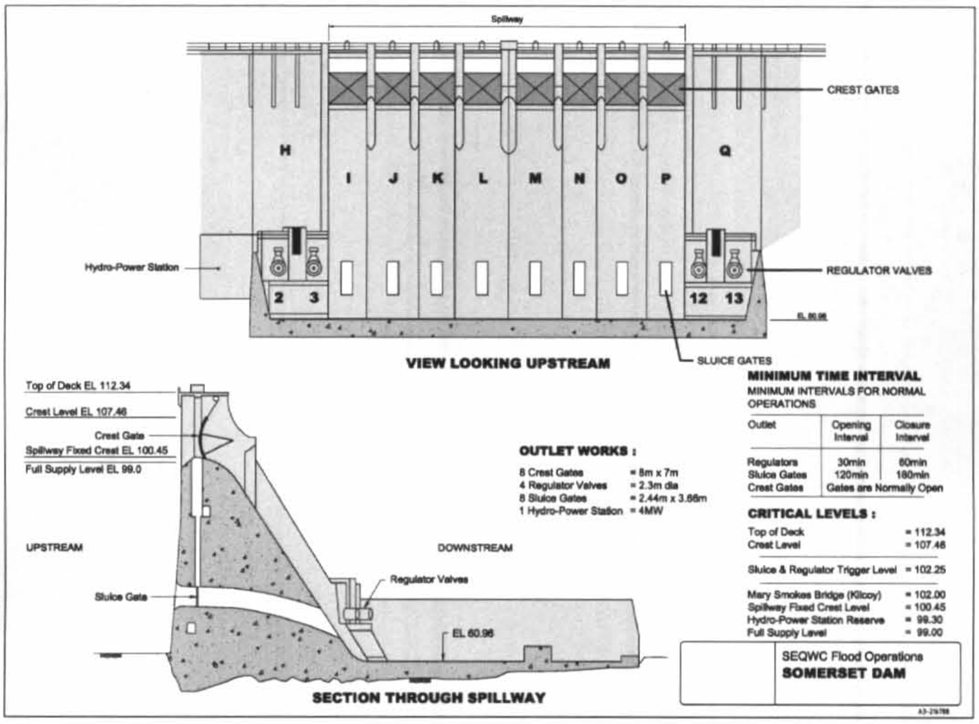
Where the operation of any or all of the fuse plug spillway bays has been triggered and a flood event occurs before the fuse plug can be reinstated, the flood operation procedures are to be modified such that:

- The discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;
- The gates are to be operated, to the extent possible, so that the same discharge restrictions apply as would have if the fuse plug embankment was intact.
- Discharge from the Auxiliary Spillway will occur before the Gate Trigger Level of EL 67.25 m AHD. This flow should be taken into account when applying the flood operation strategies relevant to the low level bridge crossings.

9 SOMERSET DAM FLOOD OPERATIONS

9.1 Introduction

Somerset Dam is capable of being operated in a number of ways to regulate Stanley River floods. Somerset Dam and Wivenhoe Dam are to be operated in conjunction to optimise the flood mitigation benefits downstream of Wivenhoe Dam. The arrangement of the Somerset Dam Radial Gates, Sluice Gates and Regulator Valves is shown in the diagram below. At EL 107.45, flood waters commence to flow over the dam crest. To account for this discharge, the dam crest is assumed to operate as a broad crested weir with a spillway width of 135.33 m:



9.2 Initial Flood Control Action

Once a Flood Event is declared, all radial gates are to be fully opened and all sluice gates and regulator valves are to be fully closed. An assessment is to be made of the magnitude of the Flood Event, including a prediction of the maximum storage levels in Wivenhoe and Somerset Dams.

9.3 Flood Operations Strategies

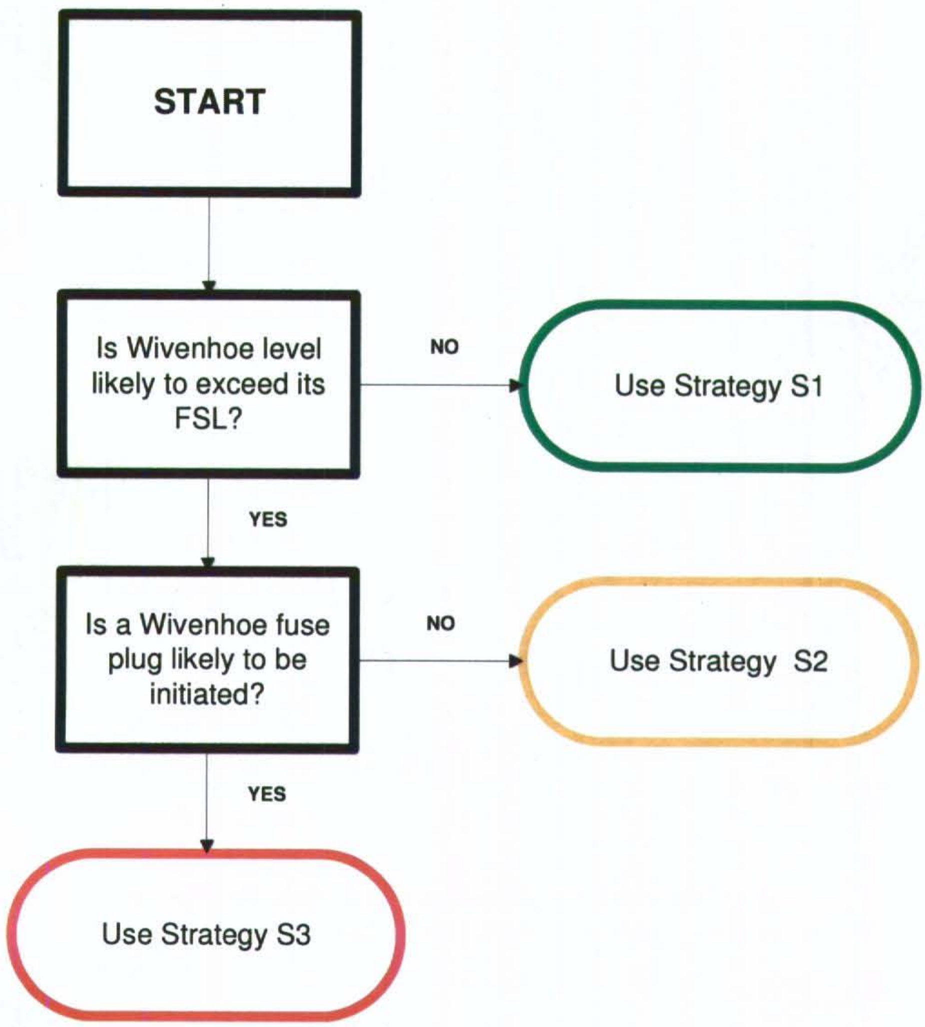
There are three strategies used when operating Somerset Dam during a flood event as outlined below. These strategies are based on the Flood Objectives of this manual. The strategy chosen at any point in time will depend on predictions of the maximum storage levels in Wivenhoe and Somerset Dams which are to be made using the best forecast rainfall and stream flow information available at the time.

Strategies are likely to change during a flood event as forecasts change and rain is received in the catchments. It is not possible to predict the range of strategies that will be used during the course of a flood event at the commencement of the event. Strategies are changed in response to changing rainfall forecasts and stream flow conditions to maximise the flood mitigation benefits of the dams.

When calculating the impacts of flood releases from Somerset Dam, the gate opening sequences outlined in Section 9.5 should be used to determine likely outflow rates from the dam.

A flowchart showing how best to select the appropriate strategy to use at any point in time is shown below:

SOMERSET FLOOD STRATEGY FLOW CHART



The order of operation for opening the sluices under each strategy is LMKNJOIP. Sluices are to be closed in reverse order of opening. Any inoperable sluices are to be dropped from the opening or closing sequences.

Strategy S1 – Minimising Impact on Rural Life Upstream

Conditions	• **Somerset Dam Level expected to exceed EL 99.0 and Wivenhoe Dam not expected to reach EL 67.0 (FSL) during the course of the Flood Event**

The intent of this strategy is to return the dam to full supply level while minimising the impact on rural life upstream of the dam. Consideration is also given to minimising the downstream environmental impacts from the release.

The crest gates at Somerset Dam are raised to enable uncontrolled discharge. The Regulator Valves and Sluice gates are to be used to maintain the level in Somerset dam below EL 102.0 (deck level of Mary Smokes Bridge). The release rate from Somerset dam is not to exceed the peak inflow into the dam.

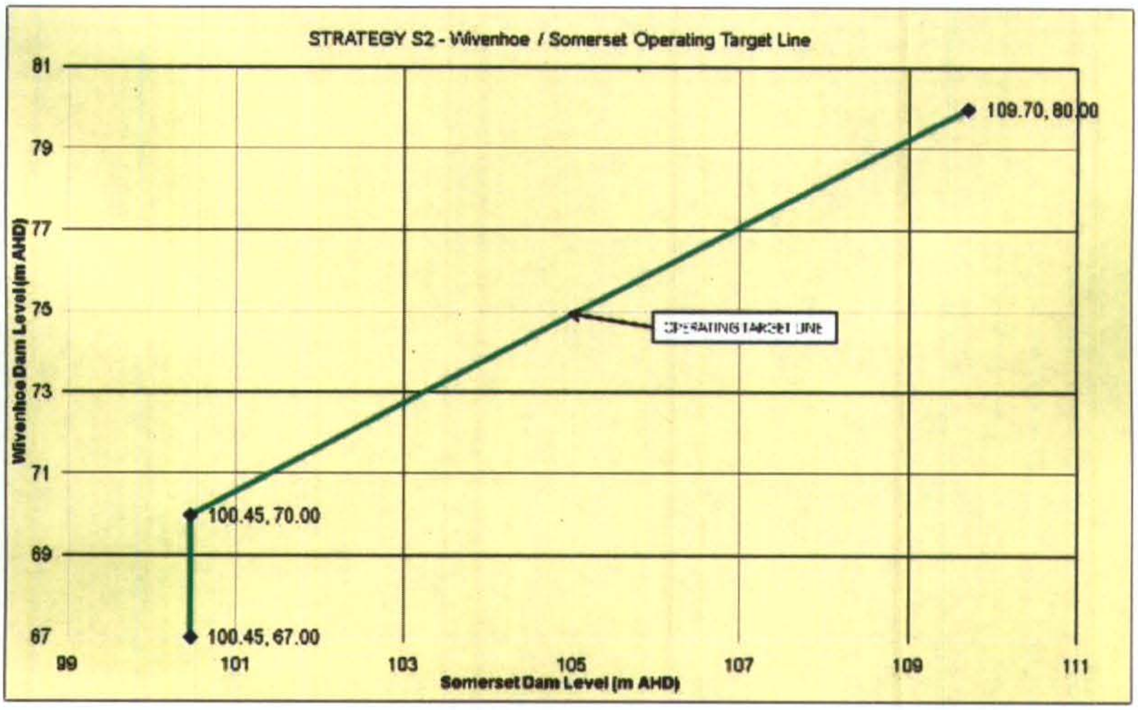
Strategy S2 – Minimise Impacts below Wivenhoe Dam

Conditions	• **Somerset Dam Level expected to exceed EL 99.0 and Wivenhoe Dam level expected to exceed EL 67.0 (FSL) but not exceed EL 75.5 (fuse plug initiation) during the course of the Flood Event.**

The intent of this strategy is to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams. The table below contains the operating conditions and actions for Strategy S2.

CONDITION	ACTION
Wivenhoe rising and Somerset level below EL 100.45.	The crest gates are raised to enable uncontrolled discharge. The low level regulators and sluices are generally kept closed.
Wivenhoe rising and Somerset level above EL 100.45.	The crest gates are raised to enable uncontrolled discharge. Operations are to target a correlation of water levels in Somerset Dam and Wivenhoe Dam as set out in the graph below. The operations target line shown on this graph is to generally be followed as the flood event progresses. The release rate from Somerset Dam is generally not to exceed the peak inflow into the dam.

Wivenhoe falling and Somerset level above EL 100.45.	The opening of the regulators and sluices generally should not cause Wivenhoe Dam to rise significantly. The release rate from Somerset Dam is generally not to exceed the peak inflow into the dam.
The Flood Event has emanated mainly from the Stanley River catchment without significant runoff in the Upper Brisbane River catchment	The crest gates at Somerset Dam are raised to enable uncontrolled discharge. The Regulator Valves and Sluice gates are to be used to maintain the level in Somerset dam below EL 102.0 (deck level of Mary Smokes Bridge). The release rate from Somerset Dam is generally not to exceed the peak inflow into the dam.



Notes:

- The Operating Target Line was selected following an optimisation study. The Target Line was selected based on the following factors:
  - Equal minimisation of flood level peaks in both dams in relation to their associated dam failure levels.
  - Minimisation of flows in the Brisbane River downstream of Wivenhoe Dam.
  - Consideration of the time needed at the onset of a Flood Event to properly assess the magnitude of the event and the likely impacts, so that the likely optimal strategy to maximise the Flood Mitigation benefits of the storages can be selected.
- The levels of 109.70 m AHD and 80.00 m AHD represent the likely failure level for Somerset Dam and the level at the top of the Wivenhoe Dam Wave Wall respectively. Note that the failure level of 109.70 m AHD for Somerset Dam assumes all radial gates are fully open and this failure level will be reduced if this cannot be achieved.

- The target point on the operating target line at any point in time is based on the maximum storage levels in Wivenhoe and Somerset Dams using the best forecast rainfall and stream flow information available at the time.
- Gate operations will enable the movement of the duty point towards the target line in a progressive manner. It will not necessarily be possible to adjust the duty point directly towards the target line in a single gate operation.

Strategy S3 - Protect the Structural Safety of the Dam

Conditions	• **Somerset Dam Level expected to exceed EL 99.0 and Wivenhoe Dam level expected to exceed EL 75.5 (fuse plug initiation) during the course of the Flood Event.**

The intent of this strategy is to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams.

In addition to the operating protocols used in Strategy S2, to prevent fuse plug initiation, consideration can be given to temporary departure from the operating protocols contained in this strategy under the following conditions:

- The safety of Somerset Dam is the primary consideration and cannot be compromised.
- The peak level in Somerset dam cannot exceed EL 109.7.

9.4 Gate Closing Strategies

In general, gate closing commences when the level in Somerset Dam begins to fall and is generally to occur in the reverse order to opening. The final gate closure should occur when the lake level has returned to Full Supply Level. The following requirements must be considered when determining gate closure sequences:

- Unless determined otherwise by the Senior Flood Operations Engineer in accordance with Section 2.8, the aim should be to empty stored floodwaters within seven days after the flood peak has passed through the dams.
- To minimise the stranding of fish downstream of the dam, final closure sequences should consider Seqwater policies relating to fish protection at the dam.

There may be a need to take into account base flow when determining final gate closure. This may mean that the lake level temporarily falls below Full Supply Level to provide for a full dam at the end of the Flood Event.

9.5 Gate Operation Sequences

Intervals between Operations

Releases from Somerset Dam flow directly into Wivenhoe Dam and therefore the downstream river impact considerations associated with radial gate operations at Wivenhoe Dam, do not directly apply to Somerset Dam. However, the following minimum intervals should generally be observed whilst opening and closing regulators, sluices and crest gates at Somerset Dam for flood mitigation purposes. These intervals have been chosen to minimise any adverse impacts caused by lake level rises above the junction of the Stanley and Brisbane Rivers.

MINIMUM INTERVALS FOR NORMAL GATE OPERATIONS

ITEM	OPENING	CLOSING
Regulator Valves	30 mins	60 mins
Sluice Gates (Dam level < EL 100.45)	120 mins	180 mins
Sluice Gates (Dam level > EL 100.45)	60 mins	60 mins
Crest Gates	Gates are normally open	-

Sluice Gate Operations

The order of operation for opening the sluices under each strategy is LMKNJOIP. Sluices are to be closed in reverse order of opening. Any inoperable sluices are to be dropped from the opening or closing sequences.

Regulator Valve Considerations

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a sluice gate by the immediate opening of one or more regulator valves (or the reverse operation). This allows for greater control of low flows and enables a smooth transition on opening and closing sequences.

It must also be noted that the Regulator Valves are not to be operated when the tail water level below Somerset Dam is above the invert of the valves (68.60 m AHD). Operating the valves under these circumstances can damage the valves. This requirement can be ignored if the structural safety of the dam is at risk.

10 EMERGENCY FLOOD OPERATIONS

10.1 Introduction

While every care has been exercised in the design and construction of the dams, there still remains a low risk that the dams may develop an emergency condition either through flood events or other causes. Vigilance is required to recognise emergency flood conditions such as:

- Occurrence of a much larger flood than the discharge capacity of the dam;
- Occurrence of a series of large storms in a short period;
- Failure of one or more gates during a flood.
- Development of a piping failure through the embankment of Wivenhoe Dam;
- Damage to the dams by earthquake;
- Damage to the dams as an act of war or terrorism;

Responses to these conditions are included in Emergency Action Plans for the dams.

10.2 Overtopping of Dams

Whatever the circumstances, every endeavour must be made to prevent overtopping of Wivenhoe Dam by the progressive opening of operative spillway gates. The Auxiliary Spillway constructed at the dam in 2005 gives the dam crest flood an AEP of approximately 1 in 100,000. Another one bay fuse plug spillway may be constructed at Saddle Dam Two in the future, thereby increasing this immunity.

Somerset Dam should not be overtopped by flood water, but if Wivenhoe Dam is threatened by overtopping, the release of water from Somerset Dam is to be reduced at the risk of overtopping Somerset Dam in order to prevent the overtopping of Wivenhoe Dam.

10.3 Communications Failure

If communications are lost between the Flood Operations Centre and either dam, the officers in charge at each dam are to adopt the procedures set out below.

Wivenhoe Dam Emergency Procedure

In the event of communications loss with the Flood Operations Centre, the Dam Supervisor at Wivenhoe Dam is to assume responsibility for flood releases from the Dam. Once it has been established that communications have been lost, the Dam Supervisor at Wivenhoe Dam is to:-

- Take all practicable measures to restore communications and periodically check the lines of communication for any change;

- Follow the procedures set out below to determine the relevant magnitude and duration of releases from Wivenhoe Dam;
- Log all actions in the Event Log;
- Ensure the dam is at full supply level at the end of the event;
- Remain in the general vicinity of the dam while on duty.

The radial gate opening sequence is as set out in Table 10.2. Individual sequence steps are shown against a target storage level. The minimum time intervals between each step in the radial gate opening sequence are shown in Table 10.1. Falling behind or being in front of the target gate openings is permissible when the storage level is less than 74.0 m AHD, but not allowed when the storage level is greater than 74.0 m AHD. When the storage level is below 74.0 m AHD, the operating intervals shown in Table 10.1 must generally be followed and can be ignored only to protect the structural safety of the dam.

Where the operation of a fuse plug spillway bay has been triggered, the relevant table contained in Appendix J is to be substituted for Table 10.2.

TABLE 10.1
MINIMUM INTERVALS BETWEEN OPERATING SEQUENCE STEPS

ITEM	MINIMUM OPENING INTERVAL	MINIMUM CLOSING INTERVAL
Radial Gates (Dam Level < EL 74.0)	10 mins	20 mins
Radial Gates (Dam Level > EL 74.0)	No Minimum	No Minimum

TABLE 10.2
RADIAL GATE OPENING SEQUENCE STEPS AND TARGET GATE OPENINGS AGAINST STORAGE LEVEL

Storage Level	Gate 1 Opening	Gate 2 Opening	Gate 3 Opening	Gate 4 Opening	Gate 5 Opening	Total Opening	Discharge	Gate Operated
m AHD	(m)	(m)	(m)	(m)	(m)	(m)	(m^3/s)	
67.00	-	-	-	-	-	-		
67.25	0.0	0.0	0.0	0.0	0.0	0	0	
67.50	0.0	0.0	0.5	0.0	0.0	0.5	50	3
67.75	0.0	0.0	1.0	0.0	0.0	1.0	100	3
68.00	0.0	0.0	1.5	0.0	0.0	1.5	150	3
68.25	0.0	0.0	2.0	0.0	0.0	2.0	210	3
68.50	0.0	0.0	2.5	0.0	0.0	2.5	260	3
68.65	0.0	0.0	3.0	0.0	0.0	3.0	310	3

TABLE 10.2 (CONTINUED)

Storage Level	Gate 1 Opening	Gate 2 Opening	Gate 3 Opening	Gate 4 Opening	Gate 5 Opening	Total Opening	Discharge	Gate Operated
m AHD	(m)	(m)	(m)	(m)	(m)	(m)	(m^3/s)	
68.80	0.0	0.0	3.5	0.0	0.0	3.5	360	3
68.95	0.0	0.5	3.5	0.0	0.0	4.0	430	2
69.10	0.0	0.5	3.5	0.5	0.0	4.5	470	4
69.25	0.0	0.5	4.0	0.5	0.0	5.0	520	3
69.40	0.0	1.0	4.0	0.5	0.0	5.5	570	2
69.55	0.0	1.0	4.0	1.0	0.0	6.0	640	4
69.70	0.5	1.0	4.0	1.0	0.0	6.5	700	1
69.85	0.5	1.0	4.0	1.0	0.5	7.0	760	5
70.00	0.5	1.5	4.0	1.0	0.5	7.5	820	2
70.15	0.5	1.5	4.0	1.5	0.5	8.0	880	4
70.30	1.0	1.5	4.0	1.5	0.5	8.5	940	1
70.45	1.0	1.5	4.0	1.5	1.0	9.0	1,000	5
70.60	1.0	2.0	4.0	1.5	1.0	9.5	1,070	2
70.70	1.0	2.0	4.0	2.0	1.0	10.0	1,130	4
70.80	1.5	2.0	4.0	2.0	1.0	10.5	1,190	1
70.90	1.5	2.0	4.0	2.0	1.5	11.0	1,250	5
71.00	1.5	2.5	4.0	2.0	1.5	11.5	1,310	2
71.10	1.5	2.5	4.0	2.5	1.5	12.0	1,370	4
71.20	1.5	2.5	4.5	2.5	1.5	12.5	1,430	3
71.30	2.0	2.5	4.5	2.5	1.5	13.0	1,500	1
71.40	2.0	2.5	4.5	2.5	2.0	13.5	1,560	5
71.50	2.5	2.5	4.5	2.5	2.0	14.0	1,620	1
71.60	2.5	2.5	4.5	2.5	2.5	14.5	1,680	5
71.70	2.5	3.0	4.5	2.5	2.5	15.0	1,750	2
71.80	2.5	3.0	4.5	3.0	2.5	15.5	1,810	4
71.90	2.5	3.5	4.5	3.0	2.5	16.0	1,870	2
72.00	2.5	3.5	4.5	3.5	2.5	16.5	1,930	4
72.10	3.0	3.5	4.5	3.5	2.5	17.0	2,000	1
72.20	3.0	3.5	4.5	3.5	3.0	17.5	2,060	5
72.30	3.0	4.0	4.5	3.5	3.0	18.0	2,130	2
72.40	3.0	4.0	4.5	4.0	3.0	18.5	2,190	4
72.50	3.0	4.0	5.0	4.0	3.0	19.0	2,250	3
72.55	3.5	4.0	5.0	4.0	3.0	19.5	2,310	1
72.60	3.5	4.0	5.0	4.0	3.5	20.0	2,370	5
72.65	3.5	4.5	5.0	4.0	3.5	20.5	2,430	2
72.70	3.5	4.5	5.0	4.5	3.5	21.0	2,490	4
72.75	4.0	4.5	5.0	4.5	3.5	21.5	2,550	1
72.80	4.0	4.5	5.0	4.5	4.0	22.0	2610	5
72.85	4.5	4.5	5.0	4.5	4.0	22.5	2670	1
72.90	4.5	4.5	5.0	4.5	4.5	23.0	2740	5
72.95	4.5	5.0	5.0	5.0	4.5	24.0	2850	2,4
73.00	5.0	5.0	5.0	5.0	5.0	25.0	2970	1,5
73.10	5.0	5.0	5.5	5.0	5.0	25.5	3030	3
73.20	5.0	5.5	5.5	5.5	5.0	26.5	3130	2,4

TABLE 10.2 (CONTINUED)

Storage Level	Gate 1 Opening	Gate 2 Opening	Gate 3 Opening	Gate 4 Opening	Gate 5 Opening	Total Opening	Discharge	Gate Operated
m AHD	(m)	(m)	(m)	(m)	(m)	(m)	(m^3/s)	
73.30	5.5	5.5	5.5	5.5	5.5	27.5	3280	1,5
73.40	5.5	5.5	6.0	5.5	5.5	28.0	3340	3
73.50	5.5	6.0	6.0	6.0	5.5	29.0	3460	2,4
73.60	6.0	6.0	6.0	6.0	6.0	30.0	3590	1,5
73.70	6.0	6.0	6.5	6.0	6.0	30.5	3680	3
73.80	6.0	6.5	6.5	6.5	6.0	31.5	3780	2,4
73.90	6.5	6.5	6.5	6.5	6.5	32.5	3900	1,5
74.00	6.5	6.5	7.0	6.5	6.5	33.0	3970	3
74.10	7.0	7.0	7.0	7.0	7.0	35.0	4210	1,2,4,5
74.20	7.5	7.5	7.5	7.5	7.5	37.5	4510	1,2,3,4,5
74.30	8.0	8.0	8.0	8.0	8.0	40.0	4810	1,2,3,4,5
74.40	8.5	8.5	8.5	8.5	8.5	42.5	5110	1,2,3,4,5
74.50	9.0	9.0	9.0	9.0	9.0	45.0	5430	1,2,3,4,5
74.60	9.5	9.5	9.5	9.5	9.5	47.5	5750	1,2,3,4,5
74.70	10.0	10.0	10.0	10.0	10.0	50.0	6070	1,2,3,4,5
74.80	11.0	11.0	11.0	11.0	11.0	55.0	6740	1,2,3,4,5
74.90	12.0	12.0	12.0	12.0	12.0	60.0	7440	1,2,3,4,5
75.00	13.0	13.0	13.0	13.0	13.0	65.0	8200	1,2,3,4,5
75.10	14.0	14.0	14.0	14.0	14.0	70.0	9010	1,2,3,4,5
75.20	15.0	15.0	15.0	15.0	15.0	75.0	9880	1,2,3,4,5
75.30	17.5	17.5	17.5	17.5	17.5	Fully Open	10160	1,2,3,4,5
≥75.40	17.5	17.5	17.5	17.5	17.5	Fully Open	10250	
75.50	17.5	17.5	17.5	17.5	17.5	Fully Open	10340	

Under extreme circumstances, the mechanical capability of the gate operating system allows the facility to open each radial gate more than five metres within a one hour period. Accordingly, unless a mechanical breakdown is experienced, physical gate opening capability in unlikely to be a constraint in meeting projected gate opening targets. However in a loss of communications scenario, when extreme rises in lake level are being experienced, dam operators will have difficulty in continually matching minimum gate settings to lake level. Accordingly, in these circumstances when the dam level exceeds 74.0 AHD, it is permissible to estimate target dam levels one hour in advance, based on lake level rises in the previous hour and undertake gate operations on this basis.

In the event of one or more radial gates becoming jammed, the remaining gates are to be operated to provide the same total opening for a particular storage level, as shown in the Table 10.2. In these circumstances, gates are generally operated in the order of 3,2,4,1,5, moving through the sequence shown in the table.

In a loss of communication scenario, the bulkhead gate is only to be used to prevent a situation occurring which could endanger the safety of the dam. At the end of the event, the full supply level of the storage is to be achieved.

Somerset Dam Emergency Procedure

In the event of communications loss with the Flood Operations Centre, the Dam Supervisor at Somerset Dam is to assume responsibility for flood releases from the Dam. Once it has been established that communications have been lost, the Dam Supervisor at Somerset Dam is to:

- Take all practicable measures to restore communications and periodically check the lines of communication for any change;
- Undertake the actions set out below to release flood water from Somerset Dam;
- Log all actions in the Event Log;
- Ensure the dam is at full supply level at the end of the event;
- Remain in the general vicinity of the dam while on duty.

The actions to be undertaken to release flood water are:

- If communications with Wivenhoe Dam are lost, the level in Wivenhoe Dam is to be assumed as the level shown on gauge boards located downstream of Somerset Dam.
- The radial gates are to be kept raised to allow uncontrolled discharge.
- The regulators are to be closed if the tail water level exceeds EL 68.60 and are generally kept closed. The only exception to this is if the regulators are used to prevent overtopping of the dam.
- Sluice gates are operated as either fully opened or fully closed. The order of operation for opening the sluice gates is LMKNJOIP. Sluices are to be closed in reverse order of opening. Any inoperable sluices are to be dropped from the opening or closing sequences. The sluice gates are to be operated in accordance with the following procedures:
    - **Case 1** - the level in Somerset Dam is below EL 100.45; or
    - **Case 2** - the level in Somerset Dam is above EL 100.45.

  These procedures are described below.

Case 1 Procedure (Level in Somerset Dam is below EL 100.45)

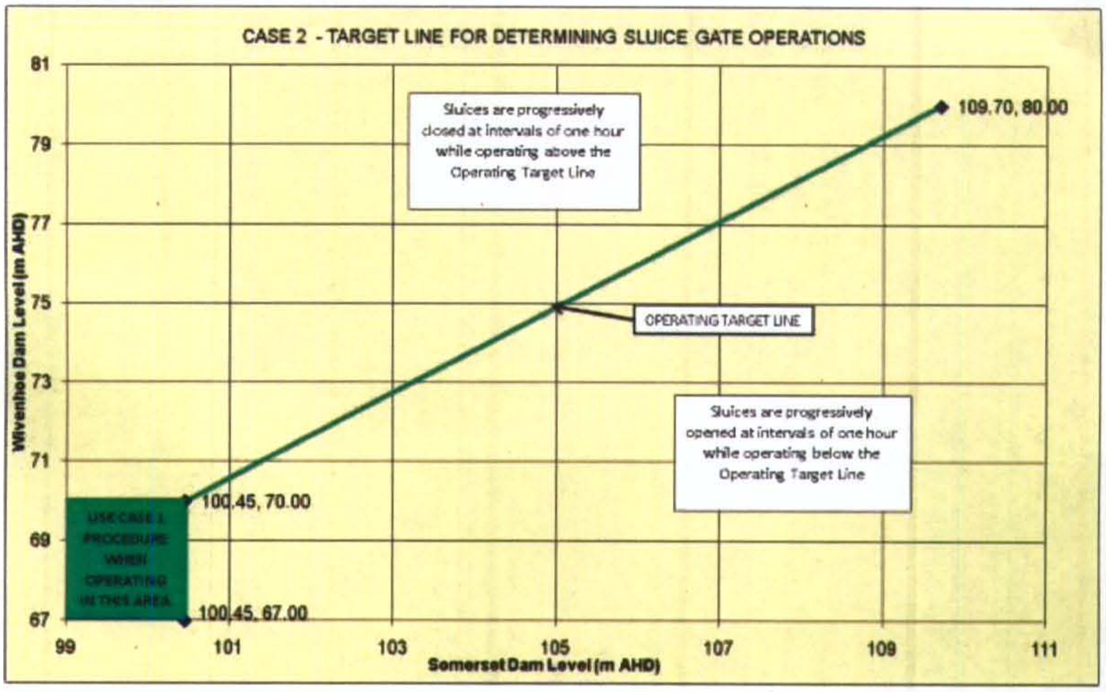
The sluice gates are to be operated in accordance with the following table:

SOMERSET DAM LOSS OF COMMUNICATIONS CASE 1 PROCEDURE	
CONDITIONS AT SOMERSET AND WIVENHOE DAMS	**ACTIONS**
Level in Somerset Dam is below EL 100.45, Level in Wivenhoe Dam is below EL 70.0 and falling.	Sluice gates are to be opened at intervals of not less than 120 minutes, provided the number of open sluice gates does not exceed that shown in the "**SOMERSET DAM - MAXIMUM SLUICE GATE OPENING**" table. Once a sluice gate is opened, no further sluice gate operations are to be undertaken for 120 minutes.
Level in Somerset Dam is below EL 100.45, Level in Wivenhoe Dam is below EL 70.0 and rising.	Sluice gates are to be closed at intervals of not less than 180 minutes. Once a sluice gate is closed, no further sluice gate operations are to be undertaken for 180 minutes.
Level in Somerset Dam is below EL 100.45, Level in Wivenhoe Dam is above EL 70.0.	Sluice gates are to be closed at intervals of not less than 60 minutes. Once a sluice gate is closed, no further sluice gate operations are to be undertaken for 60 minutes.

SOMERSET DAM MAXIMUM SLUICE GATE OPENING	
SOMERSET DAM LEVEL	**MAXIMUM NUMBER OF SLUICE GATES ALLOWED TO BE OPEN**
99.00	0
99.05	1
99.15	2
99.31	3
99.51	4
99.75	5
100.04	6
100.37	7
>100.37	8

Case 2 Procedure (Level in Somerset Dam is above EL 100.45)

The sluices gates are to be operated in accordance with the following graph:



Sluices are progressively closed at one hour intervals if operating above the Operating Target Line and progressively opened at one hour intervals if operating below the Operating Target Line. The aim is always to follow the Operating Target Line as closely as possible.

10.4 Equipment Failure

In the event of equipment failure the action to be taken is indicated in Appendix E for Wivenhoe Dam and Appendix F for Somerset Dam.

APPENDIX A
AGENCIES HOLDING CONTROLLED COPIES OF THIS MANUAL

Agency	Responsible Person	Location
Seqwater	Dam Safety and Source Operations Manager	Brisbane
Seqwater	Principal Engineer Dam Safety	Ipswich
Seqwater	Storage Supervisor	Wivenhoe Dam
Seqwater	Storage Supervisor	Somerset Dam
Seqwater	Operations Coordinator	Central
Seqwater	Senior Flood Operations Engineer	Flood Operations Centre, Brisbane
Department of Environment and Natural Resources	Director Dam Safety	Brisbane
Department of Emergency Services	Duty Officer – Disaster Management Service	Brisbane
Somerset Regional Council	Local Disaster Response Coordinator	Esk
Ipswich City Council	Local Disaster Response Coordinator	Ipswich
Brisbane City Council	Local Disaster Response Coordinator	Brisbane
Emergency Management Queensland	Regional Director, Brisbane District	Brisbane

APPENDIX B
KEY REFERENCE GAUGES

Location	Gauge Zero	1974 Gauge Height	Minor Flood		Moderate Flood		Major Flood	
			Gauge Height	Flow	Gauge Height	Flow	Gauge Height	Flow
	m AHD	m	m	m³/s	m	m³/s	m	m³/s
Stanley River at Somerset Dam	0.00	106.57	103.0		105.0		106.0	
Brisbane River at Lowood	23.68	22.02	8.0	1,000	15.0	3,300	20.0	6,000
Brisbane River at Lowood	22.74	-	8.6		15.9		21.2	
Brisbane River at Savages Crossing	18.43	23.79	9.0		16.0		21.0	
Brisbane River at Mt Crosby	0.00	26.74	11.0		13.0		21.0	
Bremer River at Ipswich	0.00	20.70	7.0		9.0		11.7	
Brisbane River at Moggill	0.00	19.95	10.0	4,000	13.0	5,000	15.5	6,500
Brisbane River at Jindalee Bridge	0.00	14.10	6.0		8.0		10.0	
Brisbane River at City Gauge	0.00	5.45	1.7		2.6		3.5	

Flows are approximate only and gauge heights are tide dependent in the lower reaches.

APPENDIX C
WIVENHOE DAM TECHNICAL DATA

STORAGE AND UNCONTROLLED GATE DISCHARGES						
Storage Level	Storage Capacity	Flood Capacity (3)	Net Inflow per 1mm rise per hour (2)	Discharge per Regulator (1)	Discharge per Spillway Bay (1)	Maximum Available Discharge
m AHD	x10^3 ML	10^6 m^3	m^3/s	m^3/s	m^3/s	m^3/s
57.0	414	-	11.1	24.9	0	50
57.5	453	-	12.0	25.2	4	69
58.0	466	-	13.0	25.4	15	128
58.5	494	-	13.9	25.7	32	211
59.0	523	-	14.8	25.9	53	'316
59.5	553	-	15.8	26.2	77	439
60.0	584	-	16.7	26.4	105	579
60.5	616	-	17.6	26.6	136	735
61.0	649	-	18.6	26.9	170	905
61.5	683	-	19.5	27.1	207	1,090
62.0	719	-	20.5	27.3	246	1,290
62.5	756	-	21.3	27.5	288	1,495
63.0	795	-	22.3	27.8	333	1,720
63.5	835	-	23.3	28.0	379	1,950
64.0	877	-	24.2	28.2	428	2,195
64.5	920	-	25.1	28.4	479	2,450
65.0	965	-	26.1	28.7	532	2,720
65.5	1,012	-	27.0	28.9	587	2,995
66.0	1,061	-	27.9	29.1	645	3,280
66.5	1,112	-	28.9	29.3	704	3,580
67.0	1,165	0	29.8	29.5	765	3,885
67.5	1,220	56	30.7	29.7	828	4,200
68.0	1,276	112	31.7	29.9	893	4,525
68.5	1,334	171	32.6	30.1	959	4,860
69.0	1,393	230	33.5	30.3	1,028	5,200

Storage Level	Storage Capacity	Flood Capacity (3)	Net Inflow per 1mm rise per hour (2)	Discharge per Regulator (1)	Discharge per Spillway Bay (1)	Maximum Available Discharge
m AHD	x10³ ML	10⁶ m³	m³/s	m³/s	m³/s	m³/s
69.5	1,454	290	34.5	30.5	1,098	5,550
70.0	1,517	350	35.4	30.7	1,170	5,910
70.5	1,581	418	36.3	30.9	1,244	6,280
71.0	1,647	485	37.3	31.1	1,319	6,660
71.5	1,714	550	38.2	31.3	1,396	7,040
72.0	1,783	615	39.1	31.5	1,474	7,430
72.5	1,854	683	40.1	31.7	1,554	7,840
73.0	1,926	750	41.0	31.9	1,636	8,240
73.5	2,000	830	41.9	32.1	1,719	8,660
74.0	2,076	910	42.9	32.3	1,804	9,080
74.5	2,153	995	43.8	32.5	1,890	9,520
75.0	2,232	1,080	44.7	32.7	1,978	9,960
75.5	2,313	1,160	45.7	32.9	2,067	10,400
76.0 (4)	2,395	1,240	46.6	33.1	2,158	10,860
76.5	2,480	1,258	47.6	33.3	2,250	11,320
77.0	2,566	1,420	48.5	33.4	2,343	11,780
77.5	2,655	1,500	49.4	36.6	2,438	12,260
78.0	2,746	1,580	50.4	33.8	2,535	12,740
78.5	2,839	1,680	51.3	34.0	2,632	13,230
79.0	2,934	1,780	52.2	34.2	2,700	13,500
79.5	3,032	1,880	54.4	34.4	2,700	13,500
80.0	3,132	1,980	55.6	34.6	2,700	13,500

(1) This is the maximum discharge of an individual spillway bay or regulator. Total discharge is calculated by adding the contributions of each gate or regulator. There are two (2) regulators to five (5) spillway bays.

(2) This assumes that all gates and sluices are closed. Discharges through the spillway have to be added to the above figures to calculate the actual inflow into the reservoir.

(3) The temporary storage above normal Full Supply Level of EL 67.0.

(4) The first fuse plug is designed to trigger at EL75.7. Above this level, fuse plug flows from Table E.3 need to be added to give the full outflow.

INDIVIDUAL RADIAL GATE - RATING TABLE (Outflows in m3/s – Gate Openings in metres open)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
67.0	0	49	98	146	194	240	285	329	372	413	453	492	530	567	603	639	675	709	744	765															
67.2	0	49	99	148	196	243	288	333	376	418	458	498	537	574	611	648	684	720	755	790															
67.4	0	50	100	149	198	245	291	336	380	422	464	504	543	582	619	657	693	730	766	802	815														
67.6	0	50	101	151	200	248	294	340	384	427	469	510	550	589	627	665	702	740	777	814	841														
67.8	0	51	102	152	202	250	297	343	388	432	474	515	556	596	635	673	712	750	787	825	863	867													
68.0	0	51	103	154	204	253	300	347	392	436	479	521	562	603	642	682	721	759	798	837	876	893													
68.2	0	52	104	155	206	255	303	350	396	441	484	527	569	610	650	690	729	769	808	848	888	919													
68.4	0	52	105	156	207	257	306	354	400	445	489	532	575	616	657	698	738	778	818	859	899	940	946												
68.6	0	53	105	158	209	260	309	357	404	450	494	538	581	623	665	706	747	788	829	870	911	953	973												
68.8	0	53	106	159	211	262	312	360	408	454	499	543	587	630	672	714	755	797	838	880	923	965	1000												
69.0	0	54	107	160	213	264	315	364	412	458	504	549	593	636	679	722	764	806	848	891	934	977	1022	1028											
69.2	0	54	108	162	215	267	317	367	415	463	509	554	599	643	686	729	772	815	858	901	945	989	1035	1056											
69.4	0	54	109	163	217	269	320	370	419	467	514	560	605	649	693	737	780	824	868	912	956	1001	1047	1084											
69.6	0	55	110	164	218	271	323	373	423	471	518	565	611	656	700	744	789	833	877	922	967	1013	1060	1107	1112										
69.8	0	55	111	166	220	273	326	377	427	475	523	570	616	662	707	752	797	842	887	932	978	1025	1072	1121	1141										
70.0	0	56	112	167	222	276	328	380	430	479	528	575	622	668	714	759	805	850	896	942	989	1036	1085	1134	1170										
70.2	0	56	112	168	224	278	331	383	434	484	532	580	628	674	721	767	813	859	905	952	1000	1048	1097	1147	1198	1199									
70.4	0	56	113	170	225	280	334	386	437	488	537	586	633	680	727	774	821	867	914	962	1010	1059	1109	1160	1212	1229									
70.6	0	57	114	171	227	282	336	389	441	492	542	591	639	687	734	781	828	876	923	972	1020	1070	1121	1173	1226	1258									
70.8	0	57	115	172	229	284	339	392	445	496	546	596	644	693	741	788	836	884	932	981	1031	1081	1133	1185	1239	1289									
71.0	0	58	116	173	230	286	341	395	448	500	551	601	650	699	747	795	844	892	941	991	1041	1092	1144	1198	1252	1309	1319								
71.2	0	58	117	175	232	289	344	398	452	504	555	605	655	705	754	802	851	900	950	1000	1051	1103	1156	1210	1266	1323	1349								
71.4	0	58	117	176	234	291	347	401	455	508	559	610	661	710	760	809	859	908	959	1009	1061	1114	1167	1222	1279	1337	1380								
71.6	0	59	118	177	235	293	349	404	458	512	564	615	666	716	766	816	866	916	967	1019	1071	1124	1179	1234	1292	1350	1410	1411							
71.8	0	59	119	178	237	295	352	407	462	515	568	620	671	722	773	823	874	924	976	1028	1081	1135	1190	1246	1304	1364	1425	1443							
72.0	0	60	120	180	239	297	354	410	465	519	572	625	676	728	779	830	881	932	984	1037	1091	1145	1201	1258	1317	1377	1439	1474							
72.2	0	60	121	181	240	299	357	413	469	523	577	629	682	733	785	837	888	940	993	1046	1100	1156	1212	1270	1330	1391	1454	1506							
72.4	0	60	121	182	242	301	359	416	472	527	581	634	687	739	791	843	895	948	1001	1055	1110	1166	1223	1282	1342	1404	1468	1533	1538						
72.6	0	61	122	183	243	303	361	419	475	531	585	639	692	745	797	850	903	956	1009	1064	1119	1176	1234	1293	1354	1417	1482	1548	1570						
71.8	0	61	123	184	245	305	364	422	478	534	589	643	697	750	803	856	910	963	1018	1073	1129	1186	1245	1305	1367	1430	1496	1563	1603						
73.0	0	62	124	185	247	307	366	425	482	538	593	648	702	756	809	863	917	971	1026	1081	1138	1196	1255	1316	1379	1443	1509	1577	1636						
73.2	2	62	124	187	248	309	369	427	485	542	597	653	707	761	815	869	924	978	1034	1090	1147	1206	1266	1327	1391	1456	1523	1592	1663	1669					
73.4	6	62	125	188	250	311	371	430	488	545	602	657	712	767	821	876	931	986	1042	1099	1156	1216	1276	1339	1403	1469	1536	1606	1678	1702					
73.6	11	64	126	189	251	313	373	433	491	549	606	662	717	772	827	882	937	993	1050	1107	1166	1225	1287	1350	1414	1481	1550	1620	1693	1736					
73.8	17	69	127	190	253	315	376	436	495	553	610	666	722	778	833	888	944	1001	1058	1116	1175	1235	1297	1361	1426	1494	1563	1635	1708	1770					

UNCONTROLLED DISCHARGE TO THE RIGHT OF THE RED LINE

GATE OVERTOPPED IN SHADED AREA

INDIVIDUAL RADIAL GATE - RATING TABLE (Outflows in m3/s – Gate Openings in metres open)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5
74.0	23	74	129	191	254	317	378	438	498	556	614	671	727	783	839	895	951	1008	1065	1124	1184	1245	1307	1372	1438	1506	1576	1648	1723	1800	1804					
74.2	31	80	133	192	256	319	380	441	501	560	618	675	732	788	845	901	958	1015	1073	1132	1192	1254	1317	1382	1449	1518	1589	1662	1738	1815	1838					
74.4	39	87	139	195	257	321	383	444	504	563	622	679	737	793	850	907	964	1022	1081	1140	1201	1264	1327	1393	1461	1530	1602	1676	1752	1831	1873					
74.6	47	94	145	200	259	322	385	447	507	567	626	684	741	799	856	913	971	1029	1089	1149	1210	1273	1337	1404	1472	1542	1615	1690	1767	1846	1908					
74.8	56	103	153	206	262	324	387	449	510	570	629	688	746	804	862	919	978	1036	1096	1157	1219	1282	1347	1414	1483	1554	1628	1703	1781	1861	1943					
75.0	66	112	161	213	267	326	390	452	513	574	633	692	751	809	867	926	984	1044	1104	1165	1227	1291	1357	1425	1494	1566	1640	1717	1795	1876	1960	1978				
75.2	76	121	169	220	274	330	392	455	516	577	637	697	756	814	873	932	991	1051	1111	1173	1236	1301	1367	1435	1506	1578	1653	1730	1809	1891	1976	2013				
75.4	87	131	178	229	281	336	394	457	519	581	641	701	760	819	878	938	997	1057	1119	1181	1245	1310	1377	1446	1517	1590	1665	1743	1823	1906	1992	2049				
75.6	98	141	188	237	289	343	399	460	522	584	645	705	765	824	884	944	1004	1064	1126	1189	1253	1319	1386	1456	1527	1601	1678	1756	1837	1921	2007	2085				
75.8	109	152	198	247	298	350	405	463	525	587	649	709	769	829	889	949	1010	1071	1133	1197	1261	1328	1396	1460	1538	1613	1690	1769	1851	1936	2023	2112	2121			
76.0	121	164	209	257	307	359	412	468	528	591	652	713	774	834	895	955	1016	1078	1141	1205	1270	1337	1405	1476	1549	1624	1702	1782	1865	1950	2038	2129	2158			
76.2	133	175	220	268	317	368	421	475	532	594	656	718	779	839	900	961	1023	1085	1148	1212	1278	1346	1415	1486	1560	1636	1714	1795	1878	1965	2053	2145	2194			
76.4	146	187	232	279	327	378	429	483	539	597	660	722	783	844	906	967	1029	1092	1155	1220	1286	1354	1424	1496	1570	1647	1726	1808	1892	1979	2069	2161	2231			
76.6	159	200	244	290	338	388	439	492	546	603	664	726	788	849	911	973	1035	1098	1162	1228	1295	1363	1434	1506	1581	1658	1738	1820	1905	1993	2084	2177	2268			
76.8	173	213	257	302	350	399	449	501	554	610	668	730	792	854	916	978	1041	1105	1170	1235	1303	1372	1443	1516	1591	1669	1750	1833	1919	2007	2099	2193	2289	2306		
77.0	186	226	270	315	362	410	460	511	564	618	674	734	797	859	921	984	1047	1112	1177	1243	1311	1380	1452	1526	1602	1680	1762	1845	1932	2021	2113	2208	2306	2343		
77.2	200	240	283	328	374	422	471	522	574	627	682	739	801	864	927	990	1054	1118	1184	1250	1319	1389	1461	1536	1612	1691	1773	1858	1945	2035	2128	2224	2322	2381		
77.4	215	254	297	341	387	435	483	533	584	637	691	747	806	869	932	996	1060	1125	1191	1258	1327	1398	1470	1545	1622	1702	1785	1870	1958	2049	2143	2239	2339	2419		
77.6	230	269	311	355	400	447	496	545	595	647	700	756	813	873	937	1001	1066	1131	1198	1265	1335	1406	1479	1555	1633	1713	1796	1882	1971	2063	2157	2255	2355	2457		
77.8	245	283	325	369	414	461	508	557	607	658	711	765	821	880	942	1007	1072	1138	1205	1273	1343	1414	1488	1564	1643	1724	1808	1894	1984	2076	2172	2270	2371	2475	2496	
78.0	260	299	340	383	428	474	522	570	619	670	722	775	831	888	948	1012	1078	1144	1211	1280	1351	1423	1497	1574	1653	1735	1819	1907	1997	2090	2186	2285	2387	2492	2535	
78.2	276	314	355	398	442	488	535	583	632	682	733	786	840	896	954	1018	1084	1150	1218	1288	1358	1431	1506	1583	1663	1745	1831	1919	2010	2104	2200	2300	2403	2509	2573	
78.4	291	329	369	412	456	501	548	595	644	693	744	796	850	905	960	1023	1090	1157	1225	1295	1366	1440	1515	1593	1673	1756	1842	1931	2022	2117	2215	2316	2419	2526	2612	
78.6	307	344	384	426	470	515	561	608	656	705	755	807	859	913	965	1029	1096	1163	1232	1302	1374	1448	1524	1602	1683	1767	1853	1943	2035	2131	2229	2331	2435	2543	2651	
78.8	322	359	399	441	484	529	574	621	668	717	766	817	869	921	971	1034	1102	1170	1239	1310	1382	1456	1533	1612	1693	1778	1865	1955	2048	2144	2244	2346	2451	2560	2689	
79.0	338	374	414	455	498	542	588	634	681	729	778	827	878	929	977	1040	1108	1176	1246	1317	1390	1465	1542	1621	1703	1788	1876	1967	2061	2158	2258	2361	2467	2577	2700	
79.2	353	389	428	470	512	556	601	646	693	740	789	838	888	938	983	1046	1114	1183	1253	1324	1398	1473	1551	1631	1714	1799	1887	1979	2074	2171	2272	2376	2483	2594	2700*	
79.4	368	404	443	484	526	570	614	659	705	752	800	848	897	946	988	1051	1120	1189	1260	1332	1406	1481	1560	1640	1724	1810	1899	1991	2086	2185	2287	2391	2499	2610	2700*	
79.6	384	419	458	498	540	583	627	672	717	764	811	859	907	954	994	1057	1126	1195	1266	1339	1413	1490	1569	1650	1734	1820	1910	2003	2099	2198	2301	2407	2516	2627	2700*	
79.8	399	435	473	513	554	597	640	685	730	775	822	869	916	963	1000	1062	1132	1202	1273	1346	1421	1498	1578	1659	1744	1831	1922	2015	2112	2212	2315	2422	2532	2644	2700*	
80.0	415	450	487	527	568	610	654	697	742	787	833	879	926	971	1006	1068	1137	1208	1280	1354	1429	1507	1586	1669	1754	1842	1933	2027	2125	2226	2330	2437	2548	2661	2700*	

GATE OVERTOPPED IN SHADED AREA

UNCONTROLLED DISCHARGE TO THE RIGHT OF THE RED LINE

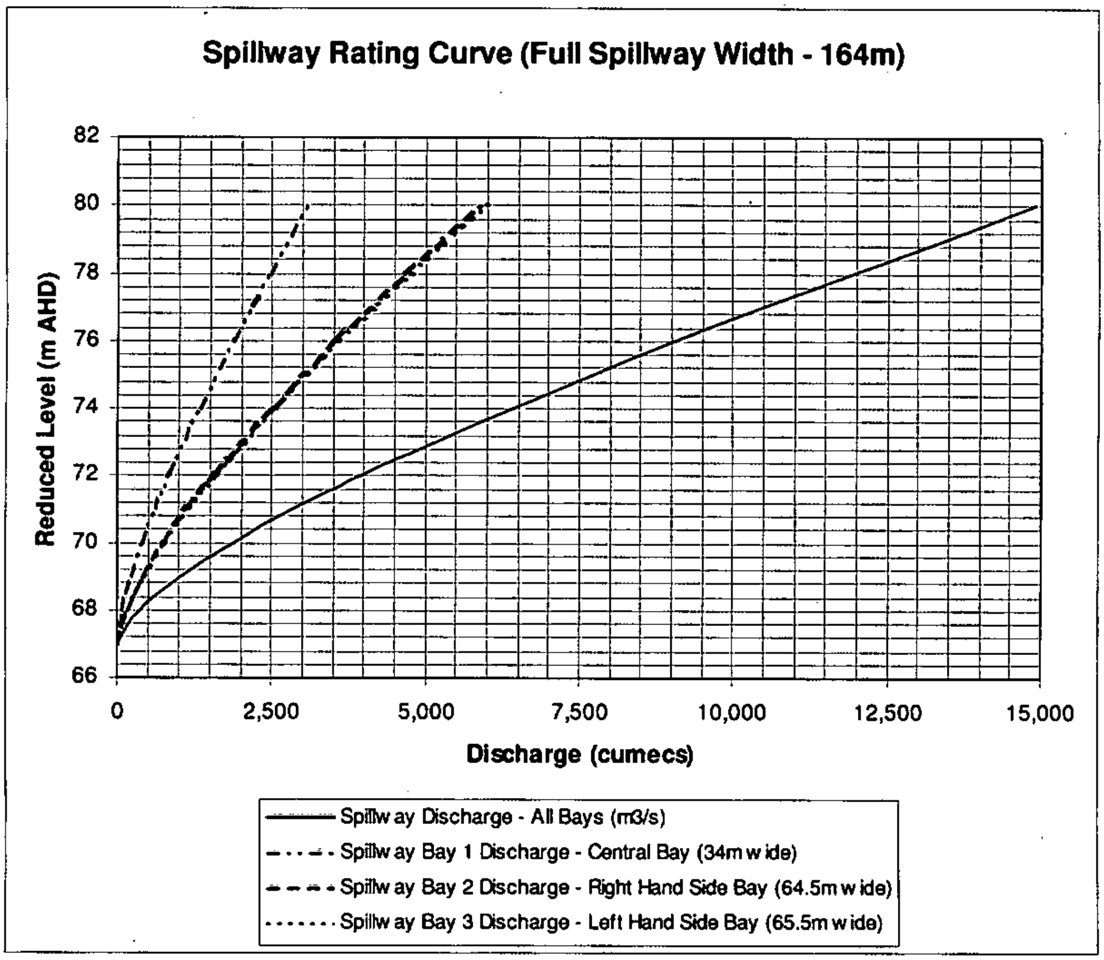
* Flow impacted by bridge deck.

WIVENHOE DAM RADIAL GATES
TOP AND BOTTOM GATE LEVELS FOR VARIOUS GATE OPENINGS

GATE OPENING (m)	BOTTOM OF GATE (m AHD)	TOP OF GATE (m AHD)	GATE OPENING (m)	BOTTOM OF GATE (m AHD)	TOP OF GATE (m AHD)
0.0	56.36	73.00	8.6	64.57	78.70
0.2	56.53	73.17	8.8	64.77	78.79
0.4	56.70	73.34	9.0	64.97	78.88
0.6	56.88	73.50	9.2	65.17	78.96
0.8	57.06	73.67	9.4	65.37	79.04
1.0	57.24	73.83	9.6	65.57	79.12
1.2	57.42	73.99	9.8	65.77	79.20
1.4	57.60	74.15	10.0	65.97	79.28
1.6	57.78	74.31	10.2	66.17	79.35
1.8	57.96	74.46	10.4	66.37	79.42
2.0	58.14	74.62	10.6	66.57	79.49
2.2	58.33	74.77	10.8	66.76	79.55
2.4	58.51	74.92	11.0	66.96	79.62
2.6	58.70	75.07	11.2	67.16	79.68
2.8	58.89	75.22	11.4	67.36	79.74
3.0	59.08	75.37	11.6	67.55	79.79
3.2	59.27	75.51	11.8	67.75	79.85
3.4	59.46	75.66	12.0	67.94	79.90
3.6	59.65	75.80	12.2	68.14	79.95
3.8	59.84	75.94	12.4	68.33	80.00
4.0	60.03	76.07	12.6	68.53	80.04
4.2	60.22	76.21	12.8	68.72	80.08
4.4	60.42	76.34	13.0	68.91	80.12
4.6	60.61	76.48	13.2	69.10	80.16
4.8	60.80	76.61	13.4	69.29	80.19
5.0	61.00	76.74	13.6	69.48	80.22
5.2	61.19	76.86	13.8	69.67	80.25
5.4	61.39	76.99	14.0	69.86	80.28
5.6	61.59	77.11	14.2	70.05	80.31
5.8	61.78	77.23	14.4	70.24	80.33
6.0	61.98	77.35	14.6	70.42	80.35
6.2	62.18	77.47	14.8	70.61	80.36
6.4	62.38	77.58	15.0	70.79	80.38
6.6	62.58	77.69	15.2	70.97	80.39
6.8	62.78	77.80	15.4	71.15	80.40
7.0	62.97	77.91	15.6	71.34	80.41
7.2	63.17	78.02	15.8	71.52	80.41
7.4	63.37	78.12	16.0	71.69	80.41
7.6	63.57	78.22	16.2	71.87	80.41
7.8	63.77	78.32	16.4	72.05	80.41
8.0	63.97	78.42	16.6	72.22	80.41
8.2	64.17	78.52	16.8	72.40	80.40
8.4	64.37	78.61	17.0	72.57	80.39
8.6	64.57	78.70	17.2	72.74	80.38
8.8	64.77	78.79	17.4	72.91	80.36
9.0	64.97	78.88	17.5	73.00	80.35

WIVENHOE DAM AUXILIARY SPILLWAY RATING TABLE

Storage Level	Spillway Discharge			
	Central Bay (34m wide)	Right Side Bay (64.5m wide)	Left Side Bay (65.5m wide)	All Bays
m AHD	m^3/s	m^3/s	m^3/s	m^3/s
67	0	0	0	0
68	75	142	144	361
69	212	401	408	1,020
70	385	731	742	1,858
71	590	1,120	1,137	2,847
72	821	1,558	1,582	3,961
74	1,329	2,521	2,560	6,409
76	1,873	3,553	3,608	9,033
78	2,468	4,683	4,755	11,907
80	3,092	5,865	5,956	14,913



APPENDIX D
SOMERSET DAM TECHNICAL DATA

STORAGE AND DISCHARGE CHARACTERISTICS							
Storage Level	Reservoir Capacity	Temporary Flood Storage	Inflow to produce 1mm rise per hour	Discharge per Regulator	Discharge per Sluice	Discharge per Spillway Bay	Maximum Available Discharge
m AHD	x10^3 ML	10^6 m^3	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
90.0	120.3	-	5.3	57	163	-	1,529
90.5	129.5	-	5.5	58	165	-	1,550
91.0	139.3	-	4.9	58	167	-	1,572
91.5	149.6	-	5.3	59	170	-	1,593
92.0	160.5	-	5.7	60	172	-	1,614
92.5	172.0	-	6.1	60	174	-	1,635
93.0	184.1	-	6.8	61	176	-	1,655
93.5	196.7	-	7.1	62	179	-	1,676
94.0	210.0	-	7.4	62	181	-	1,695
94.5	224.0	-	7.8	63	183	-	1,715
95.0	238.5	-	8.2	64	185	-	1,735
95.5	253.6	-	8.5	64	187	-	1,754
96.0	269.3	-	9.0	65	189	-	1,773
96.5	285.6	-	9.4	66	191	-	1,792
97.0	302.7	-	9.8	66	193	-	1,810
97.5	320.7	-	10.3	67	195	-	1,829
98.0	339.5	-	10.8	67	197	-	1,847
98.5	359.2	-	11.2	68	199	-	1,865
99.0	379.8	0	11.8	69	201	-	1,883
99.5	401.4	22	12.3	69	203	-	1,901
100.0	428.9	49	13.3	70	205	-	1,918
100.5	447.5	68	13.8	70	207	0	1,937
101.0	472.2	92	14.4	71	209	4	1,989
101.5	498.0	118	15.0	72	211	13	2,076
102.0	524.9	145	15.5	72	212	25	2,189
102.5	553.1	173	16.1	73	214	40	2,325
103.0	582.6	203	16.7	73	216	58	2,482
103.5	613.2	233	17.3	74	218	78	2,659
104.0	645.1	265	17.9	74	220	100	2,854
104.5	678.3	298	18.5	75	221	125	3,067
105.0	712.7	333	19.1	75	223	151	3,296

Storage Level	Reservoir Capacity	Temporary Flood Storage	Inflow to produce 1mm rise per hour	Discharge per Regulator	Discharge per Sluice	Discharge per Spillway Bay	Maximum Available Discharge
m AHD	$x10^3$ ML	10^6 m^3	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
105.5	748.3	368	19.8	76	225	180	3,542
106.0	785.2	405	20.4	76	226	211	3,803
106.5	823.4	444	21.1	77	228	243	4,079
107.0	863.1	483	21.7	77	230	278	4,370
107.5	904.0	524	22.4	78	232	314	4,675
108.0	946.4	567	23.6	78	233	352	5,084
108.5	990.1	610	24.3	79	235	391	5,570
109.0	1035.3	656	23.1	79	236	433	6,111
109.5	1081.8	702	25.8	80	238	476	6,701
110.0	1129.8	750	26.7	80	240	520	7,334

The outlet works for Somerset Dam consist of:

- Four (4) cone dispersion type regulator values.
- Eight (8) sluice gates.
- Eight (8) radial crest gates.

The regulator values are drowned out when the dam tail water level (Wivenhoe headwater level) reaches EL 68.6 m AHD and the valves should generally not be used under these conditions. Discharge for each regulator valve may be computed using the following equation:

$$Q_{Regulator} = 12.714*(\text{Dam Headwater Elevation} - 70.20)^{0.5}$$

Discharge for each sluice gate may be computed using the following equation:

$$Q_{Sluice} = 40.022*(\text{Dam Headwater Elevation} - 73.15)^{0.4963}$$

The radial crest gates are normally kept open and come into operation whenever the headwater level exceeds EL 100.45. Discharge for each radial gate may be computed using the following equation:

$$Q_{Crest} = 12.137*(\text{Dam Headwater Elevation} - 100.45)^{1.6653}$$

At EL 107.45, flood waters commence to flow over the dam crest. To account for this discharge, the dam crest is assumed to operate as a broad crested weir with a spillway width of 135.33 m and a weir coefficient of 1.7. Discharge in these circumstances may be computed using the following equation:

$$Q_{Overflow} = 1.7*135.33*(\text{Dam Headwater Elevation} - 107.455)^{1.5}$$

APPENDIX E
WIVENHOE DAM GATE OPERATION CONSIDERATIONS

SPILLWAY OPERATION PRINCIPLES

The radial gates are sequentially numbered from 1 to 5 from left to right looking in the downstream direction. Plans of the dam and spillway are contained in Appendix H.

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions, or when gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool, which has been excavated into erodible sandstone rock, and cause non-predictable erosion. Upstream migration of this erosion is to be avoided. The wing walls adjacent to the flip bucket deflect the discharge away from the walls of the plunge pool when gates 1 and 5 are operated.

Therefore in operating the spillway, the principles to be observed are, in order of priority:

(i) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

(ii) The flow in the spillway is to be generally symmetrical.

The main purpose of gating the spillway is to exercise maximum possible control over the flow in the Brisbane River insofar as river flows in excess of 4,000 m^3/s cause damage to urban areas downstream. The gates also allow the routing of much larger floods with substantial flood mitigation being achieved.

RADIAL GATE OPERATION PRINCIPLES

[redacted]

[redacted]

[redacted]

[redacted]

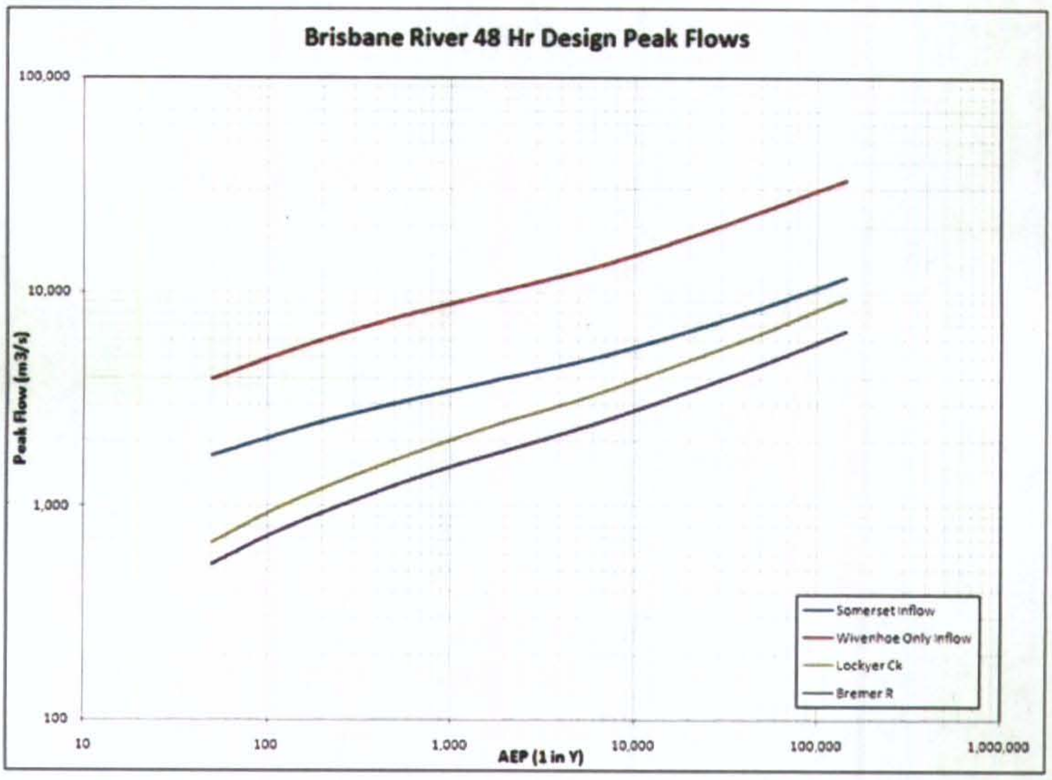
[redacted]

[redacted]

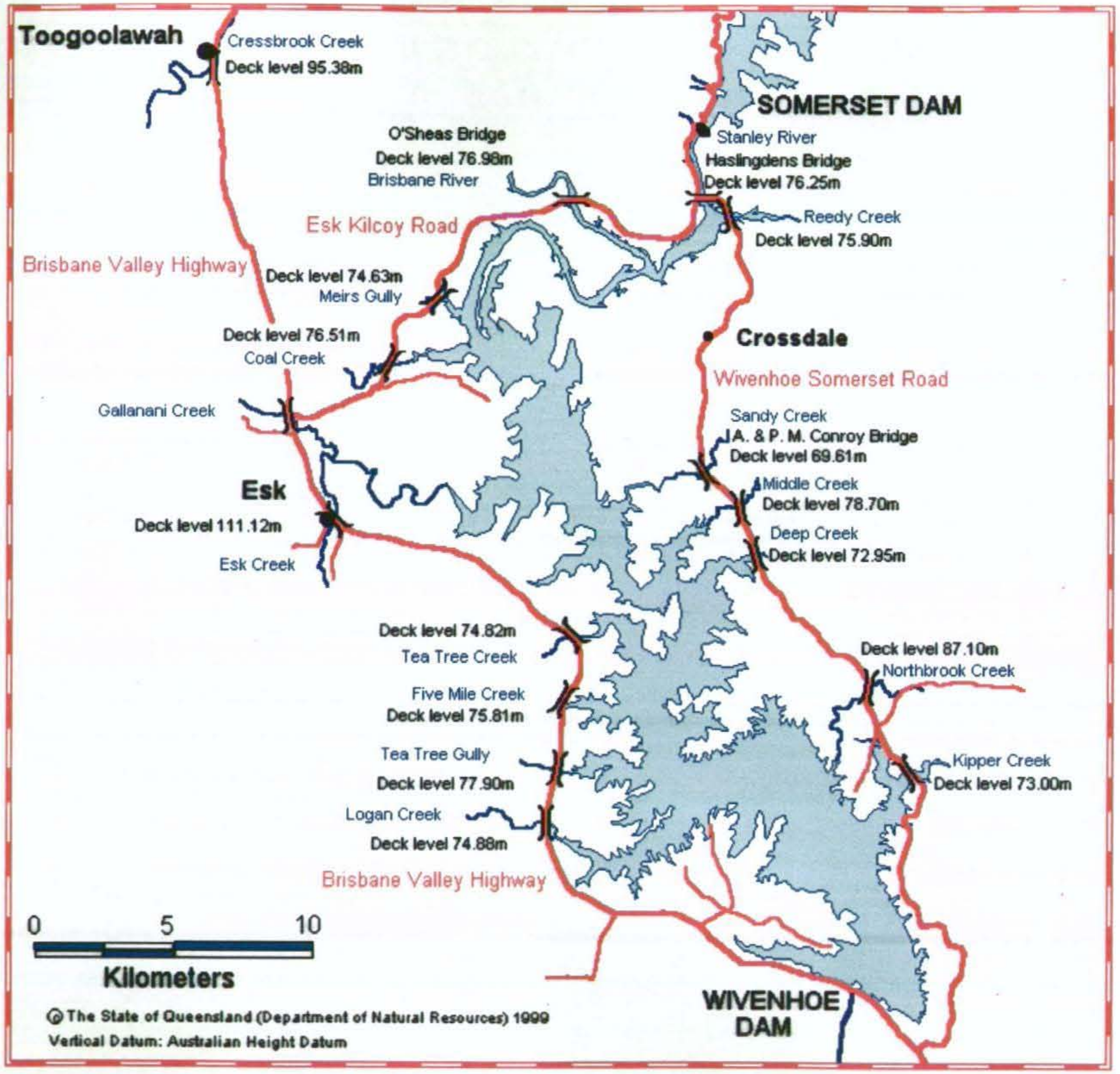
APPENDIX G
HYDROLOGIC INVESTIGATIONS

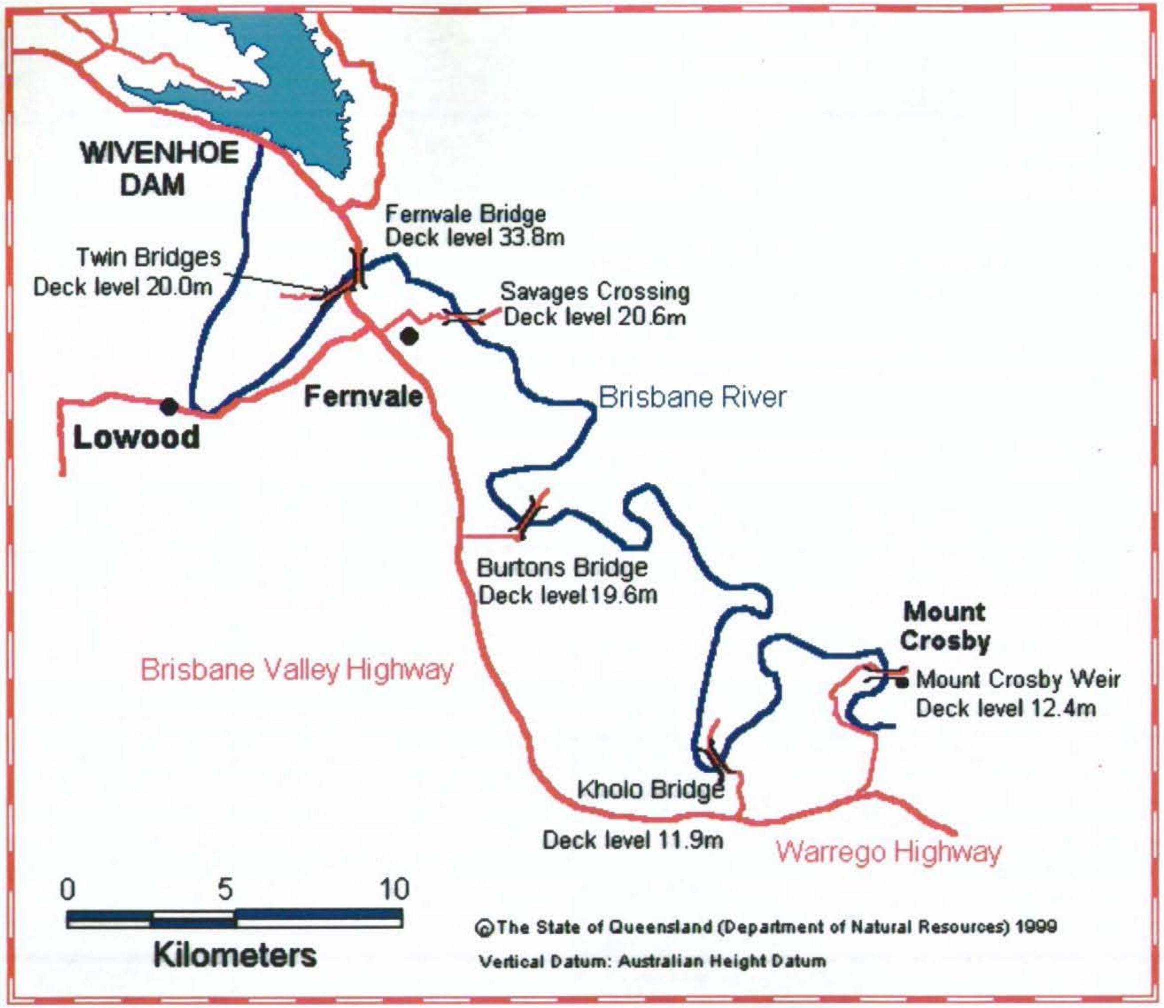
The design hydrology for the Manual is based on the design hydrology undertaken in September 2005 in conjunction with the flood discharge capacity upgrade of Wivenhoe Dam. This work was undertaken by the Wivenhoe Alliance, the group responsible for undertaking the upgrade work. (Wivenhoe Alliance, Design Discharges and Downstream Impacts of the Wivenhoe Dam Upgrade Q1091, Sep 2005)

Floods in the Brisbane River catchment above Wivenhoe Dam can originate in either the Stanley River or upper Brisbane River catchment or both. Both of the dams are capable of being operated in a number of ways, each of which will reduce the flow downstream. Indicative inflows for the dams for 48 hour storm events (the critical duration for Wivenhoe Dam) are shown in the graph below. Full results containing inflows for a range of storm events and durations are contained in the Alliance reports.

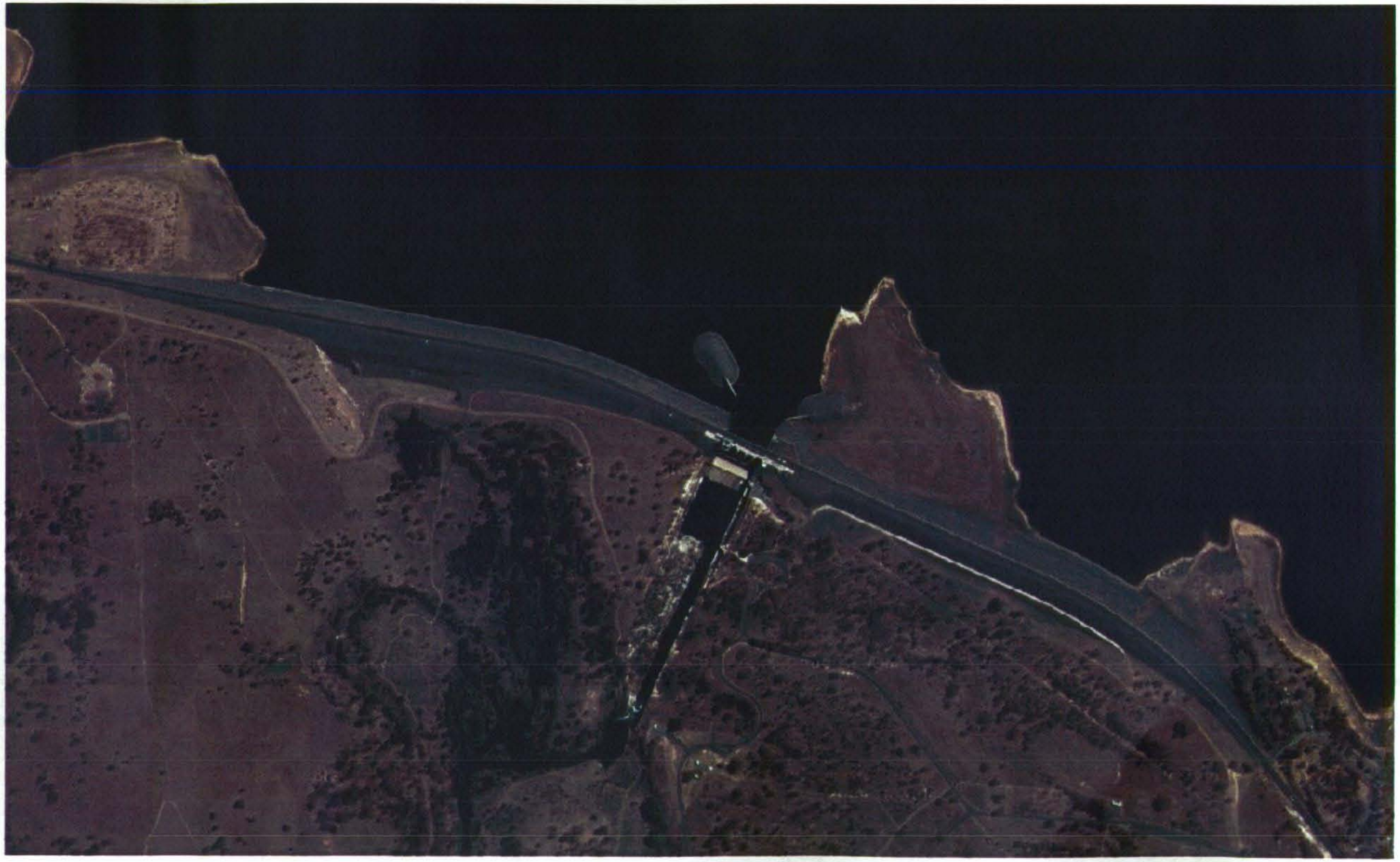


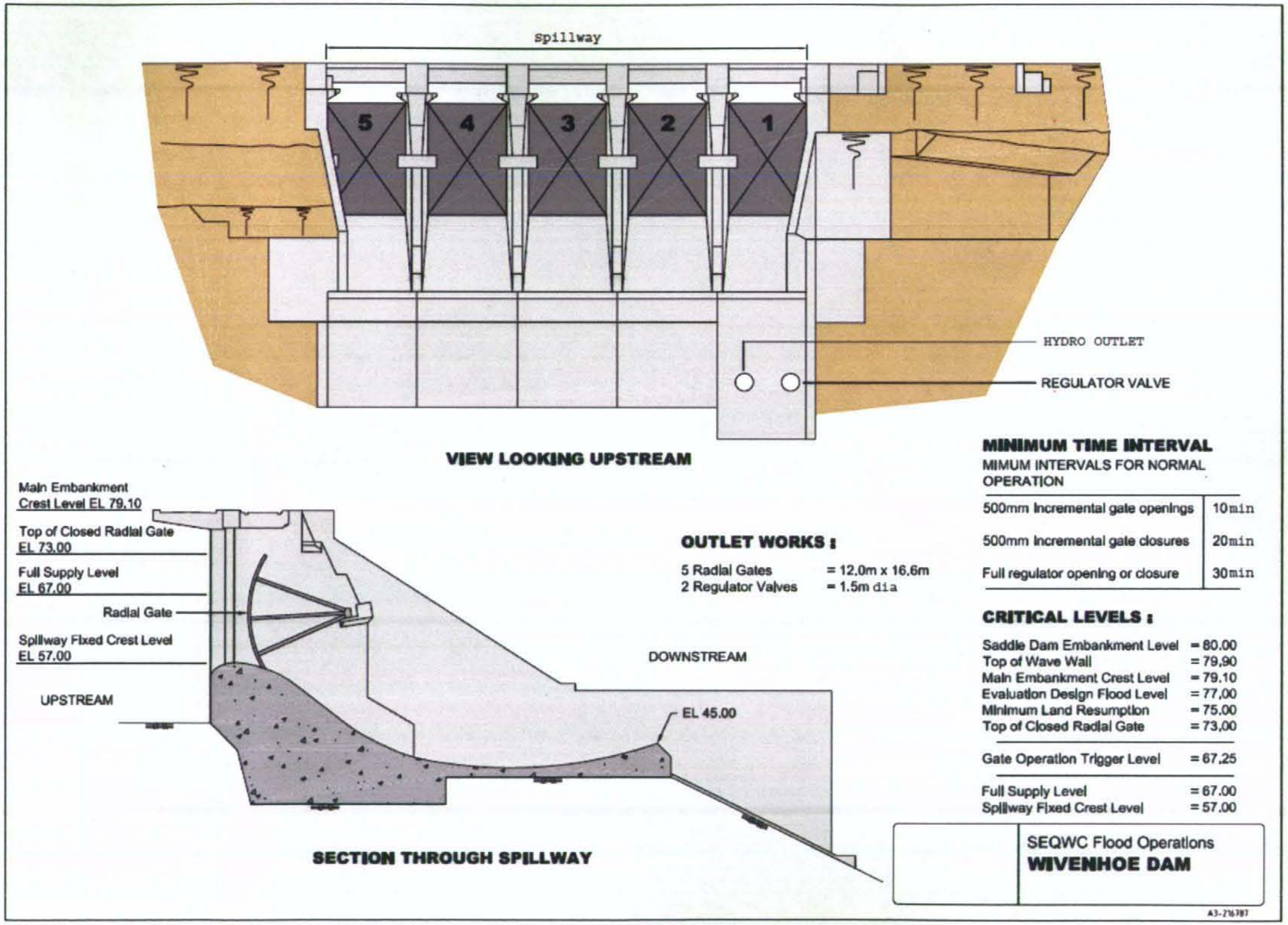
APPENDIX H
WIVENHOE DAM
PLANS, MAPS AND PHOTOGRAPHS


Toogoolawah
Cressbrook Creek
Deck level 95.38m
SOMERSET DAM
O'Sheas Bridge
Deck level 76.98m
Brisbane River
Stanley River
Haslingdens Bridge
Deck level 76.25m
Reedy Creek
Deck level 75.90m
Esk Kilcoy Road
Brisbane Valley Highway
Deck level 74.63m
Meirs Gully
Deck level 76.51m
Coal Creek
Crossdale
Wivenhoe Somerset Road
Gallanani Creek
Sandy Creek
A. & P. M. Conroy Bridge
Deck level 69.61m
Middle Creek
Deck level 78.70m
Esk
Deck level 111.12m
Esk Creek
Deep Creek
Deck level 72.95m
Deck level 74.82m
Tea Tree Creek
Deck level 87.10m
Northbrook Creek
Five Mile Creek
Deck level 75.81m
Tea Tree Gully
Deck level 77.90m
Kipper Creek
Deck level 73.00m
Logan Creek
Deck level 74.88m
Brisbane Valley Highway
0 5 10
Kilometers
© The State of Queensland (Department of Natural Resources) 1999
Vertical Datum: Australian Height Datum
WIVENHOE DAM


WIVENHOE DAM
Fernvale Bridge
Deck level 33.8m
Twin Bridges
Deck level 20.0m
Savages Crossing
Deck level 20.6m
Fernvale
Brisbane River
Lowood
Burtons Bridge
Deck level 19.6m
Mount Crosby
Mount Crosby Weir
Deck level 12.4m
Brisbane Valley Highway
Kholo Bridge
Deck level 11.9m
Warrego Highway
0 5 10
Kilometers
©The State of Queensland (Department of Natural Resources) 1999
Vertical Datum: Australian Height Datum

Wivenhoe Dam





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[redacted]

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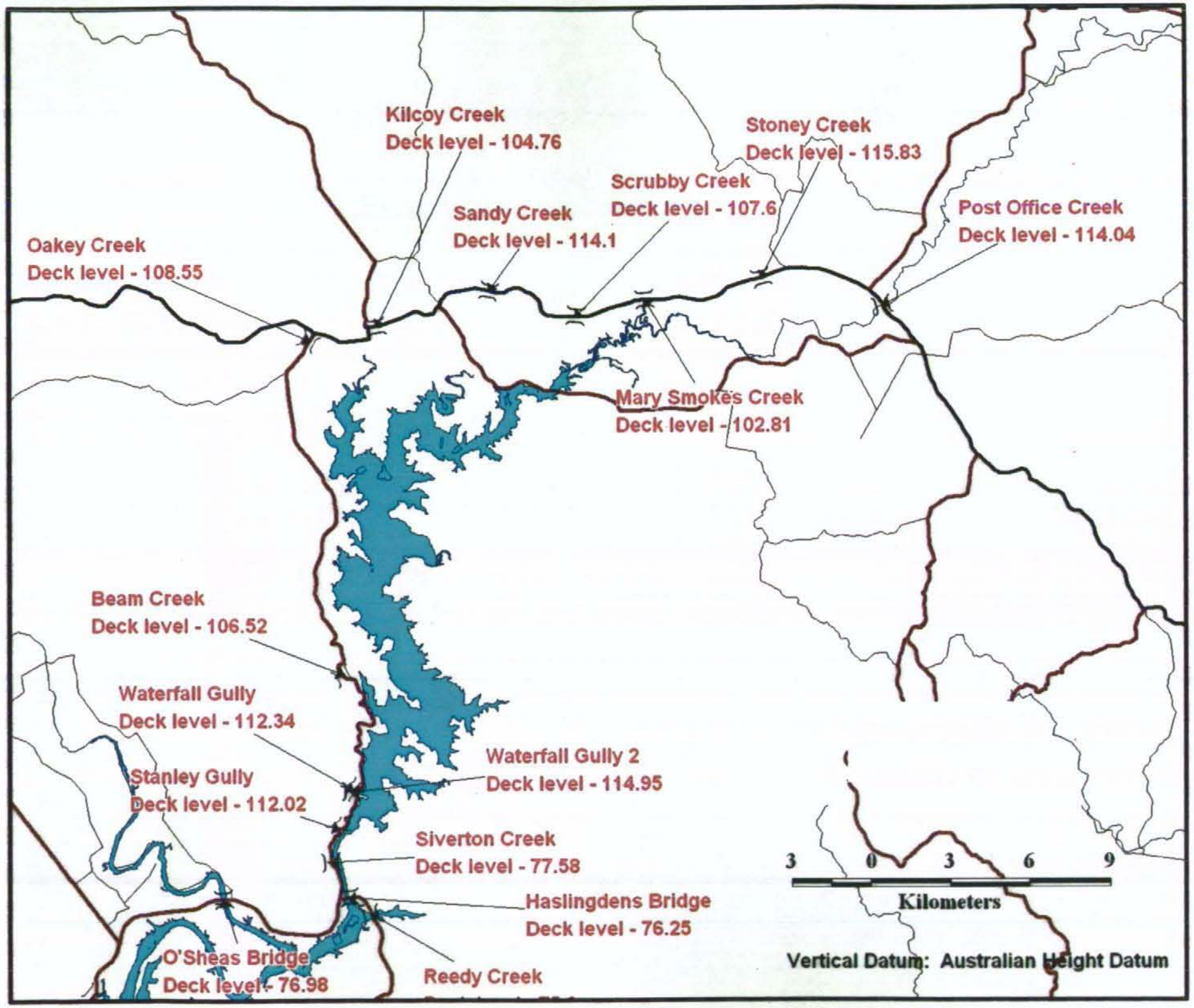
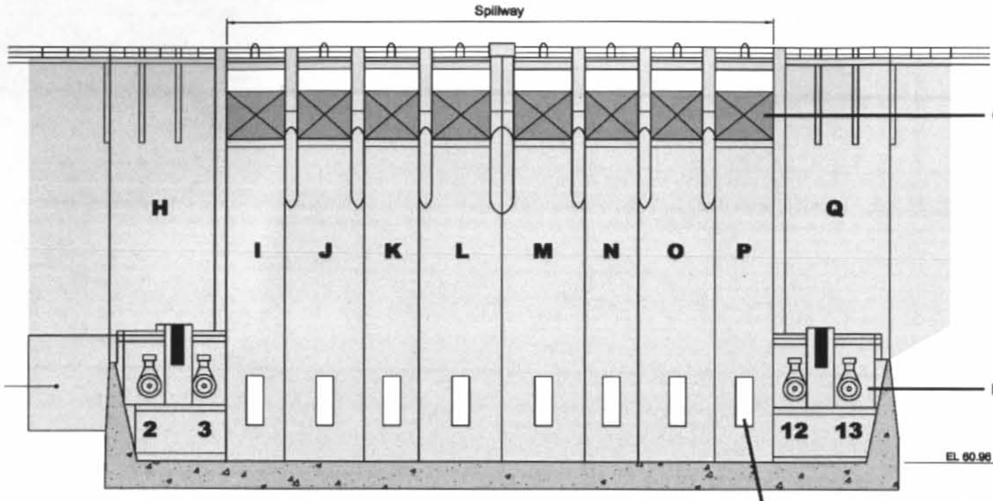
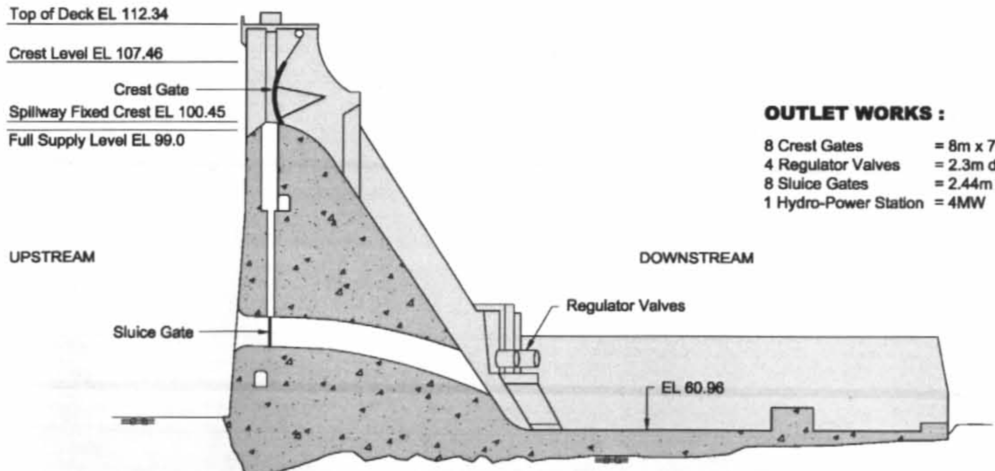
APPENDIX I
SOMERSET DAM
PLANS, MAPS AND PHOTOGRAPHS


Kilcoy Creek
Deck level - 104.76
Stoney Creek
Deck level - 115.83
Scrubby Creek
Deck level - 107.6
Sandy Creek
Deck level - 114.1
Post Office Creek
Deck level - 114.04
Oakey Creek
Deck level - 108.55
Mary Smokes Creek
Deck level - 102.81
Beam Creek
Deck level - 106.52
Waterfall Gully
Deck level - 112.34
Waterfall Gully 2
Deck level - 114.95
Stanley Gully
Deck level - 112.02
Siverton Creek
Deck level - 77.58
Haslingdens Bridge
Deck level - 76.25
O'Sheas Bridge
Deck level - 76.98
Reedy Creek
3 0 3 6 9
Kilometers
Vertical Datum: Australian Height Datum

Somerset Dam



VIEW LOOKING UPSTREAM



SECTION THROUGH SPILLWAY

OUTLET WORKS :

8 Crest Gates	= 8m x 7m
4 Regulator Valves	= 2.3m dia
8 Sluice Gates	= 2.44m x 3.66m
1 Hydro-Power Station	= 4MW

MINIMUM TIME INTERVAL

MINIMUM INTERVALS FOR NORMAL OPERATIONS

Outlet	Opening Interval	Closure Interval
Regulators	30min	60min
Sluice Gates	120min	180min
Crest Gates	Gates are Normally Open	

CRITICAL LEVELS :

Top of Deck	= 112.34
Crest Level	= 107.46
Sluice & Regulator Trigger Level	= 102.25
Mary Smokes Bridge (Kilcoy)	= 102.00
Spillway Fixed Crest Level	= 100.45
Hydro-Power Station Reserve	= 99.30
Full Supply Level	= 99.00

SEQWC Flood Operations

SOMERSET DAM

A3-216788

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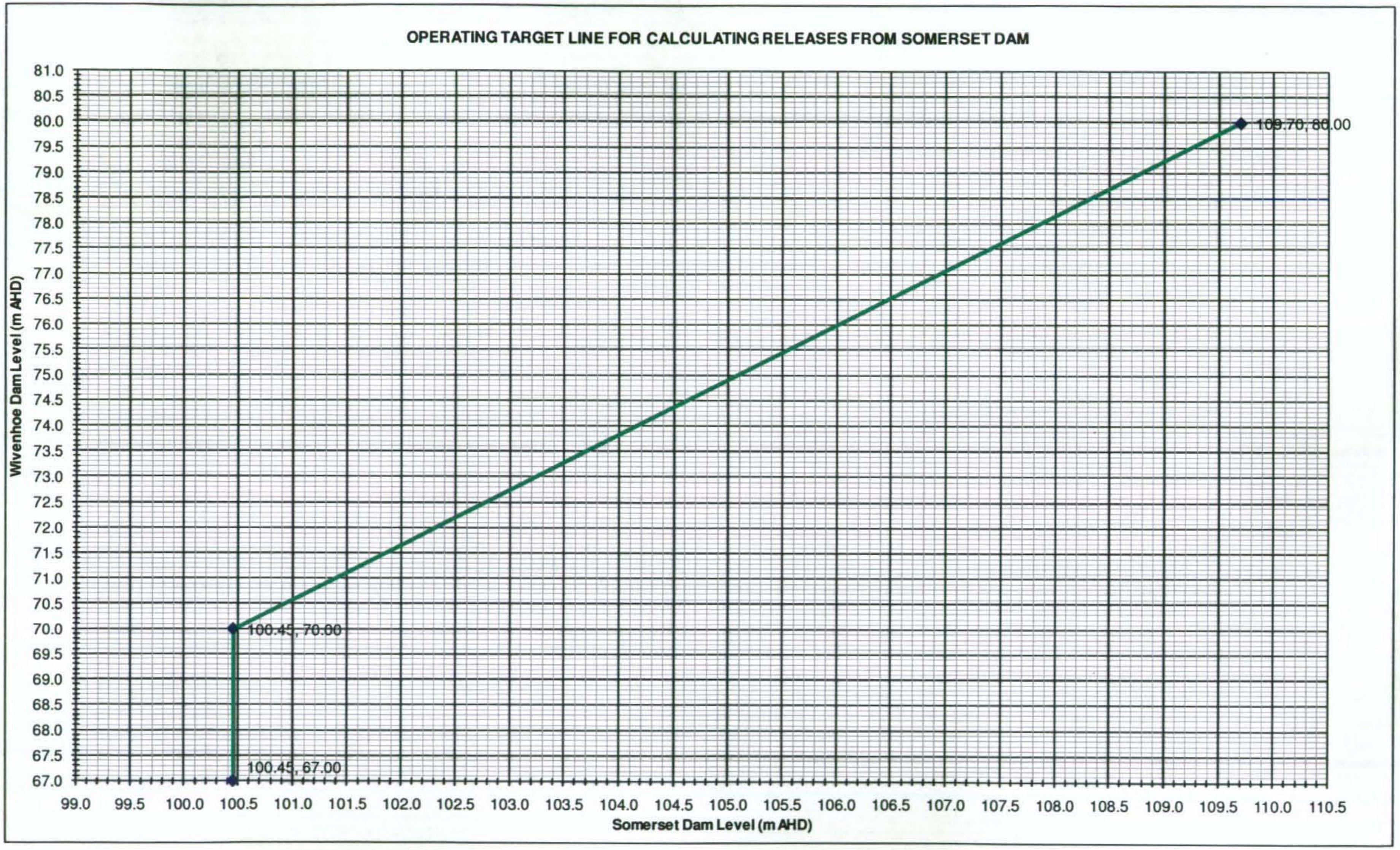
OPERATING TARGET LINE FOR CALCULATING RELEASES FROM SOMERSET DAM
Wivenhoe Dam Level (m AHD)
Somerset Dam Level (m AHD)
109.70, 80.00
100.45, 70.00
100.45, 67.00
81.0
80.5
80.0
79.5
79.0
78.5
78.0
77.5
77.0
76.5
76.0
75.5
75.0
74.5
74.0
73.5
73.0
72.5
72.0
71.5
71.0
70.5
70.0
69.5
69.0
68.5
68.0
67.5
67.0
99.0
99.5
100.0
100.5
101.0
101.5
102.0
102.5
103.0
103.5
104.0
104.5
105.0
105.5
106.0
106.5
107.0
107.5
108.0
108.5
109.0
109.5
110.0
110.5

APPENDIX J
WIVENHOE DAM – FUSE PLUG BREACH SCENARIOS

SCENARIO 1 – CENTRAL FUSE PLUG BAY INITIATED
(LEFT SIDE BAY AND RIGHT SIDE BAY INTACT)

Storage Level	Gate 1 Opening	Gate 2 Opening	Gate 3 Opening	Gate 4 Opening	Gate 5 Opening	Total Opening	Discharge	Gate Operated
m AHD	(m)	(m)	(m)	(m)	(m)	(m)	cumecs	
67.00	0.0	0.0	0.0	0.0	0.0	0.0	0	
67.75	0.0	0.0	0.5	0.0	0.0	0.5	51	3
68.25	0.0	0.0	1.0	0.0	0.0	1.0	104	3
68.65	0.0	0.0	1.5	0.0	0.0	1.5	158	3
68.80	0.0	0.0	2.0	0.0	0.0	2.0	211	3
68.95	0.0	0.0	2.5	0.0	0.0	2.5	264	3
69.25	0.0	0.0	3.0	0.0	0.0	3.0	317	3
69.40	0.0	0.0	3.5	0.0	0.0	3.5	320	3
69.55	0.0	0.5	3.5	0.0	0.0	4.0	426	2
70.00	0.0	0.5	3.5	0.5	0.0	4.5	492	4
70.30	0.0	0.5	4.0	0.5	0.0	5.0	547	3
70.60	0.0	1.0	4.0	0.5	0.0	5.5	612	2
70.70	0.0	1.0	4.0	1.0	0.0	6.0	671	4
70.90	0.5	1.0	4.0	1.0	0.0	6.5	731	1
71.10	0.5	1.0	4.0	1.0	0.5	7.0	800	5
71.20	0.5	1.5	4.0	1.0	0.5	7.5	860	2
71.40	0.5	1.5	4.0	1.5	0.5	8.0	923	4
71.60	1.0	1.5	4.0	1.5	0.5	8.5	989	1
71.70	1.0	1.5	4.0	1.5	1.0	9.0	1054	5
71.90	1.0	2.0	4.0	1.5	1.0	9.5	1120	2
72.10	1.0	2.0	4.0	2.0	1.0	10.0	1185	4
72.20	1.5	2.0	4.0	2.0	1.0	10.5	1251	1
72.40	1.5	2.0	4.0	2.0	1.5	11.0	1320	5
72.60	1.5	2.5	4.0	2.0	1.5	11.5	1396	2
72.65	1.5	2.5	4.0	2.5	1.5	12.0	1454	4
72.70	1.5	2.5	4.5	2.5	1.5	12.5	1505	3
72.75	2.0	2.5	4.5	2.5	1.5	13.0	1573	1
72.85	2.0	2.5	4.5	2.5	2.0	13.5	1634	5
72.90	2.5	2.5	4.5	2.5	2.0	14.0	1700	1
72.95	2.5	3.0	4.5	2.5	2.5	15.0	1825	5,2
73.00	2.5	3.0	4.5	3.0	2.5	15.5	1884	4
73.10	2.5	3.5	4.5	3.0	2.5	16.0	1946	2
73.20	2.5	3.5	4.5	3.5	2.5	16.5	2014	4
73.30	3.0	3.5	4.5	3.5	3.0	17.5	2139	1,5
73.40	3.0	4.0	4.5	3.5	3.0	18.0	2205	2
73.50	3.0	4.0	4.5	4.0	3.0	18.5	2266	4
73.60	3.5	4.0	5.0	4.0	3.0	19.5	2387	3,1
73.70	3.5	4.0	5.0	4.0	3.5	20.0	2462	5

73.80	3.5	4.5	5.0	4.0	3.5	20.5	2530	2
Storage Level	**Gate 1 Opening**	**Gate 2 Opening**	**Gate 3 Opening**	**Gate 4 Opening**	**Gate 5 Opening**	**Gate Openings**	**Discharge**	**Gate Operated**
m AHD	**(m)**	**(m)**	**(m)**	**(m)**	**(m)**	**(m)**	**cumecs**	
73.90	4.0	4.5	5.0	4.5	3.5	21.5	2653	4,1
74.10	4.5	4.5	5.0	4.5	4.5	23.0	2848	5,1
74.20	5.0	5.0	5.5	5.0	5.0	25.5	3147	3,2,4,1,5
74.30	5.5	5.5	6.0	5.5	5.5	28.0	3438	3,2,4,1,5
74.40	6.0	6.0	6.5	6.0	6.0	30.5	3741	3,2,4,1,5
74.50	6.5	6.5	7.0	6.5	6.5	33.0	4063	3,2,4,1,5
74.60	7.0	7.0	7.0	7.0	7.0	35.0	4280	2,4,1,5
74.70	7.5	7.5	7.5	7.5	7.5	37.5	4575	3,2,4,1,5
74.80	8.5	8.5	9.0	8.5	8.5	43.0	5240	3,2,4,1,5
74.90	9.5	9.5	10.0	9.5	9.5	48.0	5872	3,2,4,1,5
75.00	10.0	11.0	11.0	11.0	10.0	53.0	6653	3,2,4,1,5
75.10	12.0	12.0	12.0	12.0	12.0	60.0	7500	3,2,4,1,5
75.20	13.0	13.0	13.0	13.0	13.0	65.0	8265	3,2,4,1,5
75.30	13.0	13.5	13.5	13.5	13.0	66.5	8529	3,2,4
75.50	13.5	13.5	13.5	13.5	13.5	67.5	8745	1,5
≥75.70	17.5	17.5	17.5	17.5	17.5	Fully Open	10515	3,2,4,1,5

SCENARIO 2 – CENTRAL AND RIGHT SIDE FUSE PLUG BAYS INITIATED (LEFT SIDE BAY INTACT)

Storage Level	**Gate 1 Opening**	**Gate 2 Opening**	**Gate 3 Opening**	**Gate 4 Opening**	**Gate 5 Opening**	**Total Opening**	**Discharge**	**Gate Operated**
m AHD	**(m)**	**(m)**	**(m)**	**(m)**	**(m)**	**(m)**	**cumecs**	
67.00	0.0	0.0	0.0	0.0	0.0	0.0	0	
72.95	0.5	0.5	0.5	0.5	0.5	2.5	310	3,2,4,1,5
73.40	1.0	1.0	1.0	1.0	1.0	5.0	625	3,2,4,1,5
73.80	1.5	1.5	1.5	1.5	1.5	7.5	950	3,2,4,1,5
74.20	2.0	2.0	2.0	2.0	2.0	10.0	1280	3,2,4,1,5
74.60	2.5	2.5	2.5	2.5	2.5	12.5	1610	3,2,4,1,5
74.70	2.5	2.5	3.5	2.5	2.5	13.5	1740	3
74.80	3.5	3.5	3.5	3.5	3.5	17.5	2245	2,4,1,5
74.90	4.5	4.5	4.5	4.5	4.5	22.5	2860	3,2,4,1,5
75.00	6.0	6.0	6.0	6.0	6.0	30.0	3755	3,2,4,1,5
75.10	7.0	7.0	7.0	7.0	7.0	35.0	4350	3,2,4,1,5
75.20	8.5	8.5	8.5	8.5	8.5	42.5	5255	3,2,4,1,5
75.30	8.5	9.0	9.0	9.0	8.5	44.0	5453	3,2,4,
75.70	11.5	11.5	11.5	11.5	11.5	57.5	7290	3,2,4,1,5
≥76.20	17.5	17.5	17.5	17.5	17.5	Fully Open	10970	3,2,4,1,5

SCENARIO 2 – CENTRAL, RIGHT SIDE AND LEFT SIDE FUSE PLUG BAYS INITIATED (NO BAYS INTACT)

Storage Level	Gate 1 Opening	Gate 2 Opening	Gate 3 Opening	Gate 4 Opening	Gate 5 Opening	Gate Openings	Discharge	Gate Operated
m AHD	(m)	(m)	(m)	(m)	(m)	(m)	cumecs	
67.00	0.0	0.0	0.0	0.0	0.0	0.0	0	
72.95	0.5	0.5	0.5	0.5	0.5	2.5	310	3,2,4,1,5
73.40	1.0	1.0	1.0	1.0	1.0	5.0	625	3,2,4,1,5
73.80	1.5	1.5	1.5	1.5	1.5	7.5	950	3,2,4,1,5
74.20	2.0	2.0	2.0	2.0	2.0	10.0	1280	3,2,4,1,5
74.60	2.5	2.5	2.5	2.5	2.5	12.5	1610	3,2,4,1,5
75.00	3.0	3.0	3.0	3.0	3.0	15.0	1950	3,2,4,1,5
75.30	3.0	3.5	3.5	3.5	3.0	16.5	2154	3,2,4
75.40	3.5	3.5	3.5	3.5	3.5	17.5	2285	1,5
75.70	6.0	6.0	6.0	6.0	6.0	30.0	3835	3,2,4,1,5
76.20	11.5	11.5	11.5	11.5	11.5	57.5	7430	3,2,4,1,5
≥76.80	17.5	17.5	17.5	17.5	17.5	Fully Open	11530	3,2,4,1,5

APPENDIX K
BRIDGES IMPACTED BY FLOOD RELEASES AND ELEVATED STORAGE LEVELS

BRIDGES IMPACTED BY ELEVATED STORAGE LEVELS IN SOMERSET DAM			
BRIDGE NAME	**ROAD**	**BRIDGE DECK ELEVATION (m AHD)**	**LOCAL AUTHORITY**
Mary Smokes Creek	D'Aguilar Highway	102.81	Somerset Regional
Kilcoy Creek	D'Aguilar Highway	104.76	Somerset Regional
Beam Creek	Esk Kilcoy Road	106.52	Somerset Regional
Scrubby Creek	D'Aguilar Highway	107.60	Somerset Regional
Oakey Creek	Esk Kilcoy Road	108.55	Somerset Regional

BRIDGES IMPACTED BY ELEVATED STORAGE LEVELS IN WIVENHOE DAM			
BRIDGE NAME	**ROAD**	**BRIDGE DECK ELEVATION (m AHD)**	**LOCAL AUTHORITY**
Sandy Creek A&PM Conroy Bridge	Wivenhoe Somerset Road	69.61	Somerset Regional
Deep Creek	Wivenhoe Somerset Road	72.95	Somerset Regional
Kipper Creek	Wivenhoe Somerset Road	73.00	Somerset Regional
Meirs Gully	Esk Kilcoy Road	74.63	Somerset Regional
Tea Tree Creek	Brisbane Valley Highway	74.82	Somerset Regional
Logan Creek	Brisbane Valley Highway	74.88	Somerset Regional
Five Mile Creek	Brisbane Valley Highway	75.81	Somerset Regional
Reedy Creek	Wivenhoe Somerset Road	75.90	Somerset Regional
Stanley River Haslingdens Bridge	Esk Kilcoy Road	76.25	Somerset Regional
Coal Creek	Brisbane Valley Highway	76.51	Somerset Regional
Brisbane River O'Sheas Bridge	Esk Kilcoy Road	76.98	Somerset Regional
Tea Tree Gully	Brisbane Valley Highway	77.90	Somerset Regional
Middle Creek	Wivenhoe Somerset Road	78.70	Somerset Regional

BRIDGES IMPACTED BY FLOOD RELEASES FROM WIVENHOE DAM			
BRIDGE NAME	**ROAD**	**SUBMERGENCE FLOW AND BRIDGE DECK ELEVATION**	**LOCAL AUTHORITY**
Twin Bridges	Wivenhoe Pocket Road	50 m^3/s 20.0 m AHD	Somerset Regional
Savages Crossing	Banks Creek Road	130 m^3/s 20.6 m AHD	Somerset Regional
Colleges Crossing*	Mt Crosby Road	175 - 200 m^3/s -	Brisbane/Ipswich City Councils
Burtons Bridge	E Summerville Road	430 m^3/s 19.6 m AHD	Somerset Regional
Kholo Bridge	Kholo Road	550 m^3/s 11.9 m AHD	Brisbane/Ipswich City Councils
Mt Crosby Weir	Allawah Road	1900 m^3/s 12.4 m AHD	Brisbane/Ipswich City Councils
Fernvale Bridge	Brisbane Valley Highway	2000 m^3/s 33.8 m AHD	Somerset Regional

* Affected by tidal flows.