

# OPERATION OF SPILLWAY GATES – HOW TO AVOID THE PROBLEMS AND PITFALLS



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# OPERATION OF SPILLWAY GATES – HOW TO AVOID THE PROBLEMS AND PITFALLS

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## ABSTRACT

The regulation of dam safety in Queensland is administered by the Dam Safety group of the Department of Environment and Resource Management. The department applies dam safety conditions to dams that would put lives at risk if they were to fail.

Spillway gates allow the dam owner some flexibility in the operation of a dam both in terms of flood operations and for environmental releases. However, this flexibility comes at a cost. They require ongoing preparedness and trained personnel need to be on hand at all times.

The paper details how spillway gates are normally operated; the systems and training necessary to operate spillway gates effectively; the regulatory arrangements that apply to referable dams in Queensland; some of the problems encountered and how to avoid these problems.

## KEY WORDS

Referable dams, Spillway gates, Regulation of gated spillways, Incidents at gated dams

## 1.0 INTRODUCTION

The responsibility for dam safety in Queensland rests solely with the dam owner. The chief executive of the Department of Environment and Resource Management (DERM) is responsible for administering the dam safety provisions in the *Water Supply (Safety & Reliability) Act 2008*. This is done by applying dam safety conditions which require the establishment of a dam safety management system for all referable dams. Referable dams are those dams that would put population at risk if they were to fail.

If you are an operator of a referable dam in Queensland you should familiarise yourself with the conditions which apply to your dam. These conditions reference the ‘Queensland Dam Safety Management Guidelines’ (NRM 2002) which give further details. They are tailored for individual dams but tend to cover:

- Design and construction standards
- The maintenance and storage of dam documentation
- Reporting of incidents and failures
- The maintenance of dam data books, standing operating procedures and operation and maintenance manuals
- Periodic (annual) and comprehensive (5 yearly) inspections
- Periodic safety reviews
- The preparation and maintenance of Emergency Action Plans

This paper will discuss the operation of gated spillways for large referable dams. These tend to be owned by water boards or government owned corporations but also include some local authorities. The operation of inflatable rubber bags that are seen on some Queensland weirs is not covered.

## 2.0 TYPES OF SPILLWAY GATES

Spillway gates are designed to maximise the storage capacity of a dam while increasing the spillway capacity for a given headwater level. They can also be used for ‘environmental releases’ which cannot be discharged from the outlet works. Gated spillways have been around for a long time and have been used at a number of Queensland dams. The examples include:

**Table 1:** *Examples of Gated Spillways*

Type of Gate	Queensland Examples
Radial or tainter gates	Somerset, Wivenhoe, North Pine, Leslie, Coolmunda, Ross River
Vertical lift gates	Beardmore, Leslie Harrison, Fitzroy Barrage
Sector or drum gates	Little Nerang
Tops gates	Lenthalls

Gates tend to be raised or lowered by winch systems or hydraulic rams but some have automatic systems based on balancing of water loads. There needs to be some redundancy in such systems to ensure they can operate on demand in stressful circumstances.

The amount a gate is opened in response to floodwaters has to be determined in response to pre-determined operating rules. These operating rules must ensure the safety of the dam in the event of a maximum design flood. For major dams this is typically the ‘probable maximum flood’ which is the theoretically greatest flood that could occur on the dam catchment.

Operators need to:

- Be fully trained to operate their flood gates and to periodically exercise the gates
- Be onsite whenever gate operations are likely to be needed
- Be aware of the dam safety conditions and requirements that apply to their dam
- Know what gate operations are expected during a flood event including what to do in the event of a gate failing to operate
- Know how to maintain and do running repairs to gate opening systems
- Know when they are not operating ‘as expected’

## 3.0 TYPICAL GATE OPERATING RULES

The most common operating rule is to set gate opening for a nominated headwater level. There is sometimes a minimum time between successive gate openings but, if the reservoir rise is too rapid and the gates fails to keep up, there is usually provision to progressively halve the gate movement intervals to allow the gate operations to keep pace with reservoir rises.

The overriding rules are generally that the safety of the dam is paramount and that the rate of outflow does not exceed the rate of inflow during the rising stage of an incoming flood.

In Queensland, the pinnacle of gate operations occurs at Wivenhoe and Somerset Dams in the Brisbane valley. They are operated as a tandem system to maximise the flood mitigation potential of the storages to protect the downstream areas of Brisbane, Ipswich

and a number of other communities. This degree of operation requires major investments in ALERT rainfall and river height sensors and real time modelling systems. In smaller floods decisions on gate openings are based on limiting the flows at Lowood and Moggill with the magnitude of the discharge being dependent on the reservoir level. The Wivenhoe Dam rules are illustrated in Table 1. Not all these criteria will be achievable at all times.

To achieve them we may have to open and close gates during the initial stages of the flood event. e.g. If the flow in the Lockyer is increasing, we may need to close down the discharge from Wivenhoe to keep a bridge open but once the Lockyer flow inundates the bridge, the release from Wivenhoe can be increased to satisfy the next limit.

**Table 2: Flood operating rules for Wivenhoe Dam**

Procedure	Reservoir Level	Applicable Limits		
0	EL < 67.25	$Q_{Wivenhoe} = 0 \text{ m}^3/\text{sec}$ ie. NO releases		
1A	67.25 < EL < 67.5	$Q_{Wivenhoe} < 110 \text{ m}^3/\text{sec}$	$Q_{Colleges \text{ Crossing}} < 175 \text{ m}^3/\text{sec}$ with care not to submerge Twin Bridges prematurely	
1B	67.5 < EL < 67.75	$Q_{Wivenhoe} < 210 \text{ m}^3/\text{sec}$	$Q_{Burtons/Noogoorah} < 250 \text{ m}^3/\text{sec}$ with care not to submerge Colleges Crossing prematurely	$Q_{Moggill} < 4000 \text{ m}^3/\text{sec}$
1C	67.75 < EL < 68.0	$Q_{Wivenhoe} < 500 \text{ m}^3/\text{sec}$	$Q_{Kholo} < 550 \text{ m}^3/\text{sec}$ with care not to submerge Burtons/Noogoorah prematurely	
1D	68.0 < EL < 68.25	$Q_{Wivenhoe} < 900 \text{ m}^3/\text{sec}$	$Q_{Mt \text{ Crosby}} < 1900 \text{ m}^3/\text{sec}$ with care not to submerge Kholo prematurely	
1E	68.25 < EL < 68.5	$Q_{Wivenhoe} < 1500 \text{ m}^3/\text{sec}$	$Q_{Mt \text{ Crosby}} < 1900 \text{ m}^3/\text{sec}$ with care not to submerge Kholo prematurely	
2	68.5 < EL < 74.0	$Q_{Lowood} < 3500 \text{ m}^3/\text{sec}$	$Q_{Lowood} < \text{peak of Lockyer \&}$ $Q_{Lowood} < \text{peak of Bremer}$	
3	68.5 < EL < 74.0	$Q_{Lowood} < 3500 \text{ m}^3/\text{sec}$	$Q_{Moggill} < 4000 \text{ m}^3/\text{sec}$	Gates ARE NOT to be overtopped
4	EL > 74.0 OR Dam safety may be compromised	Gates are to be opened until reservoir level begins to fall	Gate opening interval restrictions NO longer apply	

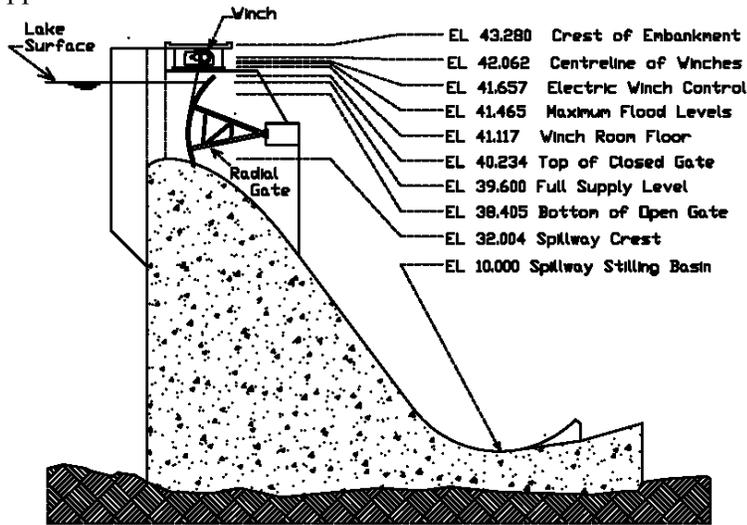
#### 4.0 GATE OPERATING INCIDENTS

There have been several incidents at gated dams in Queensland. Fortunately none of these has led to a major failure although that is not a reason to relax.

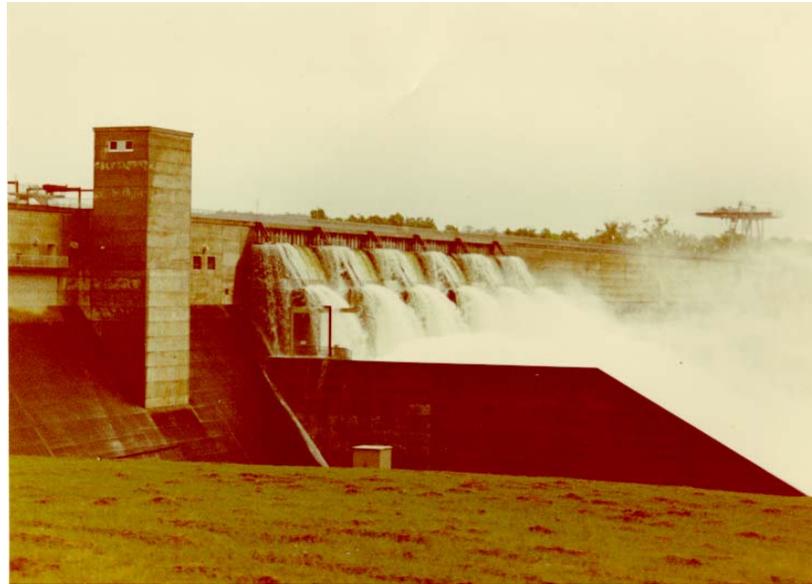
There was an incident at Leslie Dam near Warwick in the mid-late 1980s when, during a heavy mist, a water level sensor misread the reservoir level and the automatic gate operating system thought there was a flood in progress and it opened a gate prematurely. Fortunately, the reservoir level was below the gates and no water was lost but it caused a lot of rethinking on level sensors and the way the automatic operating system was employed.

North Pine Dam just north of Brisbane had an incident in January 1982 when, it is understood, the flood engineer concluded that a flood event was 'over' and shut down the flood control centre and went home (the flood engineer was the only person who could authorise gate movements). Soon after, there was another major burst of rainfall on an already saturated catchment.

Because none of the operators on site was authorised to open the gates, the water level rose rapidly to inundate the electrically powered gate lifting gear (which was housed under the bridge decking) and the gates were unable to be opened and the gates were overtopped.



**Figure 1:** North Pine Dam Spillway Gates



**Figure 2:** North Pine Dam – Overtopping of gates during January 1982

I remember going out to the dam and seeing the ‘Channel 7’ helicopter hovering overhead and sure enough, it featured on the news that night with the story indicating what a good thing it was to see the dams overflowing. Those who knew anything about what was actually happening realised what a close run thing it was to dam failure and were horrified.

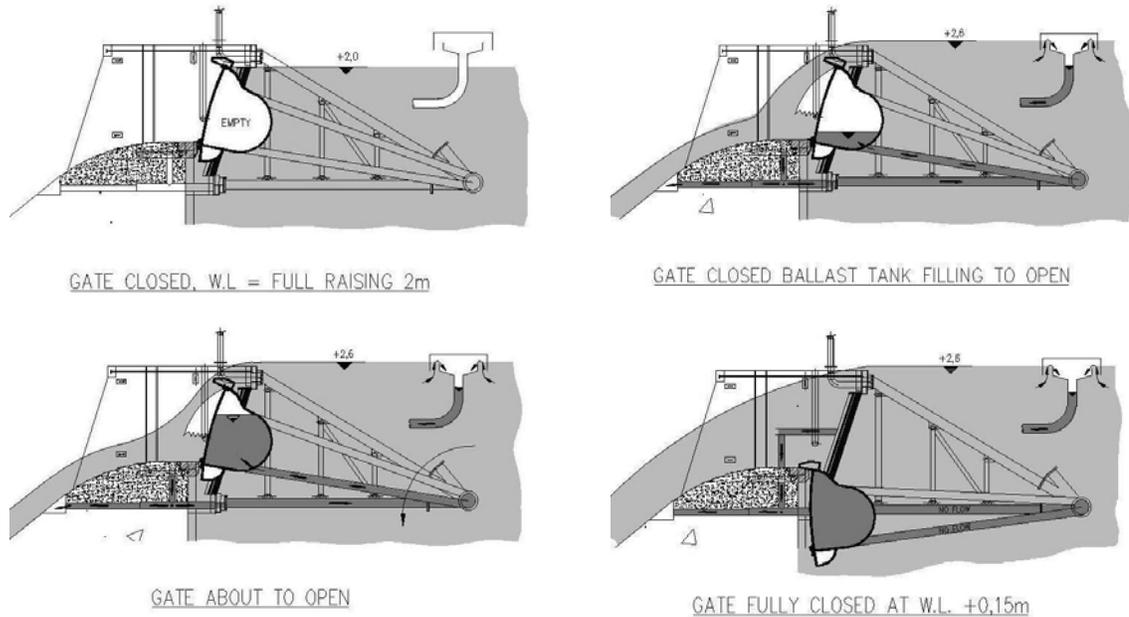
There have been many changes to the North Pine operating rules and data gathering systems since that time. These developments, which have also been enshrined at other similar dams, include:

- improved real time rainfall and river height monitoring throughout the catchment

- in combination with weather radar and improved forecasting and flood modelling;
- greater redundancy in gate opening systems;
- better trained operators who are empowered to operate gates in the event of ‘loss of communications’ with flood controllers.

There was an incident at Coolmunda Dam near Inglewood during a flood in 1978 when there was a blockage of a screen at the inflow into the automatic gate operating system which caused a gate to prematurely close. Fortunately the operators noticed something was going on and manually operated the gates until they eventually succeeded in removing the weeds blocking the inlet.

Most recently there has been an incident at Lenthalls Dam just north of Maryborough in 2008. TOPS spillway gates were installed as part of a two metre raising of the full supply level (FSL) in 2007. Gates were designed to operate automatically in a progressive manner with water filling or draining from the buoyancy tank which formed the downstream skinplate of the gate. The operating system is illustrated in Figure 3.



**Figure 3:** *Lenthalls Dam opening sequence*



**Figure 4:** *Lenthalls Dam spillway*



**Figure 5:** *Lenthalls Dam bottom gate seal*

During a flood event of Feb 2008, the gates failed to operate and the headwater rose to 1.27 metres above FSL without the gates opening ‘as designed’. Another lesser flood event occurred in July 2008 and one gate had to be manually operated.



**Figure 6:** *Lenthalls Dam during February 2008 flood*

Investigations eventually concluded that there was too much bottom seal friction to allow the gates to drop open when the buoyancy tank was filled. When you consider the deformation of the gates under load and the consequential additional compression on the seals with the addition of the overtopping water load, it also explains why the gates could be operated manually in ‘test’ mode prior to the onset of the flood. The seals have since been modified to reduce this seal friction and there is every expectation that they will operate “as designed” during the next flood event.

One outcome of this event was that people who lived upstream of the dam felt their safety was compromised by the failure of the gates to open and they increased their pressure for action by the dam owner to respond to both reduce the risk to them and to inform

downstream residents of the risks they were being exposed to. At the time of writing of this paper this is still to be resolved.

## **5.0 CONCLUSIONS**

Spillway gates are complex structures which need to be designed, operated and maintained by specialists who know what they are doing. Dam owners need to be aware of the responsibilities they incur when they own them. Operators need to be fully trained in their operation and to be eternally vigilant and aware of incoming events and of the consequences of failure.

## **6.0 REFERENCES**

NRM, “Queensland Dam Safety Management Guidelines”, 2002. *These guidelines can be downloaded from:* [http://www.nrw.qld.gov.au/compliance/wic/referable\\_dams.html](http://www.nrw.qld.gov.au/compliance/wic/referable_dams.html)