Haldon Range Dam.

Small dam, **big task**

Water flowing in the spillway channel.
Excavation of the first trench to lower the reservoir 1m.

Craig Scott from MWH gives an engineer's personal reflections on managing an emergency dam decommissioning

Is that dam safe? Are my children safe? Will my house be flooded if the dam fails? These are just a few examples of the many questions asked of me after the August 2013 earthquakes which forced the emergency dewatering of the Haldon Range Dam reservoir in Marlborough, New Zealand, to protect the population of nearby Seddon.

At the time of writing this article I am following the flood and spillway events unfolding at the Oroville Dam in located in the US. Approximately 190,000 people comprising families, pets and belongings have been asked to evacuate as a precaution in the event of dam failure. With the Oroville dam some 235m high, the impacts would be catastrophic and devastating to the local community.

The Haldon Range dam is however at the other extreme of impacts to Oroville – a 25m high earthfill farm dam constructed for irrigation water to supply a new vineyard development. It is located upstream of the town of Seddon which has a population of 507, with a large local employer being a lime and salt works. The Haldon Range dam is similar to the many tens of thousands of irrigation and water supply dams that exist globally to manage water supply for individual landowners, small communities or groupings of farmers. Similar to Oroville, the anticipation or actual structural failure of any dam or its appurtenant structures causes significant stress for the local population. It captures the attention of the media. It can be the subject of numerous court cases, and for a long period the structure can exist as a risk to the downstream population until actions are completed to reduce that risk.

This article is a synopsis of my personal experience as an engineer, engaged by the Marlborough District to inspect the damaged Haldon Range Dam immediately following earthquake induced damage; recommend actions to reduce the risk; then manage the implementation of the physical work to reduce the risk in as short a time as possible.

Damaging earthquakes

The Haldon Range dam is a privately owned, modern design 25m high zoned earth fill dam constructed in 2008. It has a full height chimney drain, drainage outlets to record seepage flow, two sets of standpipes for recording internal water levels, and deformation survey pins for monitoring. It has a 'Medium Hazard' rating in accordance with the NZSOLD Dam Safety Guidelines.

Notably, it had no low level outlet for drainage of the lake, only an overflow spillway discharging across a terrace, with all irrigation water pumped from the reservoir.

In late July 2013, a series of sizeable earthquakes struck the Marlborough region over a period of a few days. The strongest was a magnitude 6.5 and having its epicentre in Cook Strait separating the two large islands of New Zealand, with a dam site estimate of 0.2g acceleration. This earthquake caused minor to moderate observable damage to the dam.

A month later, on Friday 16 August 2013, a magnitude 6.6 (0.76g) earthquake with its epicentre under Lake Grassmere, very close to the dam, struck at about 2:30 PM which significantly damaged the dam.

Observations and dam decommissioning summary

After the dam had sustained damage during the July earthquakes, the owner contacted Marlborough District Council as the dams regulator in the region, and the media.

I was engaged by the Marlborough District Council to inspect the damage which included partial longitudinal crack of the crest and minor slumping of the upstream dam face. I reported that there was no immediate risk of the dam failing, that repairs to the dam were required, and the reservoir level should be drawn down 4m as a precautionary measure to reduce the impacts of a dam failure should larger aftershocks damage the dam further leading to a breach.

A month later, the Marlborough region and the dam was subject to a second series of earthquakes, this time much stronger with the epicentre very close to the dam location. Again I inspected the dam; noting significant crest cracking, right abutment separation, and complete slumping failure of the entire upstream face. In the region there was significant damage to regional infrastructure including homes, businesses and local infrastructure such as roads and bridges and services.

Immediately after the August inspection, when on site, I informed the CEO of the council that the dam was damaged to an extent that its integrity to retain the reservoir could not be guaranteed. Coupled with the reservoir level rising due to heavy rainfall and a flood situation developing in the catchment, plus with on-going earthquakes, I recommended that the only viable means to reduce the risk of failure impacting on properties downstream was to reduce the reservoir's storage water volume immediately.

Contractors were on site two hours after my inspection and a series of four stages of excavation works were undertaken over the next seven days to lower the reservoir level 4m; a level I assessed as likely not to cause property damage in the event of a sudden release to the reservoir.

Throughout the process of reservoir lowering, continual inspection and monitoring of the dam was undertaken by myself and Paul Woperis of MWH. Notably on day three, the dam filter discharge water became 'cloudy' and piezometric levels increased in the standpipes increasing the urgency for decommissioning. The stages of lowering works were:

- **Day 1** – The August 16 earthquake, 2.30pm.
- **Day 2** – Dam inspection by myself and the council. Legal takeover of the dam site. Removal of the spillway weir to lower the reservoir up to 500mm.
- **Day 3 and 4** – Excavation of a trench across a 300m wide terrace along the alignment of the spillway to an adjacent catchment to lower the reservoir up to 1m.
- **Day 4 to 7** – Excavation of a 10m+ trench around the left abutment and lowering of the reservoir 4m below full supply level.
- **Day 8** – Works completed to lower the reservoir 4m, tidy up, access road restored, Council handed dam responsibility back to the land owner.

Personal experiences, observations and suggestions

Inspecting the Dam and ICOLD Bulletin 62 (now 166)

With no personnel notable past experience of the Haldon Range Dam prior to the earthquakes, my first detailed review of information related to the design, approval permits, construction, and safety documentation for the dam, was completed from the council files on route to the dam to inspect it following the July earthquake. The dam had good documentation in place, and it had a surveillance and an emergency action plan. Prior to attending site for both earthquake inspections in July and August respectively, I elected to make my inspection following the ICOLD Bulletin 62 (1988) Inspection of dams after earthquakes (now updated to B.166 – 2016). I found using the B.62 Bulletin very useful and an excellent reference document in the absence of any prior history of the dam.

The earthquake and flood as a combined event

The dam is located near the Kaikoura Mountain range region. The owner, prior to the event had drawn down the reservoir by over 1m.

When I visited the dam site after the larger damaging event in August, the dam was visually significantly damaged. However, the region was experiencing very heavy rainfall at the time, with high inflows to the reservoir filling to the spillway level within a 45-minute period during the initial post-earthquake inspection.

At the time of inspection the dam was subject to earthquake aftershocks and the incoming water. I was reporting through emergency staff to the council CEO that the threat posed by the dam was high, and in fact increasing as the reservoir filled to spillway level.

My recommendation to implement an emergency draw down was based on the damage observable, ongoing earthquakes and 'flood' conditions at the time. From my recommendation, the emergency authorities implemented legislative legal powers to immediately take over 'the dam site' land and implement my suggested actions to reduce the risks posed by the reservoir.

Working with emergency staff

The Marlborough Council is the emergency authority in the region and controller if and when a state of emergency is declared. The earthquake had a significant impact on the region and the authorities had many functions to perform; addressing the Haldon Range dam was only one of many of their major concerns.

The council and the CEO were intimately aware of all of our actions through one of the staff being in attendance with me at all times at the dam. We generally met at 6am every two days with the CEO and emergency staff throughout the week, to report on the dam's condition and the state of works. The council appointed a senior emergency controller to partner me throughout the works. We acted as a decision-making team, each with different skills, mine technical and his regulatory and emergency response. This dual role responsibility proved very successful in managing the situation which included addressing the reservoir lowering, interfacing with the local population, and facing the media.

My principal observations of my interface with

Excavation works in the spillway channel to lower the reservoir 1m. Excavating from the downstream spillway plunge pool back to the reservoir.

Excavation of the dam left abutment trench to lower the reservoir 4m. Discharge flow visible in the narrow cut at the base of the wide trench.

Aerial view of the excavation works. The early stage works to lower the reservoir 1m is viewed to the left of the photo. The works to lower the reservoir 4m are commencing in the centre of the photo with the trench under construction following the left abutment of the dam.

the emergency authorities was the faith they put in my technical opinions. The authorities had numerous other regional earthquake damage issues to address and the damage to the dam was of media interest. Recognition that the authorities have many other requirements in earthquake situations should be incorporated into emergency planning scenarios.

Handling the media

Media presence throughout the week of work was constant, with three major television stations having cameras on site, and the local newspaper and national radio stations regularly reporting on the dam and our actions.

I was required several times to engage with all media outlets. Addressing the subtleties of what and how to communicate with the media and the local population is an important issue – the media are the first to directly ask "will the dam fail?" or "is it safe?" During the media briefings I was required to outline my and MWH's role in the work, state specific timelines of actions, and comment on the state of the dam.

My learnings from the event was that dealing with the media as an expert during an emergency is not to be underestimated. My recommendation to those who may be put in a similar position in relation to a dam(s) emergency (ie owner, consultant or advisors) is to include media training as part of their professional development.

Keeping on top of communication channels

The Haldon Dam site is located in remote farming country. Access to power was limited and internet and phone signals were weak. During the event I was in constant need of communication with numerous people such as emergency staff, the dam designer, contractors, MWH, and other dam advisors. Others wanted to contact me such as my family, friends and colleagues.

The modern world generally allows good communication and for all its benefits, I found some downsides. The downside was the large amount of communication I received which was not always directly related to my needs. In itself, over communication was not a problem, rather it was the time it took to find information I needed within my systems, and importantly the impacts it had on the battery life of my phone and computer. I found battery life and charging facilities a particularly difficult issue and an unexpected challenge of my involvement in the emergency.

One the positives of modern technology was that the interests of legal representatives of various organisations was strongly evident to me throughout my time on site. I found the easiest means of documenting my actions was using the timestamped voice recorder and camera on my mobile phone for capturing all my observations and the basis for my decision making.

Example dam upstream face slumping crack. This cracking extended the full length of the crest.

Craig Scott gave his personal reflections on managing the dam emergency at Haldon range Dam. The photo shows equipment excavating the 4m lowering trench on the dam left abutment.

Panorama view to the dam face with the extent of the excavation works to lower the reservoir 4m shown visible on the left abutment.

Consulting the dam owner

As a result of my recommendation, the council instigated the legislative and legal processes to implement the works it deemed necessary to make the public safe. The council had the powers to bring to site earthmoving equipment and specialists like myself to help address the risk posed by the dam.

The owner was very concerned about the state of the dam and the potential impact on Seddon if it failed, and was generally very helpful to us. From the time of the August earthquake the dam owner had employed a specialist lawyer to be on site 24 hours a day. I did not find the lawyer's presence on site as a negative, rather it was positive and helped produce very considered verbalisation of the decisions I and the council were taking and the rationale behind them. As described earlier, capturing this decision making at this time by recording it was a means of mitigating any misunderstanding.

Talking to the local community

The local community was largely the population of Seddon located downstream of the dam, and the nearby town of Marlborough.

During my week on site I passed through Seddon many times, stopped to buy food, petrol, and stay for overnight accommodation. I interacted with many people in the community and many knew me by sight because of the television and newspaper coverage of the dam. Similarly, many locals visited the dam site for their own interest, or as acquaintances of the dam owner.

When I was interacting with the community I communicated with them as I would with the media, overtly truthful, factual and informative. I found this a very delicate situation as some were very emotional and still suffering from the stress of the initial earthquake, the ongoing aftershocks, damage to property and infrastructure. The dam, because of the media attention, was a 'lightning rod' for their emotion.

Haldon Range Dam in 2017 and beyond

The dam itself has had three years of 'making good works' involving installation of a low level outlet in the abutment trench constructed as part of the emergency work, investigation of the failure, design and permitting of full remedial works.

The dam now is undergoing remedial works likely to include an upstream buttress, downstream buttress, filter/drainage improvements and alteration of spillway levels.

From my own perspective, the key learnings I took from the process are:

- For inspection of a dam when you have no familiarity with it, utilising ICOLD Bulletin 62 (now 166) as a formalised guide is a very good tool.
- The simultaneous risk occurrence of earthquake and flood /heavy rain can occur.
- Immediately reducing the risk a reservoir can pose if it has no low level outlets, for a small dam, can take a long time. For the Haldon Range Dam this was 8 days.
- Media training for a 'dam' professional should be strongly considered as part of personal development programmes.
- Modern technological modes of communication are very useful, however, management of the volume of communication to people involved in emergencies requires control. The equipment requires significant power consumption, and the means of providing this should be in place.
- Lawyer involvement from the outset of an emergency is valuable and can ensure considered and verbalised decision making.
- It takes a team to implement emergency decommissioning of even a small dam. Our team comprised three people (2 MWH, 1 council) plus their organisational support, and onsite 5 contractor staff and their earthmoving equipment. ■

About the author

Craig Scott is Hydropower, Water Resources and Dams Sector Leader in Europe and Africa for MWH, now part of Stantec. This article is a summary of a presentation Craig recently gave to the British Dams Society. MWH is contracted by Marlborough District Council (MDC) to advise on dams in accordance with the relevant statutory requirements. Following the earthquake in July 2013, MWH acted as the technical specialist advisor for MDC and carried out a safety inspection of the dam and assisted MDC in determining risk reduction works. MWH was not involved with the design or construction of the dam in any other capacity.