LENTHALLS DAM GATES FAILURE 2008 – A CASE STUDY IN GATE RELIABILITY AND HUMAN FACTORS, FAILURE TO IMPLEMENT RISK MANAGEMENT PROCEDURE.

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Abstract

The city of Hervey Bay is a growing tourist community that is located a comfortable 3.5 hour drive north from Brisbane. To meet growing water demands in the community, Wide Bay Water Corporation (WBW) required the raising of its water supply – Lenthals Dam.
Queensland Dam owners are aware of their obligation to manage their dams to minimise adverse environmental impacts and public risk.

In 2002 Tim Waldron CEO Wide Bay Water Corporation, KD Murray and Allan Crichton Principal Dam Engineer GHD published a study of options for the increase of Lenthals Dam, the paper is titled Raising Lenthals Dam – A Case Study in New Technology and the Environment. This publication referenced the final choice chosen for the dam increase; 2m crest gates to raise the full supply level to AHD26. A gated system was seen as beneficial in meeting post winter flood objectives[1].

The dam is assessed as Failure Impact Assessment Category 2, population at risk 270 not including upstream population and upstream state forest recreational users. The relevant standard is QLD Dam Safety Management Guidelines February 2002.
The Lenthals Dam Crest gates were installed in 2007 and failed to operate as designed from January 2008. In February 2008 high rainfall led to a moderate flood event, all gates inoperable. The gates failed to lower to release flood water.
In this incident, manual operation of the gates did not occur it is believed the mechanism was not operable. The operating authority failed to implement the Emergency Action Plan and failed to evacuate flood impacted upstream sites. Three persons were put at risk due to upstream flooding. Had the flooding been more prolonged or severe the persons trapped faced injury or death.

Australia has a strong reputation with respect Dam Safety and Incident management, this near fatal incident offers an opportunity to review and amend existing Dam Safety Requirements, Risk Management and Gate Reliability Criteria...
This incident provides ANCOLD with an opportunity to review all current guidelines and enhance Dam Safety standards with emphasis on the importance of mitigating human failure and ensuring public safety.

Introduction

Emergency Management Plans and arrangements are designed to treat residual risk and this is their place in the process.[2] It is clearly evident that the Dam Owner/ Operator, Regulators, Community and Emergency Management Planners need to establish clear communication.

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[1] Tim Waldron, K D Murray and Allan Crichton. *Raising Lenthalls Dam - A Case Study in New Technology and the Environment.* Dam Infrastructure Technology Review, Wide Bay Water , Hervey Bay: IPWEA, 2002.

[2] Dam Safety Risk Treatments Steve Warren Australian Journal of Emergency Management2001

Reducing consequences can be achieved by workable functioning evacuation plans and warning systems[3] that seem to be absent in the Lenthals Dam Feb 2008 Incident.
Human behaviour is an important consideration in the management of Dam Failure risk; "…simple mistakes, operational, mismanagement, unnecessary oversights, or destructive intent can interact with other hazards to compound the possibility of failure[4]"

This case study considers the Human Failures that contributed to the upstream flood risk in the Lenthals Dam Failure February 2008. To what extent did a failure to follow Lenthals Dam Emergency Action Plan (EAP) requirements enhance the risks posed to the public?
It is in the public interest to ask a series of questions regarding the implementation of the Emergency Action Plan during the February 2008 event and the draft format of the EAP when the Lenthals Dam Incident occurred.

- Is it acceptable that the EAP was in draft when the Lenthals Dam Gate Failure occurred?
- Is it acceptable that the section of the EAP titled affected landholders was blank?
- Is it acceptable that the regulator approved the dam increase and gates whilst still waiting on key compliance requirements to be met?
- How could it be that the crest gate system chosen got the seal plate and gate seal clearance so wrong?
- Is it acceptable that prior to the Lenthals Dam Failure Incident upstream landholders were not contacted, consulted or briefed as to the circumstances in which evacuation would occur?
- Should members of the public exposed to such a risk, be relocated prior to construction, there-by eliminating many of the risks faced and alleviating the constructing authority from the more onerous aspects of risk management, liability and negligence exposure?
- Despite assurances by Wide Bay Water Corporation that the gates were to operate automatically and lower at lower water levels after the Feb08 event, the gates did not operate automatically. In fact one was lowered manually and the rest did not lower manually despite water levels lowering. How is it that the dam operator was so uninformed during the incident regarding the operational and risks of failure in flood that they could not provide the regulator with accurate information?

To what extent would a strict adherence to the requirements in the Emergency Action Plan have minimised the risks posed to members of the public isolated by flood waters?

In the light of the Lenthals Dam Gate Failure Incident, Water Infrastructure Operators and Risk Managers should now address the changes required to be made to Dam Safety Risk Management and Dam Safety Requirements to ensure that future Dam Failure Incidents in Australia do not occur.
In the event of an incident steps must now be taken to ensure that EAP requirements are consistently adhered to.

[3] Dam Safety Risk Treatments Australian Journal of Emergency Management Steve Warren Victoria State Emergency Service

[4] Indiana Department of Natural Resources Dam Safety Inspection Manual 280803

Background

Lenthals Dam was constructed in 1983- 1984 to supply water to the Hervey Bay City Council area. The capacity of the storage is 17,256 ML for a Full Supply Level (FSL) at 24.0m AHD.

The existing dam consists of a zoned earthfill embankment, which is approximately 350 metres long. The elevation of the embankment crest is 34.0 metres AHD. The mass concrete ogee spillway is located on the right bank and is 75 metres wide energy dissipation channel, tapering over a distance of approximately 95 metres.

Two weirs downstream of Lenthals, Burrum Number 1 (AMTD 23.3 K=km) and Burrum Number 2 AMTD 28.2 km) complete the in river distribution system which diverts water from Lenthals Dam to water treatment plants.

The storage capacity for Lenthals Dam is based on photogrammetric mapping. The catchment covers 500km2 with the majority of the flow generated by the two tributaries Doongul and Logbridge Creek.

To ensure that there is adequate water supply for the future needs of Hervey Bay region, it was proposed that the FSL of Lenthals Dam be raised by two metres from its existing FSL of 24.0m AHD to 26.0m AHD. This provided an additional 11,150 ML of storage[5]. (Tim Waldron 2002)

In December 2007 the full supply level was raised 2m using Crest Gates. The Crest Gate is a patented system produced by Flowgate Projects (Pty) Ltd, South Africa[6].

The Lenthals Dam Raising Design Report[7] describes the construction as 2m Crest Gates comprising "…4 no. 14.8m wide gates and 1 no. 9.8m wide gate (total Length of spillway crest reduced from 75.3m to 69m). The crest gates open by moving downwards.

The gates failed to operate as designed from January 2008; the Principal Dam Gate Failure Incident occurred in 2008. Rectification works on the Crest Gates are still underway at the time of writing.

Individuals at Risk

- 270 Individuals down stream
- 12 Individuals Upstream (approx not included in EAP) and unknown numbers of campers at Wongi Campsite

At the time of the incident 3 individuals were isolated by rising flood waters at a farm house upstream. Those cut off by rising upstream floodwaters were not initially aware of the Gate Failure Incident and were not notified by the Dam Operator WBWC.

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[5] Raising Lenthals Dam – A Case Study in New Technology and the Environment Tim Waldron Wide Bay Water Corporation, K D Murray Sun Water and Allan Crichton GHD

[6] Raising Lenthals Dam – A Case Study in New Technology and the Environment Tim Waldron K D Murray and Allan Crichton 2002

[7] 411/16039/00/60817 February 2006

Lenthals Dam Gate Failure February 2008 - the Incident

The incident is best described by the Dam Operator Wide Bay Water (WBWC) the following is quoted from correspondence, 10 March WBWC to Principal Engineer (Dam Safety) Water Industry Regulation, Department of Natural Resources QLD (Author Peter Care Director Engineering Consultancy Services (WBWC).

- On the 29th January Wide Bay Water (WBWC) staff were successful in opening (lowering) the centre and smallest gate installed on the dam structure water level at the time was 25.44m. The dam designers were notified at the time.
  Author Note: It is unclear if this Incident was reported to Dam Safety at the time, when Dam Safety were contacted on the 14th of February the regulator was not aware that the gates were not operable (manually or otherwise) This would constitute an incident.
- On the 5th of February 2008 heavy rainfall in the Lenthals Dam catchment resulted in the dam water level exceeding RL26 and overtopping the crest gates.
- By 6th of February the dam water level had reached RL26.55m and none of the five gates had opened as designed. The first gate should have opened at 26.15 with each gate opening at 50mm reservoir levels.
- On the 11th February the dam water level had dropped to 26.20m with still no gates opening. The Crest Gate Designers, GHD attended the site to view the gate in operation.
  Author Note – the affected land holders and individuals were not notified of the gate malfunction in the continuing rain event.

- Continued heavy rainfall in the catchment resulted in the dam level reaching 27.41 on the 12th of February with **no gates opening. GHD** and their sub-consultant Flowgate Projects from South Africa were notified of the events. WBWC were notified by GHD that there was potential for all gates to drop of their own accord if the dam levels exceeded27.55 and that the smallest gate may drop as water levels receded.
  Author note: The EAP called for evacuation after water levels reached RL26.91 and no evacuation of the affected public occurred, there was no public announcement of risk or the need to evacuate.
- On the 16th of January 2008 around midday the smallest gate opened and remained down for about 15 hours to release flows down the Burrum River. The gate closed automatically at the correct now reduced reservoir level.
- On the 18th of February, GHD and WBW were able to open Gate 1, adjacent to the walkway, with the assistance of a hydraulic jack. Once open the gate responded normally to manual control and closed without incident within 15 minutes on operating the manual control valve.
- GHD and Flowgate Projects staff attended the site on 25th February to determine the cause of the gates failure to open as designed. Gate 1 was lowered again with the assistance of a hydraulic jack which established that the primary cause of the inoperability was due to the seal friction as a result of the high pressure exerted on the gate seals. An external load of approximately 600kg was sufficient to operate the gate and allow the gate to lower. Subsequent operation was achieved with 200kg of external load. The gate outlet was adjusted to reduce the flow out of the gate and increase the volume of water within the gate during filling to increase the opening weight of the gate and allow it to lower. This was trialled and Gate 1 operated without any external assistance.

- The outlets for each of the five gates have subsequently been adjusted to allow automatic operation along with the lowering of the emergency inlet weirs- to ensure complete buoyancy tank filling at a lower water level.
  Author note: this does not seem an accurate reflection of the situation as the gates did not lower and it was not possible to lower them automatically, the gates did not automatically open subsequent event in June 2008 and there is evidence to suggest the gates could not be manually lowered in June 2008.
- Measurements of the gap between the spillway lintel seal plates and the seal clamping plate on each gates confirmed that the compression of the seal is greater than calculated during the design stage. **Author Note**: Why wasn't this discovered at final certification.
- During the repeated operation of Gate 1 the movement of the gate was carefully observed and the gate once clear of the seal plate moves easily and freely. Gate closure after closing of the manual control valve is consistent and without incident.
- GHD and Flowgate Projects are presently evaluating options for adjusting the current gate arrangement, in the short term to ensure reliable operation of the gates, and in the long term to provide a permanent solution to prevent high load on the lintel seal. The long term solution may require the dam level to be below RL24.0m or the installation of stop logs on the dam crest to allow modification to be made.
  Author note: gates still under repair manual lowering is believed impeded.

Immediately prior to the February 2008 Lenthals Dam water level was at FSL RL26. The January rain had filled the catchment.
It is believed that the Crest Gates installed, were inoperable from the date of installation.
The recorded peak water level at Lenthals Dam was RL27.4 on 12 February 2008.

Properties and the Wongi Water Hole Campground are directly upstream from the impoundment where the Burrum River is joined by tributaries Doongul Creek and Lenthals Dam. Raised water levels in this location caused by flooding and gate failure are a significant risk as egress from these sites is impeded by cut roads in flood events.

The affect of the Lenthals Dam Gate failure was upstream flooding (to higher levels than recorded at the impoundment wall), roads were cut off and water rose around the residence where 3 individuals were stranded. The flood level 1.4m over the seized gates was higher than modelling for previous incidents recorded in the EAP but not much lower than publicly documented historical flood incidents.

Risk Management and Incident Reporting Requirements.

At the time of the Incident in February 2008 the Lenthals Dam Emergency Action Plan was still in Draft, and the affected land holders contact section was blank. The requirements in that Lenthals Dam EAP were:

- *Reservoir Level is approaching RL26.5 and further rain is forecast or reservoir is rising, check all gates are open when reservoir level reaches 26.5. If all gates are not opened operate manually the gates in order to open those*[8]
- *Reservoir Level is approaching RL26.91and further rain is forecast or reservoir is rising (Historical Peak 26.91…The major flooding will prompt the evacuation of many houses … Declare a Major*

[8] Lenthals Dam Emergency Action Plan Table 5.6 41/16885/02/358620

Flood Incident, advise the CEO, WBW of status and evacuation process… Continue to advise the CEO, WBW that the evacuation is in process[9]
The Dam Safety Condition Schedule Lenthals Dam (#309) stated:
".2 where the reservoir headwaters are such that inundation of any upstream dwellings is likely, such dwellings must be considered in the preparation of any action Emergency Action Plan. "
The current EAP at the time of the incident did not consider upstream dwellings.

"*The EAP must cover the potential failure of any part of the structure that can put a population at risk either upstream or downstream. The emergency events described in the EAP shall cover those events as outlined in the Queensland Dam Safety Management Guidelines – February 2002, and include such failure modes as: …..c. Failure of control structures such as intake works, outlet works and gated spillways i. loss of one and all gates in a sunny day event, ii) Loss of one and all gates in a flood event.*
4. Inundation mapping shall be developed as outlined in Queensland Dam Safety Management Guidelines – Feb 2002 and shall be of sufficiently large a scale so as to easily identify those areas subject to possible danger."[10]
"
It was noted than in the event of an emergency*, "the dam operator must notify the Chief Executive, Natural Resources and Water within forty- eight (48) hours. The notification shall include a brief description of the event and the time of activation of the Emergency Action Plan. It was noted in*"[11].

It was noted in the Lenthals Dam Safety Conditions Audit Report that "The *biggest issue for Wide Bay Water (WBW) is the lack of systems / staff for operating the dam with the commencement of wet season so WBW should give priority to finalise this O&M manual and train staff to operate and maintain the equipment." "There is no record of any past inspections carried out on the Dam, with the completion of the Dam upgrade works Annual inspections should be carried out for 2008"*[12]

It is in the public interest to ask, why Lenthals Dam was given approval and commissioned if these issues were unaddressed.
How is it, the Dam Safety Regulator was told on initial enquiry with Wide Bay Water that the gates were not commissioned i.e. were in the lowered flow release position rather than commissioned and unable to release flow?

Human Factors: Failure to implement risk management procedures as required by Lenthals Dam Emergency Action Plan

The Lenthals Dam operator <u>did</u> <u>not</u> <u>follow</u> <u>Emergency</u> <u>Action</u> <u>Plan</u> <u>procedures</u> when the gates failed. After the water reached RL26.5 it was not possible to manually lower gates[13]**.** Water levels reached 27.4 no evacuation was carried out as required in the Lenthals Dam Emergency

[9] Lenthals Dam Emergency Action Plan Table 5.7 41/16885/02/358620
[10] Dam Safety Condition Schedule Lenthals Dam Condition Schedule.doc NRW
[11] Page 6 section 11 Dam Safety Condition Schedule Lenthals Dam Condition Schedule.doc NRW
[12] Page 10 Lenthals Dam Wide Bay Water Dam Safety Audit 2007 Natural Resources and Water QLD Govt.
[13] Lenthals Dam Emergency Action Plan Table 5.6 41/16885/02/358620

Action Plan Table 5.7 41/16885/02/358620. Affected members of the public were not notified of the gate failure or of the risk, not surprising when this section (Affected Landholders) was blank in the only draft of the document available.

- Both Tables 5.6 and 5.7 require the notification of SES and Police. Members of the public contacted Police at Maryborough and State Emergency Services (SES) at the time of emergency they did not know there was a problem with the Lenthals gate operation or that individuals were isolated in rising floodwater upstream.
- The version of the EAP in February 2008 did not have a section covering "the *potential failure of any part of the structure that can put a population at risk either* **upstream** *or downstream."* The EAP in existence in Feb 08 did not seem to address in detail steps to deal with a gate failure in a flood event even though tables in the document address possible levels should this occur. The EAP did not have any mention of **upstream** flood risk or methods of evacuation should this occur.

It is apparent that the affected upstream public and stakeholders were not consulted when the consultants GHD compiled the Lenthals Dam Emergency Action Plan and it is recommended that greater consultation and openness be a requirement in the compilation of Emergency Action Plans. The provision of Inundation mapping for flood and dam failure and consultation preconstruction may well have eliminated the risks to upstream individuals entirely.

Local knowledge can contribute to a greater understanding of flows into a catchment when historical recorded data is not available. It must be a requirement of future Dam planning and Dam safety planning that this knowledge is included in modelling and tested against the hypothesis and conclusions in the modelling of probable dam failure and flood incidents.

It is recommended that when Dam Infrastructure is planned Emergency Action Plans are complete and Dam Safety requirements are met before the infrastructure is installed and operational. Suitably trained staff must be in employ prior to installation/ completion rather than at some later point.
Risk Assessments and Risk Assessment Trees are no substitute for commonsense on behalf of the constructing authority and Dam operator. Sometimes a simple cost benefit analysis will provide a solution. if Individuals face significant harm in the event of a failure and a cost benefit analysis reveals a low cost solution (compared with the overall project and liability risk over the life time of the infrastructure)– then this low cost solution must be taken up. Relocating upstream parties prior to construction would have eliminated the majority of the risks faced. Due to the low upstream population this could have been achieved at minimal cost – why was this option rejected by a well funded constructing authority, why does the dam operator reject this option now, the risks are unchanged.

The risks faced by the public were greatly enhanced in the February 2008 incident as documents (EAP) were incomplete and processes were not followed (no evacuation undertaken).
In the interests of public safety it must be asked if between July 2007 and February 2008 given identified issues of *lack of systems / staff for operating the dam*[14] *,* any steps had been taken to address the inadequacies identified by Dam Safety Natural Resources and Water.

[14] Page 10 Lenthals Dam Wide Bay Water Dam Safety Audit 2007 Natural Resources and Water QLD Govt

It must be asked would public safety be enhanced if the regulator was better resourced to penalise and take action against Dam Operators who don't comply with the requirements set out.
It might be asked if Building Industry Regulators have a legislated capacity to apply punitive action why doesn't the regulator of Dam Safety in this specific instance 270 persons are at risk and the infrastructure is significant. What is the QLD government doing about this?

The Lenthals Dam Gate Failure February 2008 Incident provides an opportunity for further investigation and greater understanding of how it is that a well resourced Dam operator (Wide Bay Water) could fail to follow the recommendations made by Natural Resources and Water QLD within the time frames.
This situation may well have added to the Human Failures that magnified the risk posed by individuals when the gate infrastructure failed.

It is vital to consider that the results of the gate failure and associated human factors were minimised by the cessation of rain not by any action taken by the operator or the regulator or emergency services. Luck was the critical factor in the lack of injury or fatality this is unacceptable.

The public have a high expectation of infrastructure managers and in this case the public expectation was not met, worse could have happened.

Dam Safety NRW QLD are continuing to monitor the situation and can provide more details:
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