PLANNING FOR CASES OF POTENTIAL DAM FAILURE:

AN AUDIT OF PROGRESS IN NEW SOUTH WALES

C Keys[1]

ABSTRACT

This paper describes the work which has been done in NSW to plan for the impact of potential dam-failure flooding. It details the arrangements which have been devised to guide the preparation of the plans and summarises progress to date by identifying what has been done on a case-by-case basis. Some comments are also made about necessary review work and the problems of ensuring that plans remain effective.

KEYWORDS: emergencies, flooding, warning, evacuation, population displacement.

INTRODUCTION

During the late 1980s, when it was becoming apparent that several storage dams in NSW were not capable of safely passing very large floods, the state's preparedness for the catastrophic flooding which would result from dam failure was minimal. Dam owners were unsure of how to develop the warning systems and evacuation procedures that would be vital in helping keep downstream communities safe, while emergency managers at the time tended to focus on at-the-moment responses to disasters like floods and had not come systematically to grips with the application of preparedness measures to aid those responses.

Since those days, much has changed for the better. The State Emergency Service, since 1989 the state's legislated `combat agency' for floods, has taken on the task of planning for floods of all possible magnitudes - including those potentially caused or exacerbated by dam failure. In partnership with dam owners through the Emergency Management Sub-Committee of the NSW Dams Safety Committee, the SES has agreed to incorporate in its flood plans (which cover all flood liable areas in the state) the possibility of dam failure where deficiencies in particular dams have been identified. Several of these flood plans, which are written for local council areas and for SES Divisions, now incorporate arrangements which relate to potential dam failure. These plans describe the operation of the warning systems and arrangements which have been devised and the procedures which have been developed to guide evacuation. Dam Safety Emergency Plans, meanwhile, have been prepared by dam owners to guide the management of their dams. Amongst other things, these latter plans include arrangements for notifying downstream emergency managers of spills and releases which might contribute to flooding, and for the passage of information on any potential or actual dam-failure situation which might develop.

Both kinds of planning are now well advanced. This paper outlines the arrangements agreed by the Emergency

[1] C Keys MA PhD, State Planning Co-ordinator, NSW State Emergency Service.

Management Sub-Committee as they relate to the preparation of downstream flood plans, describes what has been done in this planning project to date, and makes some observations about the planning process itself.

THE ARRANGEMENTS

During the early 1990s, as the SES began to come to grips with the need to plan for potential dam failure, the organisation saw the need to integrate the emergency management activities of the Dams Safety Committee with the emergency management structure introduced by recent state legislation[2]. In 1992 the SES proposed to the Dams Safety Committee, a body on which no formal emergency management expertise or agency was represented, a sub-committee to advise it on matters pertaining to emergency management.

In NSW, the key players in dam safety field are the owners of dams, the Dams Safety Committee (the standard-setting and monitoring agency) and the SES (the combat agency for floods and the relevant emergency management body). All three have places on the Emergency Management Sub-Committee. The Chairman represents the Department of Land and Water Conservation, which owns most of the state's major water supply dams, and the Dams Safety Committee. NSW Public Works owns other dams and at the same time has a legislated regulatory role in relation to the large number of local government organisations which operate dams.

The sub-committee, which first met early in 1993, acts as a conduit for the passage of information between the three groups and as a forum for the discussion of procedural arrangements to guide the planning process. More formally, its function is to ensure that the state approaches emergency management related to dams in a fully integrated and comprehensive manner. To achieve this, the sub-committee performs the following tasks. It:

1. advises the Dams Safety Committee and dam owners on emergency management matters,

2. advises emergency management agencies in relation to dam safety matters, and

3. develops the detailed procedural arrangements (including statements of responsibility) required to ensure that:

   (a) the SES is able to prepare for and respond to floods caused or made worse by dam failure.

   (b) the impacts of dam emergency procedures are recognised in flood plans for downstream communities, and

   (c) appropriate emergency operations controllers are able to assist dam emergency operations by co-ordinating support for them.

An early consideration of the committee related to the question of which areas below dams required detailed planning for potential dam-failure flooding. The agreed

answer here was that planning should be carried out for areas below dams with a recognised deficiency which could lead to failure.

Since 1993 the following arrangements have been agreed. They guide the development of flood plans and will be incorporated in Part Three (Preparation and Planning) of the NSW State Flood Plan when it is reviewed later in the 1996-97 financial year.

1. The owners of prescribed dams advise the Dams Safety Committee in writing whenever they have reason to be concerned for the security of a dam or as identified by five-yearly Surveillance Reports on dams.

2. Where required, by the Dams Safety Committee, the owners of prescribed dams provide copies of dambreak flood analysis and Safety Review reports to the Dams Safety Committee. In the case of council-owned dams such reports would also be submitted to NSW Public Works for review.

3. The Dams Safety Committee maintains an up-to-date list of `deficient dams' and their hazard ratings. The list categorises dams as:

   (a)deficient (and lists the cause or causes of deficiency ie deficiency relating to lack of flood-passing ability, potential failure due to earthquake, or other structural problems).

   (b)under review (which indicates that a potential deficiency is under investigation).

4. The deficient dams list is updated/amended in writing each time the Dams Safety Committee changes the status of a dam. The list and revisions are provided to:

   (a)`owners' of deficient dams in regard to their own dam.

   (b)the Director General, State Emergency Service.

   (c)NSW Public Works and Services (council dams only).

   (d)the minister responsible for the Dams Safety Act.

5. On receipt of advice from the Dams Safety Committee that a high or significant hazard dam has been classified as `deficient' and the reasons for that deficiency, the SES requests the dam owner to provide any additional information as follows:

   (a)If the dam has an earthquake or other structural deficiency:

[2] The State Emergency Service Act 1989 and the State Rescue and Emergency Management Act 1989

•the period over which dam failure might occur,

•the nature of the resulting dam failure flood wave (eg inundation map, impacts etc),

•travel times for the flood wave to reach critical downstream locations (indicating both the front of the wave and its crest where possible) and flood velocities.

(b)If the dam has inadequate flood capability:

•the IFF/PMF ratio as a relative indicator of risk,

•a description of the hydro-meteorological conditions which might lead to the development of an IFF or greater flood,

•a description of the IFF conditions downstream of the dam (eg inundation map),

•travel times for the flood wave to reach critical downstream locations (indicating both the front of the wave and the crest where possible).

6. The State Emergency Service then:

(a)determines the type of flood plan required.

(b)leads in the development of that plan or revision of an existing flood plan.

(c)advises the dam owner on warning requirements.

(d)advises the dam owner on what assistance is available in the management of dam safety emergencies and acts as the link between the dam owner and appropriate Emergency Management Committees at District and/or Local level.

(e)provides the Dams Safety Committee and the dam owner (or the NSW Public Works for Council dams) with copies of appropriate plans at each of the key stages of development (ie `draft', `interim' and `final').

7. The Director General, SES provides a written report on the status of flood planning in relation to `deficient dams' by 1 June each year for reference in the Dams Safety Committee Annual Report.

8. When a dam is removed from the list of `deficient dams' the State Emergency Service will review the appropriate flood plans(s). This will be done with a view to:

(a)deleting aspects of the plans(s) related specifically to dam failure, and

(b)determining with the dam owners/operators whether or not all or part of the dam

failure warning systems may be decommissioned.

9. The owner of a prescribed high (or significant) hazard dam which has not been declared deficient should provide a copy of any Dam Safety Emergency Plan to the SES State Headquarters for appropriate distribution.

THE FLOOD PLANS

Since 1990, some 130 flood plans have been prepared in NSW for council areas (or combinations of council areas) with known flood threats. It can now be said that some planning has been done for all parts of the state with a flood problem. In addition, there are seventeen flood plans which have been written for SES Divisions. Several of these plans incorporate references to potential dam-failure situations.

The references vary considerably in scope, from simple mentions that a dam has been defined as deficient to fully detailed arrangements governing notification, warning system operation and evacuation procedures. The scope of the references depends on the progress of the work to determine the nature of the deficiency and the nature of the downstream impact of failure (area inundated, speed of onset, etc) as well as on progress in the negotiation of the arrangements and procedures and in the installation of any physical warning systems such as telemetred gauges, radio sets and pagers. Progress in getting the plans completed has, necessarily, been slow: the various study processes which must be undertaken by dam owners are time-consuming as is the planning which cannot be carried out in detail until the studies are completed. Many organisations are involved in the preparation of the flood plans apart from the dam owner and the SES, and an extensive process of consultation and briefing is required before the plans can be ratified and become public documents. To some extent, of course, this slowness is no bad thing: thorough planning is a consultative process which cannot be done in haste.

The following list describes the current position in NSW in regard to planning for local council areas downstream of deficient dams. It is up to date as of early September, 1996, and identifies what has been done in terms of notification, warning and evacuation procedures on a dam-by-dam basis.

- **Chaffey**: Arrangements have been recorded in the Nundle and Tamworth/Parry Local Flood Plans.

- **Chichester**: Arrangements have been recorded in the Dungog, Maitland and Port Stephens Local Flood Plans. Some clarification of the number and location of the dwellings which could be affected is still needed for the Dungog Council area.

- **Chifley**: Arrangements have been recorded in the Bathurst-Evans Local Flood Plan.

- **Clarrie Hall**: Detailed suggestions have been put forward for arrangements to be incorporated in the Tweed Local Flood Plan.

- **Cochrane**: Arrangements have been recorded in the Bega Valley Local Flood Plan.

- **Coepolly Creek No. 2**: Arrangements have been recorded

in the Quirindi Local Flood Plan.

- **Company**: Reference to possible failure has been included in the Weddin Local Flood Plan. Further work awaits council advice on the future of the dam.

- **Emigrant Creek**: Arrangements have been recorded in the Ballina Local Flood Plan.

- **Glennies Creek**: Arrangements have been recorded in the Singleton, Cessnock, Maitland, Port Stephens and Newcastle Local Flood Plans.

- **Grahamstown**: Arrangements have been recorded in the Port Stephens, Maitland and Newcastle Local Flood Plans.

- **Hume**: Arrangements have been recorded in the Albury-Hume and Corowa Local Flood Plans.

- **Malpas**: Detailed suggestions have been put forward for arrangements to be incorporated in the Armidale/Dumaresq Local Flood Plan.

- **Prospect**: No specific mention has been made in the Fairfield Local Flood Plan, but arrangements for hazards in general are incorporated in the Fairfield Local Disaster Plan.

- **Redbank**: Negotiations are in train about suggestions for arrangements to be incorporated in the Mudgee Local Flood Plan.

- **Rylstone**: Arrangements have been recorded in the Rylstone Local Flood Plan.

- **Sooley**: Arrangements have been recorded in the Mulwaree/Goulburn Local Flood Plan.

- **Spring Creek**: Detailed suggestions have been put forward for arrangements to be incorporated in the Orange Local Flood Plan.

- **Suma Park**: Detailed suggestions have been put forward for arrangements to be incorporated in the Orange Local Flood Plan.

- **Warragamba**: Arrangements have been recorded in a series of plans (the Hawkesbury Nepean Flood Emergency Plan, the Sydney Western SES Division Flood Plan, the Sydney West Zone Hawkesbury Nepean Flood Emergency Plan, the Sydney North West Zone Hawkesbury Nepean Flood Emergency Plan and the Penrith, Blue Mountains, Blacktown, Hawkesbury and Baulkham Hills Local Flood Plans. All of these plans are scheduled to be reviewed in the 1996-97 financial year.

- **Wellington**: Negotiations are in train about suggestions for arrangements to be incorporated in the Wellington Local Flood Plan.

- **Winburndale**: Arrangements have been recorded in the Bathurst/Evans Local Flood Plan.

No flood planning work has yet been done in relation to dams for which no dam break study reports have been received. These are the Bonalbo, Brogo, Burrendong, Copeton, Keepit, Lake Endeavour, Split Rock, Tenterfield Creek and Wyangala dams. Some plans which previously

included reference to and arrangements for potential dam failure flooding no longer cover these issues because rectification work has meant that the dams are no longer classed as deficient. The Lyell and Rydal dams, in the Lithgow Council area, are cases in point.

During the planning process some guiding generalisations have evolved. For residents located near to dams, personalised warning systems involving pagers or radios have been installed in some instances, whereas people located at considerable distances from the dams and with concomitantly long warning times will be warned and advised to evacuate by more conventional means - that is, by doorknock and by messages broadcast over local radio stations. This reflects the fact that areas well downstream tend to have problems more akin to those of `normal' - albeit very severe - flooding than areas close to the dams themselves.

A convention has arisen that most of the plans define three alerting levels, labelled for convenience `White', `Orange' and `Red' and each with its own defined notification and warning (or evacuation) actions. Generally, the White level involves no more than the notification of response organisations and some monitoring activity, while Orange connotes initial warning of the population at risk (usually by several warning modes including doorknocks) and Red connotes the advice to evacuate immediately. In the case of some of the smaller dams, the intermediate level is omitted because of the very short period of time which could elapse between the point at which concerns for the dam's security are first felt and the point at which failure becomes possible. In these instances, attempts have been made to ensure that the White and Red levels are more conservatively defined than might be the case elsewhere.

For areas close to deficient dams, where the households at risk can be identified clearly, these households are being incorporated in the planning process. This is being done by means of public briefings and by the provision of a summary of relevant arrangements which is provided to each household for prominent display. An example of such a summary is provided in the Appendix to this paper along with the notification, warning and evacuation arrangements which apply in this case (Chifley Dam). This appendix, then, gives an example of the output of the planning process as it applies to the problem of potential dam failure.

In several cases, the planning has outstripped the provision of the necessary hardware to support the warning arrangements. Some of the cases in the list above refer to plans which have been prepared and agreed in the relevant Local Emergency Management Committees but where the telemetred notification and warning systems have not yet been installed. The Chifley, Winburndale and Rylstone cases are examples.

SOME COMMENTS

While the planning project is now well advanced and considerable progress has been made since 1990, there is a long way still to go before adequate notification, warning and evacuation arrangements can be said to have been established below all deficient dams. Much of the basic planning work has still to be done, and some of the plans which were written in the early 1990s are due for review. More work is required, too, to ensure that emergency managers are kept aware of the dam-failure issue in their areas and that the plans are regularly exercised and tested. Plans can die very

quickly if this is not done: an example is provided by a plan written in 1987 specifically to guide the response to a potential failure of Chichester Dam, located upstream of Dungog. When the author sought to integrate the content of this document with the preparation of the first draft of the Dungog Local Flood Plan in 1995, it was discovered that the Chichester Dam Plan was unknown to the SES, police and council staff. Accordingly, it would not have been useful had a severe flood event developed and threatened the security of the dam.

This example attests to an easily-overlooked aspect of planning. Plans, like dams, can fail if not carefully managed and if steps are not taken to rectify deficiencies. It is inevitable that if plans are not adequately maintained, reviewed and practised they will die and will be unable to play their intended part in the protection of the communities on whose behalf they are written. Even when they **are** well devised and carefully maintained, of course, they will need to be backed by sound operational procedures and training if they are to be effective.

It is important to record the significance of the integration of the dam owners, the regulators and the emergency managers. No matter how efficient each of the stakeholders may have been in the past, there was no way that the planning for dam failure could have been effective, and they must continue to interact and work together if the community is to receive the protection against dam failure that it warrants.

APPENDIX I

ANNEX F TO THE BATHURST/EVANS LOCAL FLOOD PLAN: DETAILS OF WARNING SYSTEMS AND ARRANGEMENTS FOR POTENTIAL DAM-FAILURE FLOODING

GENERAL

Special arrangements have been devised to protect residents at risk from potential dam-failure flooding and to facilitate their evacuation should failure of either Ben Chifley Dam or Winburndale Dam become possible. A total of 11 dwellings in the Evans council area at The Lagoon could be flooded by a failure of Ben Chifley Dam and seven by a failure of Winburndale Dam. In the Bathurst Council area, the impact of a failure of Ben Chifley Dam would be to raise the already existing flood level by 0.6 metres: assessments of which dwellings could be affected in Bathurst and would need to be warned would be made using Bureau of Meteorology Flood Warnings as guides.

These arrangements are summarised in the table at the end of this annex and consist of:

1. Notification procedures to ensure that appropriate agencies are made aware of any threat and can mobilise necessary resources. These include:

    a. The monitoring devices of the Bathurst ALERT (Automated Local Evaluation in Real Time) and SCADA (Supervision Control and Data Acquisition) systems, which provide information on rainfall and streamflow conditions and the depth of water in the spillways of the dams.

    b. Automatic alarms which are transmitted to Bathurst City Council and Central West SES Division Headquarters personnel when these monitoring devices reach particular, pre-set levels.

    c. Procedures for notifying other agencies of concerns about the security of the dams.

    d. Procedures to initiate monitoring of the dams and surveillance of downstream areas.

2. Procedures for warning at-risk residents and advising them as to appropriate actions. These actions could be to prepare to evacuate or to actually do so. Warning of residents in the Lagoon area would be by pager in the first instance, followed up by phone calls and doorknocks as necessary. Warning of residents in the valley of Winburndale Rivulet would be by pager and telephone.

3. Arrangements to guide evacuations. Should evacuation become necessary, the following would apply:

    a. For residents of the Evans council area downstream of Ben Chifley Dam, an evacuation centre would be established at The Lagoon Public School. In addition, it is expected that evacuees would be able to gain access to evacuation centres located in the Perthville Public School or at the Bathurst City

Hall Civic Centre, William St, Bathurst.

b. For residents in the Bathurst City Council area, the evacuation centre would be located in the Bathurst City Hall Civic Centre, William St, Bathurst.

c. For residents downstream of Winburndale Dam, lack of time and the probable difficulty of travel outside the valley of Winburndale Rivulet make it most unlikely that access to evacuation centres would be feasible. For these residents, the advice given would probably be to move to a more elevated location nearby and await further information or rescue.

PRIOR ADVICE TO RESIDENTS

Residents of the at-risk dwellings in the Evans council area downstream of Ben Chifley Dam and Winburndale Dam have been issued with laminated `advice sheets' intended to be placed in a prominent place in the house and summarising:

1. The circumstances under which dam failure could occur.

2. Arrangements governing the issuing of warnings.

3. What to do when advised to prepare to evacuate or to actually do so.

The written summaries, headed `Notice to Occupants of this Dwelling', are appended to this annex.

To ensure the on-going preparedness of the residents, the pagers used to warn them during a potential dam-failure flood will be set off periodically with reminder messages.

THE PROCEDURES IN DETAIL

Summaries of procedures for notifying agencies and for warning and evacuating people at risk in areas downstream of Ben Chifley and Winburndale Dam are provided in the following tables. Note that:

1. Actions indicated as occurring at particular Alert Levels may be brought forward if the development of a flood event warrants.

2. The `Approximate Elapsed Times' are estimates of the worst possible case based upon PMF hydrographs. In real events which threaten to cause either dam to fail, it is likely that **much** more time would elapse between defined levels than is indicated in the tables. This is particularly so in the case of Winburndale Dam. Assessments of the speed of onset of developing events would be made at the time and advice given to residents would reflect these assessments.

NOTIFICATION, WARNING AND EVACUATION ARRANGEMENTS FOR A POTENTIAL FAILURE OF BEN CHIFLEY DAM

ALERT LEVEL	DEFINING CONDITIONS	APPROX ELAPSED TIMES IN WORST CASE	FLOOD EFFECTS	NOTIFICATION ARRANGEMENTS AND ACTIONS				
				BATHURST CITY COUNCIL	CENTRAL WEST SES DIVISION HEADQUARTERS	BATHURST SES LOCAL HEADQUARTERS	EVANS SES LOCAL HEADQUARTERS	PEOPLE AT THREAT
WHITE (emergency services notification level)	• Rainfall of 25mm or more in an hour at any rain gauge in catchment. • Depth of water over spillway= 0.5 metres. • Water level at dam rises 240mm or more per hour. • Stream gauge 1.5k above storage lake reaches 2.0	From WHITE alert stage to ORANGE alert stage: **1 hour**	Possible minor flooding in The Lagoon area: roads unaffected.	• Personnel informed automatically by pager of any Defining Condition being reached. • Continues monitoring at dam. • Advises Central West SES Division Headquarters.	• Personnel informed automatically by pager of any Defining Condition being reached. • Advises Bathurst and Evans SES Local Headquarters. • Co-ordinates physical surveillance of The Lagoon area.	• Activates Local Flood Plan. • Advises NSW Police Service (Bathurst), Local Emergency Operations Controller, Bathurst/Evans Fire Control Officer and Bathurst Disaster Welfare Service. • Ensures that doorknockers are placed on standby.	• Assists in ensuring that doorknockers are placed on standby.	• No action: Defining Conditions in themselves imply no short term danger.

ALERT LEVEL	DEFINING CONDITIONS	APPROX ELAPSED TIMES IN WORST CASE	FLOOD EFFECTS	NOTIFICATION ARRANGEMENTS AND ACTIONS				
				BATHURST CITY COUNCIL	CENTRAL WEST SES DIVISION HEADQUARTERS	BATHURST SES LOCAL HEADQUARTERS	EVANS SES LOCAL HEADQUARTERS	PEOPLE AT THREAT
	metres.							
ORANGE (all at-risk households warned)	Depth of water over spillway = 1.5 metres (flow 250 cubic metres per second)	From ORANGE alert stage to RED alert stage: **1 hour**	Possible access problems within The Lagoon area.	• Continues monitoring at dam and advises Central West SES Division Headquarters. • Issues pager message to people to prepare to evacuate.	• Confirms that pagers of people at threat have been notified of Orange Alert. • Broadcasts warnings over radio stations. • Co-ordinates warning by phone and doorknock.	• Ensures evacuation centres are made ready.	• Assists Bathurst SES Local Headquarters with doorknocks as necessary.	• Acknowledge pager message. • Prepare to evacuate.
RED (all at-risk households advised to evacuate)	Depth of water over spillway = 2.8 metres (flow 800 cubic metres per second)	From issue of RED alert stage to failure of dam wall: **3 hours**	Lagoon-O'Connell and Lagoon-Bathurst roads cut, some houses flooded at The Lagoon.	• Issues pager message to people advising evacuation.	• Broadcasts warnings over radio stations. • Continues physical surveillance. • Co-ordinates warning by phone and doorknock.	• Assists evacuees as necessary.	• Assists evacuees as necessary.	• Acknowledge pager message. • Evacuate to evacuation centre.

ALERT LEVEL	DEFINING CONDITIONS	APPROX ELAPSED TIMES IN WORST CASE	FLOOD EFFECTS	NOTIFICATION ARRANGEMENTS AND ACTIONS				
				BATHURST CITY COUNCIL	CENTRAL WEST SES DIVISION HEADQUARTERS	BATHURST SES LOCAL HEADQUARTERS	EVANS SES LOCAL HEADQUARTERS	PEOPLE AT THREAT
THEORETICAL FAILURE LEVEL	Depth of water over spillway = 5.0 metres.			• Continues monitoring at dam and advises Central West Division Headquarters.				
ALL CLEAR	Danger assessed as being over.	NA	NA	• Issues pager message to people after SES advice.	• Issues All Clear over radio stations. • Co-ordinates issue of All Clear at evacuation centres or by phone/ doorknock.	• Delivers All Clear as necessary.	• Delivers All Clear as necessary.	• Return home or await further advice.

NOTICE TO THE OCCUPANTS OF THIS PROPERTY (THE LAGOON)

The purpose of this notice is to remind you of what will happen and what you must do if Ben Chifley Dam is threatened with failure. The chance of failure is extremely small, but should it occur this property could be severely flooded with dangerously fast-flowing and deep flood waters. To ensure your safety it is vital that you read this card carefully, keep it in a visible indoors location and refer to it periodically.

Ben Chifley Dam is under regular surveillance and you will be warned by the owner (Bathurst City Council) or the State Emergency Service if a flood capable of causing dam failure or the operation of the emergency spillway becomes possible. Such a warning will be issued by a Bathurst City Council initiated paging system as part of a planned emergency response. In addition, warnings will be broadcast over radio station 2BS and the SES will organise phone calls and doorknocks if necessary.

Warnings will be provided well before actual dam failure becomes possible, and there will be time for you to prepare to evacuate.

If you are advised to evacuate, you should:

- Gather together your medicines, personal valuables and papers, money, photograph albums, family mementoes and other belongings which you can fit into your vehicle.
- Turn off the power, gas and water.
- Make your way to the nearest accessible evacuation centre. These will be established at:
    - The Apsley Downs Shearing Shed.
    - The Lagoon Public School.
    - The Bathurst City Hall Civic Centre, William Street, Bathurst.
- If you need help to evacuate, you should call the Central West State Emergency Service Division Headquarters on 323 656.

Transport and temporary accommodation will be provided for you if you need it, and the Police will provide security for your property while you are away.

When the danger has passed, you will be advised either at home or at an evacuation centre. As soon as possible, you will be visited by an employee of the Bathurst City Council or a member of the State Emergency Service to ensure that you are safe and to explain what has happened and what is likely in the future.

If you have any queries about the dam or about the arrangements, please phone the Bathurst City Council's Engineering Department on 336 225 or the State Emergency Service on 323 656.

ANCOLD Bulletin, 106, 71-82, 1997.

CURRICULUM VITAE

Chas Keys was educated in New Zealand and Canada before taking up an academic post at the University of Wollongong where he specialised in urban and regional development and population studies and developed interests in environmental management. Since 1990 he has been employed by the NSW State Emergency Service where his main tasks are in the fields of flood planning, warning system development, operational management during floods and storms, and community education about disaster. He is the SES's representative on the Emergency Management Sub-Committee of the NSW Dams Safety Committee and presented papers on SES work in relation to planning for potential dam failure at the ANCOLD conferences in 1991, 1992 and 1993.