

FLOOD DETENTION BASINS – PROTECTION OR RISK? THE DILEMMA FACED BY NSW COUNCILS

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Abstract

Many NSW Councils own flood detention basins that were constructed in the 1970's-1990's to cater for new residential developments. Whilst these basins helped to alleviate more frequent flooding, they also add a silent risk to the people living directly downstream. In line with NSW Dams Safety Committee guidelines the owners of these flood detention basins must quantify the risks associated with their failure which leaves Councils faced with a number of dilemmas:

- Should residents be informed of the potential risk, or should Council simply get on with rectification works?
- Is the potential risk relevant when assessing development applications?
- How will the NSW SES plan for and respond to emergency situations with such short warning times?
- How will the NSW SES convince people to evacuate when they are unaware of the potential risk?

This paper will discuss the issues and provide possible options to address them.

Introduction

The main aim of the *NSW Dams Safety Act 1978* is to ensure the safety of dams across NSW. The NSW Dams Safety Committee (DSC) was constituted under the Act to provide guidance to dam owners. The *NSW Dams Safety Act 1978* was intended to cover detention basins however the priority for investigation was given to large water supply dams; more recently the focus has shifted to also include flood detention basins. It is the dam/detention basin owner's responsibility to undertake investigations to determine the cause/s of possible dam failure and the extent of flooding downstream caused by the failure. Depending on the population downstream, a certain level of safety is required to be met, as well as the preparation of a Dam Safety Emergency Plan (DSEP) which describes the process to follow in the event of an emergency.

Flood detention basins are often built to temporarily store flood water to reduce flood levels downstream. They typically comprise of walls or embankments to provide an area for storing water during times of heavy rainfall over the catchment. An outlet controls water flows exiting the basin and a spillway directs water that exceeds the basin design capacity downstream in a more controlled fashion (Flood Detention Basin, 2014).

Most flood detention basins were constructed in the 1970s to 1990s to safely convey a certain design flood and therefore protect urban areas from flooding. This practice occurred after the urban area was developed. Little consideration was given to the consequences of events larger than this design flood or of the possibility of outlet blockage (De Silva et al, 2010). A recent review of Fairfield City Councils flood detention basins has shown that many spill in events more frequent than the typical 1% AEP design standard.

Flood detention basins, like many other structural flood mitigation options such as levees, have been successful in reducing flood risk, however they can give the local community a false sense of security as they are typically designed to store flood water from only minor to moderate events. Larger events that cause overtopping or failure can cause increased risk to life due to large volumes of water moving extremely fast. Long duration or multi-peak storms (where the basin fills in the first peak) can increase the likelihood of overtopping or failure and provide little attenuation when overtopping occurs.

Of the 15 (14 responded) NSW Councils who own 'prescribed' flood detention basins, it seems only one council has done any form of community notification, and this has been done via a notation on the s149 Planning Certificate. Generally Section 149 certificates do not consider failure risks from basins and dams. However, the notation is focussed on the existence of the DSEP, rather than the increase in flood risk as a result of the dam failure. A number of councils believe it is an important element of emergency response and plan to notify the community in the future, however the means by which it will be done are yet to be identified.

Population at Risk (PAR) vs Probable Loss of Life (PLL)

NSW DSC guideline DSC3A requires that Consequence Categories (CC) are based on a two-tiered approach. Where probable loss of life (PLL) figures are available, they should be used, if not population at risk (PAR) can be used. The PAR for dam-break is just the additional area flooded as a consequence of dam failure, not including the PAR in the area affected by natural flooding prior to the dam break.

PLL is calculated using the method described by Graham (1999) which considers factors including flood severity, warning time and understanding of flood severity.

Smith et al (2009) considers that there are also a number of social factors that contribute to risk to life including:

- Population density/distribution
- % of transient population
- Mobility
- Age distribution
- Physical health
- Flood awareness
- Willingness to evacuate

Smith et al (2009) concludes that these factors must be addressed in determining floodplain management strategies, rather than simply estimating flood risk to property.

Dam Break Consequence Categories

The PLL or PAR is used to determine the Consequence Category (CC) as stipulated by the NSW DSC.

Consequence categories, as described by the NSW DSC in DSC3A (DSC, 2010a), are classified on a seven-point scale ranging from very low to extreme (Figure 1).

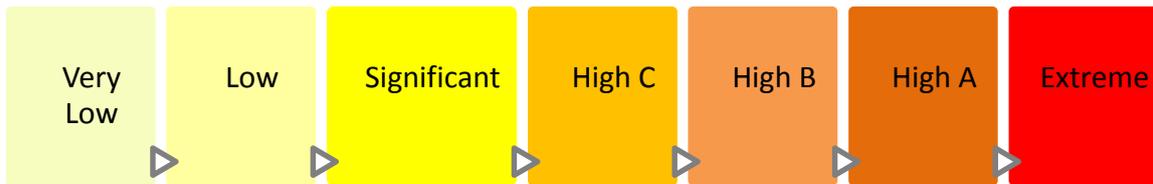


Figure 1. The seven consequence categories for dams (after Dams Safety Committee, 2010a)

Very low is most likely to apply to small farm dams due to the small capacity and where the PAR would be very small due to the sparse population in rural areas. Extreme consequence category dams would most likely be large water supply dams and if dam break occurs, would cause immense consequences in terms of loss of life, damage to property and infrastructure. Flood detention basins would most likely fit on the scale somewhere in between.

If a basin has a Significant CC or greater, the basin is then put on the 'prescribed dams list' managed by the NSW DSC as Schedule 1 of the *Dams Safety Act 1978*. This means it is then considered to be a 'dangerous' dam. The CC is also used to identify the necessary upgrade works to bring the basin to an acceptable level of safety. A Dam Safety Emergency Plan (DSEP) must also be prepared for the basin (DSC, 2010a), as per the DSC2G (DSC, 2010b).

Fairfield: A Case Study

One of Fairfield's residential catchments contains 14 flood detention basins, nine of which have been prescribed by the NSW DSC. Council, as the owner of these basins, is required to upgrade four of them to safer conditions and to prepare a DSEP detailing the steps to be undertaken in the event of a flood emergency.

Works required at each individual basin will vary, however most will require a formalised spillway, embankment strengthening and potentially embankment raising. A risk assessment has been undertaken to determine the urgency and extent of works required at each basin and to prepare a prioritised list of remedial works.

Some of these flood detention basins start to spill in the 5% AEP event, and geotechnical studies have shown that once these earth embankments start to overtop, they are likely to fail (Douglas Partners, 2011). These are moderately frequent events; however the water level in the basins has never overtopped the embankments. This means that the community has had no exposure to flooding of this kind.

The catchment is mainly low density residential with some pockets of commercial land use and is fully developed. There are no plans for intensifying development in the catchment at this stage and so future development would mainly consist of increasing house footprints on the individual lots. Council's current On Site Detention (OSD) Policy only applies to residential developments of triplex or above, which would mean that there could be increased runoff due to the increased impervious area if this type of development occurs, although onsite detention itself has its limitations (Still, 1999).

Should residents be informed of the potential risk, or should Council simply get on with rectification works?

The NSW Floodplain Development Manual (DIPNR, 2005) states councils have a duty of care to inform residents about their flood risk, although it remains a difficult decision for councils to make due to the fear of community angst. This duty of care should recognise that flood risk management and disaster planning must consider all possible floods. Failure to do this will expose communities to higher risks to life and property (Ribbons, 2011).

Councillors and home-owners alike are often concerned that by placing a flood notation on a property, that the property value will decrease. A study by Yeo (2004) across Australia, New Zealand, Canada and the United States shows that it is not the notation that causes house values to drop; it is an actual flood event that causes it. Yeo's research also showed that development controls or notifying or educating the community about flood risk also did not affect property prices.

NSW DSC Guidelines do not stipulate that dam owners notify the downstream community of potential dam failure, they merely recommend it be undertaken. As far as some councils are concerned, they will only do what is legally required rather than cause angst in the community. Furthermore, if residents are not aware of their risk, they are unlikely to respond safely and timely.

The first NSW Floodplain Development Manual (the Manual) was released by the NSW Government in 1984. The Manual gave councils a process to follow in developing Floodplain Risk Management Plans and also set the 1% Annual Exceedance Probability (AEP) flood event as the standard for designing floodplain risk management measures. Many of these basins would have been constructed by Council acting in good faith prior to 1984 as they would have formed part of a general flood mitigation strategy for the release areas to minimise flood risk. Council may not be seen as acting in good faith by not releasing the dam break flooding maps to the public – especially if a disaster was to actually occur. This is highlighted in the recent Queensland Floods Commission of Inquiry (Section 2.9), where it was recommended that hazard information and maps should be made public (QLD Floods Commission of Inquiry, 2012).

McLuckie (2013) writes that in order for the community to make informed decisions about flood risk and investment in the floodplain, information is essential. It needs to be made available openly, transparently and inclusively. It is widely known that education and engagement of the community will enhance community resilience to floods. However, McLuckie (2013) also says that the degree of flood knowledge required for community resilience varies with the exposure of the community to flooding, complexity of the flood situation and the potential for growth in risk due to new development.

People do not appear too concerned about where flooding comes from (for example mainstream or overland flooding); they just care if their property is at risk of flooding, and what Council is going to do about it. If Council has a program of works to upgrade the basins then this could be seen as a good news story.

By informing the community of their additional flood risk from potential dam failure (or basin), so they may be prepared to evacuate, Council may save additional lives. Surely saving just one life is worth the potential community concern. Council must reduce risk as far as reasonably practicable to demonstrate duty of care, at the same time as addressing community concerns. Good community engagement is an effective way of demonstrating duty of care.

The complex nature of flooding from detention basin failure means that it would not be easily understood by the community, given that 'normal' mainstream flooding seems to be a difficult concept for the community to understand. It is also important to note that a number of factors influence the flood level within the basins such as variations in rainfall intensity across the catchment, rainfall duration, antecedent catchment conditions, shape of the flood hydrograph and impacts of climate change which means that the predicted water level from the design storm could be quite different to real-life conditions. There is also uncertainty in predicting basin failure mechanisms, which makes flood emergency planning and response for basin failure much more difficult than when dealing with 'normal' flooding.

Another factor in the debate is the question of time. Fairfield City Council must upgrade four basins, however with no cost estimate for the works at this stage, it is hard to determine how long this will take to complete. Supposing Council is able to fund, with the help of NSW Government grant funding, upgrade works to one basin per year. This would mean it could take four years to bring all prescribed basins to an acceptable level of safety, and four more years of communities being exposed to risks of which they are unaware.

There are a number of methods that can be utilised to inform the community of the risk including personalised letters, making dam break mapping available on Council's website and/or a notation on the s149 Planning Certificate. The most effective solution would be to undertake all of these methods and engage with owners and residents on a regular basis. This should be done in partnership with the NSW SES as they have responsibility for educating the community in the floodplain, as per the *SES Act 1989*.

Is the potential risk relevant when assessing development applications?

The need for development controls arises from the increase in depth and velocity of floodwater as a consequence of dam failure as opposed to "normal" flooding. The types of development controls imposed due to dam break could include floor level, structural soundness, flood compatible building components and evacuation planning.

The difference in time from "safe" to "failure" can be a matter of moments and therefore the time available to warn and evacuate is almost non-existent. The floods resulting when an embankment is breached are very different than a natural flood (Thakkar, 2007). Floods resulting from dam failure can be particularly damaging because of their speed, size and suddenness. Installing flood depth markers within the basin with coloured bands corresponding with the dam failure alert levels (white, amber and red) may assist council to monitor the levels, but these would also need to be telemetered given the number of basins in the catchment. Once the water level in the basin reaches an alert level, NSW SES notification is required. On a red alert level, evacuation would be required to ensure that once the basin starts overtopping, there would be no-one within the dam-break zone downstream. If the basin did not overtop or did not fail, the community could become complacent and not want to evacuate next time. A survey conducted by Molino Stewart after the floods in northern NSW showed that evacuees behind a levee had mixed opinions of having to evacuate even though a breach of the levee did not occur. This is a situation we should not avoid just to save face. It is better to evacuate unnecessarily than to not evacuate and lose lives. However, in an event large enough to cause the basin to overtop, emergency personnel are likely to be mobilised across the catchment with the event likely to also causing flooding elsewhere in the catchment.

DSC requires dam owners to inspect and maintain their dams on a regular basis and submit surveillance reports detailing the same. This can include mowing the embankment to give a clear view of the structure to be able to check for animal burrows, bank scour, and cracking, build-up of debris, slump or failure (Flood Detention Basin, 2014). If any of these are found they should be rectified immediately to ensure structural integrity for the next flood event. Surveillance and maintenance will help to reduce the likelihood of failure, but failure is inevitable without upgrade works being carried out.

In order for communities to cope with flooding as well as flooding as a result of dam break, they should be involved in decisions on flood risk mitigation planning (COAG, 2011). At Council, the community is consulted through the Floodplain Management Committee and Councillors. Community consultation is undertaken during flood studies and floodplain risk management studies by sending letters to those affected, media releases, etc., but there is never much interest. People are too busy getting on with their lives to really get involved in flooding decisions – especially when they believe these floods will never happen. Educating people about a topic they are not really interested in or even understand is a difficult task! But for the safety of the community it is imperative that we just keep trying. We need to engage, send letters, host meetings, visit meetings held by community groups, meet the community in their street, communicate in different languages, place advertisements on the radio and television etc. and then do it all over again. Repetition of engagement is the key to a message sinking in. One or two letters over the course of the study simply will not have the intended effect, and merely adding a notation on the Section 149 Planning Certificate will do nothing to educate and warn the community about the potentials dangers they live with.

In order for government, industry and the community to make informed decisions about flood risk, it is important that flood information is freely available to everyone (McLuckie, 2013). The more information about flood risk that is in the public domain and the more we involve them in the process of problem solving the hazard, the more the general community will understand the terminology and will gain an appreciation for the size of floods and potential impacts and what to do before, during and after a flood. This in turn will assist in enhancing community resilience to floods. It may also encourage the community to get flood prevention higher on the national agenda, rather than spending more on flood recovery.

A survey conducted by Molino Stewart in 2001 showed that over 70% of respondents believe it is unacceptable for their house to flood above floor level, and the majority of the remaining 30% believe it could happen at most once in their lifetime. Over 90% of respondents never want flooding to occur that causes structural damage to their home. In order for Council reduce the amount of properties potentially flooded above floor level, notations must be placed on the property and development controls are also required. It was concluded that there is a difference between regulated “acceptable” flood risks and what the community perceives to be an “acceptable” flood risk (Opper et al, 2007). The community expects a higher level of protection from severe consequences of flooding than what is currently regulated through State and Local floodplain management practice.

As engineers, it is possible to quantify risks and so in determining the likelihood of failure and preparing detention failure mapping, make a number of assumptions on top of all the ones already embedded in the “normal” flood modelling including failure mode, time of embankment collapse, etc. just so a workable number is created at the end of the calculations. The problem with that is it is hard to justify the importance of making the community aware when it is perceived by non-engineers as guess work. Yes, it is the industry norm, and informed by geotechnical, dam and flood modelling specialists, but sometimes engineers can be seen to over exaggerate consequences,

especially with no recent local experience of flooding. Factors of safety and conservative estimates do not always do engineers favours when trying to convince non-engineers!

It is probably not justifiable to put constraints on development when it could only be for a short period of time that they are exposed to these risks until the basins are upgraded. The additional cost to developers would be an unnecessary burden – especially when their neighbours have not had to comply with these constraints. However, further development downstream of the basin could increase the hazard presented by the basin, thereby increasing the liability of the owner (Himsley, 2013). Even following upgrades, there is always an element of risk. It is therefore important that the land use zoning is appropriate to ensure intensification of development does not occur.

How will the NSW SES plan for and respond to emergency situations with such short warning times?

The NSW SES is the lead combat agency for flooding in NSW, including dam failure as per the SES Act 1989. The comprehensive combat role has long since evolved from purely response to include floodplain risk management, community engagement, flood emergency planning *and* flood response (Opper et al, 2007).

These elements of prevention, preparedness, response and recovery are detailed within the NSW State Flood Plan 2015, a sub plan the State Emergency Management Plan (EMPLAN) as well as local flood plans for Local Government Areas with an identified flood risk. These plans identify evacuation as one of the response strategies, where people should be pre-emptively evacuated from dangerous or potentially dangerous places created by the flood hazard to safe locations away from the hazard. Therefore, to minimise the risk to the community and emergency personnel it is imperative to ensure that evacuation occurs before the detention basin overtops or prior to evacuation routes being cut off.

One of the critical difficulties in deciding to evacuate is estimating the time available to complete the evacuation before the area is inundated to dangerous depths and velocities (Mark et al, 2010) or evacuation routes are lost. The amount of time available may not be known as it depends on a number of factors such as the length of the breach, the rate of the development of the breach and the volume of floodwaters flowing through the breach (Mark et al, 2010).

The time required for evacuation will depend on a number of factors including the number of persons and dwellings at risk, the types of dwellings at risk, the number of available warning teams, whether the evacuees can self-evacuate, the vulnerability of the community and awareness of the risk (contributing to what is termed warning lag factors and warning acceptance factors), as well as the availability of evacuation routes and any bottlenecks, as well as a traffic safety factor (Molino et al, 2013; Simonovic and Ahmad, 2005). It is likely to be longer in urbanised areas, with few evacuation routes and many residents. This length of warning time is not always available, particularly in flash flood catchments and for detention basin failure. The time required also is influenced by what flooding is already occurring, as NSW SES may already be mobilised. These uncertainties and potential severe consequences of failure mean that evacuation decisions must be made early, when little information is available.

The most important consideration in determining whether to evacuate a community is the personal safety of people (Mark et al, 2010). Within the Local Flood Plans, detention basins are identified and described as a hazard and risk. The Local Flood

Plans are used alongside a suite of resources to engage with the community on their flood risk and identify the ways in which to mitigate the risk before, during and after a flood.

Alongside the risks, the social factors identified in the Australian Bureau of Statistics (ABS) census (such as those described by Smith et al (2009)) are also considered and documented to assist in devising effective strategies specific to each floodplain. NSW SES maintains detailed evacuation plans within their local flood plans for dams identified as highest risk by the NSW DSC. These detail the consequences of failure including the houses and infrastructure at risk, travel times, details of the flood behaviour including velocity and depth, monitoring systems if any, notification and warning procedures, and inundation areas for sunny day failure and flood failure as relevant. For all other prescribed dams in NSW, reference is made to the DSEPs and consequence summaries within Local Flood Plans. The NSW DSC Guidelines (DSC2G) (DSC, 2010b) provides important guidance to the detention basin/dam owners that assist NSW SES in planning for and responding to these emergencies.

A telemetered water level gauge within the basins often helps to inform council and subsequently the NSW SES of the imminent risk, however predicting heights for the basin gauges and providing sufficient warning time is not always feasible. Dam failure alerts (as identified in the DSEP) are issued to NSW SES State Operations Centre and are used to trigger appropriate response actions. There are three alert levels to guide emergency response, White, Amber and Red. White Alert is a “heads up” and there is no action required. Amber Alert means that persons at risk should be prepared for evacuation and Red Alert means that evacuation is required immediately. The heights of these alert levels should be based on the time required to complete these actions, and related to rates of rise in a probable maximum flood.

How will the NSW SES convince people to evacuate when they are unaware of the potential risk?

Flood detention basins can be compared with flood levees in that they provide similar flood mitigation benefits in smaller floods, but they also exhibit similar risks of community complacency and potential for failure. They are designed to withhold a particular design flood: neither is designed to remove all danger to all people (Smith, 1998).

Urban communities as a whole can be particularly disconnected from their waterways. Even individuals who notice that Council has constructed a flood detention basin in their area believe that any potential flooding problem has been solved. It may well be true that communities in rural areas have more of an understanding of their river systems; however they are still likely to believe that the levee protecting their town will continue to do so if it has never been breached previously (for example, Pfister, 2001). Added to the permanent resident complacency is the unaware transient community that may utilise the at risk urban area for work or in their commute to and from work.

The potential communication methods regarding evacuation are summarised in the State Flood Plan and Local Flood Plans. These include doorknocking, mobile public address announcements, Emergency Alert (a telephone based system for land lines and mobile phones based on location), and use of local radio stations (especially in other languages within the Fairfield LGA). However, this is not always effective in that people who have heard flood warnings in the past believed it did not apply to them as they did not believe they could flood, or their specific locality was not mentioned (Opper et al, 2007).

Following substantial flooding on the North Coast of NSW in 2005, a community survey was undertaken on behalf of the NSW SES. Very few respondents thought that flooding posed a threat to their personal safety, even when their properties were being flooded. This shows that asking the community to prepare for floods based on their personal safety may not be an effective strategy (Opper et al, 2007). Similar results have been observed in a number of locations across NSW, including Grafton (Pfister, 2001) and Eugowra (Gissing et al, 2007). The results from these investigations highlights the fact that it is a hard enough task to educate and evacuate a community when faced with a “normal” flood emergency, let alone in the situation of a dam break where the community perceives that the detention basin is a protection measure, not a potential additional risk (Smith, 1998). This paradigm is explored further in the National Strategy for Disaster Resilience (COAG, 2011) and currently in NSW SES pilot projects, through the involvement of the community in their emergency (Webber and Rae, 2015).

An example of where the community education is being targeted for dam failure is within the Orange LGA, where a floodsafe guide was developed by NSW SES in partnership with the Council. The guide identifies the slight risk of dam failure for the residents downstream of the Suma Park Dam. There are also examples of telephony systems linked by the dam owner to alarm residents downstream within dwellings at risk (for example Lyell Dam and Oberon Dam), which require additional community engagement and education. Despite the success of these strategies not yet assessed, they do provide examples of techniques that may be used to address awareness and understanding of what can be done to reduce risk to life, which may be pursued in the continuing partnership between NSW SES and Council.

Conclusion

As owners of prescribed flood detention basins, Councils are faced with a number of dilemmas about timing of required upgrade works, whether to and how to inform the community of the additional potential risk and whether development controls are appropriate. The NSW SES has access to the DSEP and associated dam break mapping as well as ABS statistics which help inform Local Flood Planning; however any community engagement programs will depend on the decisions made by Council. Evacuation during times of flood is a difficult, risky and resource intensive exercise. Evacuation of uninformed communities downstream of flood detention basins with short warning times will be an ever harder task.

It may be prudent to ensure that there is a consistent method across the state for dam owners, in collaboration with NSW SES to engage with the community about the risks associated with potential dam break, including detention basins.

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