THE COMBINED EMERGENCY SERVICES
FOUNDATION

DAM SAFETY

REPORT ON STUDY TRIP TO
NEW SOUTH WALES AND USA

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Introduction

I am honoured to have received a scholarship to conduct a study into the development and implementation of Dam Emergency Management Plans in the USA with a particular focus on community awareness, preparedness and warnings systems. The extensive work undertaken in NSW by the SES and State Dam Safety committee was also studied before travelling overseas. My visit to NSW was undertaken in June 1998 and the trip to USA during the month of October 1998.

As with many previous recipients of the Combined Emergency Services scholarship, I was amazed by the generous reception I received from other emergency management personnel. The materials and information that was offered was overwhelming (excess baggage of 50kgs) and has not stopped since returning to Australia. Much of my trip was organised via e-mail over the Internet and this continues to be the avenue for contact with other emergency management personnel over current issues such as Y2K.

Dam owners/operators are a very close community, which does not usually disclose risk information to the community and emergency management agencies. It was pleasing to note that my visit to some organisations has meant that local networks have now been established. Some of the dam emergency management plans that I was given had not been distributed amongst local emergency management agencies until after my visit.

Most of Australia's dams were built on scientific knowledge from the Northern Hemisphere and it was not understood how our rivers are different. Many Australian dams were designed to cope with a "100 year storm", but recent analysis of weather patterns has shown that the "100 year storm" was underestimated. Australian dams are now having their spillways enlarged or extensions made to their wall height. The Warragamba Dam, near Sydney, would require an extension of twenty metres in dam wall height to cope with a "100 year storm". Since my visit to Warragamba dam it has been announced that a new emergency spillway would be built.

The failure of dams is not new to the 20th century. One of the earliest recorded dam failures occurred in Egypt at Sadad el-Kafara Dam around 2600BC. In contrast, the Homs Dam in Egypt was built over 3000 years ago and is still being used today.

Research has shown that approximately 40% of all dams fail by overtopping as a result of inadequate spillway capacity (e.g. Johnstown Dam –1889, Canyon Lake Dam – 1972, Frias Dam – 1970, Macchu II Dam – 1979). Another 30% of dam failures are caused by foundation problems (e.g. Baldwin Hills Da, - 1963, Malpaset Dam – 1959, St. Frances Dam – 1928) and 20% by the seepage of water through the embankment or foundation (e.g. Fontenelle Da, - 1928, Teton Dam – 1976). The remainder of dam failures are caused by a variety of factors including seismic (e.g. Van Norman Dam – 1971), human factors (e.g. Mohne & Elder Dam – 1943) and abutment sliding (e.g. Vaiont Dam – 1963).

The current knowledge on rainfall, stream flow patterns and extreme storms is used to determine probable maximum precipitation (PMP). Because this knowledge is recent, it could mean that dams designed ten years ago maybe deficient to handle the probable maximum flood (PMF) of today. Storm events in Australia over the last ten years have approached 80% of the latest revised PMP/PMF estimates, so the concept of PMP appears to be a credible upper limit event for flood design of a high hazard dam (i.e. dams whose failure would cause loss of life).

There are many engineering solutions to reduce the likelihood of a dam failure due to overtopping, embankment failure or foundation leakage. To assist emergency planners in gaining an understanding of some engineering solutions they may encounter, some of these are also listed in this report. If funding is available, these engineering methods can reduce the likelihood of a dam failing during extreme events.

Some of the issues covered in this report include:

My study into dam safety issues involved visits to the New South Wales State Emergency Service, New South Wales State Dam Safety Committee Executive, California Governor's Office of Emergency Services, Santa Barbara County Office of Emergency Services, Bureau of Reclamation, Rexburg – Madison County Fire Department, Rexburg Chamber of Commerce, Idaho Bureau of Disaster Services, Ada City - County Emergency Management, Idaho Power, Idaho Department of Water Resources, Oregon Emergency Management, Oregon Department of Water Resources and a conference of the Association of State Dam Safety Officials in Las Vegas.

Dams that I visited during this study include Warragamba NSW, Fish River NSW, Bradbury CALIFORNIA, Hoover NEVADA-ARIZONA, Glen Canyon ARIZONA, Island Park IDAHO, Jackson Lake WYOMING, Teton IDAHO, Arrowrock IDAHO, Lucky Peak IDAHO, Dallas OREGON and Bonneville OREGON.

Warning Systems

All high hazard dams have some sort of system to monitor their stability. This could range from weekly visual inspections through to electronic systems that monitor wall movement, earth tremors, water levels, inflow rates and seepage rates. The range of monitoring systems available to dam owner/operators is now very comprehensive. These can be a simple manual system or complex computerised network that can be remotely monitored.

Examples where monitoring systems maybe incorporated within the dam area are;

- water flow in the catchment, over the spillway and seepage in the wall
- strain gauges on the anchors, wire cabling, and concrete sections
- inclinometers for earth movement and settlement in foundations and embankments
- piezometers for sub-surface water flow or seepage
- extensometers for settlement, deformation in soil and rock
- settlement/load/pressure cell instruments for measuring forces on the dam

Warning systems can be activated by either the particular electronic monitoring system automatically or manually after predictions or personal observation. It is important to remember that the alarm is only part of a warning system. What the community does when warned and how well they accept the system is just as important as the rest of the system.

In the immediate inundation area of the Ben Chifley dam in NSW, some local residents had opted at a public meeting to carry pagers so that they could be warned of possible dam failure. The level of the dam, rainfall in the catchment, spillway and stream flows is monitored electronically to determine whether the dam may fail due to overtopping. The pagers are then activated with a message that indicates the level of threat. "Orange" is the code for people to start preparing to evacuate. Code "Red" means those residents should evacuate and seek higher ground immediately.

The paging system is tested regularly, but this is causing some problems. Not all residents are used to a paging service and having to carry them everywhere. Many have let their pager batteries go flat and some residents have even recently returned their pagers. The dam owner will now have to warn these people in another manner such as general radio messages or have people go from door to door to warn the residents.

In America, a warning system such as the automatic 'AM' radio by Federal Sirens can be activated by the dam monitoring system and is installed on some high-risk dams. This system can utilise receivers such as the 'Voice Alert' which are available to warn schools, industries, hospitals, volunteers, nursing homes, radio stations, shopping malls and television stations of the ongoing situation. The receivers are like a pager that only activates to receive messages when it receives the correct frequency tones. The 'Voice Alert' is the size of a desk telephone and requires normal power supply.

Other areas use the education of brochures and public meetings to set up their warning system and also inform the community. The residents of the Cities of Lompoc, Solvang, and Buellton have been issued a brochure to warn them of the possibility of a dam collapse after an earthquake in the area. In this case, any earthquake in the area could trigger the dam collapse. In fact the warning system is actually the earthquake.

See attachment at end of report.

The brochure details the inundation area, actions the residents can undertake before and after the earthquake and where they can obtain more information. The residents in this particular area were called upon to attend a public meeting where county dam safety officials, federal department personnel and dam owners outlined the measures being undertaken to fix the dam and the procedures that will be used if there is a problem. The public meetings were well attended and held over many nights in the three Cities to ensure that as many residents as possible could attend. Having an identified risk in the area certainly brought out the people to attend the meetings and they monitored the progress of the dam modifications in the local press.

Unfortunately my tight itinerary did not allow me to visit a community with a siren based warning system connected to a dam. The system that is used in the state capital of Idaho, BOISE, which has a number of siren based warning systems that are designed for flash flooding rather that dam problems. It is similar to dam systems except for the originator of the activation information. These sirens could also be used to warn some of the Boise residents of a dam collapse. Like many cities, Boise has been built around a river but in this case there are three major dams upstream. The failure of one of the upstream dams would inundate much of the city. The supervisor in the Ada City/County Police/Sheriff computerised aided dispatch centre activates the sirens after notification from the weather department of significant rainfall in the area.

Siren system is activated by the buttons on top of the monitor.

The sirens are tested on the first Saturday of every month and give a continuous tone that will last about 30 seconds. The tests are publicised so residents know that it is a test. During an actual emergency the tone is sounded for 3 minutes. The siren system could be used during a dam collapse but there are thousands of people that are not in the siren area that would need to be evacuated.

Sirens are still the most effective method to warn the population at large in the shortest amount of time. People who may be outdoors at ball games, in their yard, or anywhere else where they are not in contact with the normal news media channels such as radio, TV or local public address systems.

Even with the global conflict reduced, there are still many areas that sirens still are effectively used to warn people of possible threats to their safety.

- Tornado's
- Severe Thunderstorms
- Hazardous Material Spills
    - Rail Road
    - Highway
    - In-plant
    - Waterway
- Fire Call's
- Chemical Plants
- Refineries
- Hurricanes

Sirens can be activated be local switches, or can be equipped to operate remotely. Remote control can be accomplished by telephone line control, or by two-way radio.

In a telephone line control, a common telephone line is attached to each siren, with the control end going to a police station, fire department, government centre or wherever else they are to be activated from. To activate the sirens, a charge is passed over the telephone lines to all of the sirens. The voltage energises a relay at each siren site. The sirens sound as long as the voltage is present.

Phone line systems have the disadvantage in that a common line problem can disable the entire system. Also a short on the telephone line can prevent any voltage from reaching the intended sites, and thus shut down the entire system. Due to this and the changes in most telephone companies internal and external equipment, as well as rising monthly connect charges, the telephone line control is being phased out.

Radio Control is the most popular method of activating sirens. To activate the siren system, the operator presses a button and a radio signal is transmitted. The signal can be either DTMF or a Two-tone paging signal.

The receivers at the sirens pick up the signals. They decode the paging signals to determine what they are to do. A particular signal may instruct the sirens to give a weather warning call, another signal may have the sirens give a Fire Department call, while still another may cause the sirens to stop their sounding. With the new generation of communication signal processors, the variations are limitless.

Activation by radio control has many advantages...

- There can be multiple activation sites. The Police Dept., Fire Dept. and City Hall can all have encoders to activate the system. Each acting as a backup to the others.
- Mobile and hand-held encoders for flexible primary or backup activation.
- Fully isolated and distributed system. A short at one site cannot disable all of the other sites.
- Night or weekend activation can be performed by a 24 hour centre located in another city. Such as a Sheriff's office for the county.
- No monthly phone line charges.
- Sirens can be activated on an individual basis as well as all at the same time. This is especially valuable for warning smaller areas for events such as a hazardous material spill, rail-road accident, etc.
- Telephone "dial-up" encoders are available that allow you to activate the system from any touch-tone telephone.

Typical sirens

Sirens are rated in decibels, dB for short. To determine how loud a siren is, tests are made with a dB meter while the siren is running. The standard test setup is for the meter to be located 100 feet away from the siren, and "on-axis". On-axis means that if the siren is mounted on top of a pole, than the meter needs to be the same height up in the air also. Sirens range from a small 102 dB output, to some that go in excess of 130 dB. In the realm of sound output, every 3 dB that you go up, the sound output increases by double. So if you had a 110 dB siren and a 113 dB siren, the 113 dB unit would have double the sound output. As a rule of thumb, a 128 dB siren has a coverage area of about 1500 metres in all directions. A 115 dB siren covers about 1000 metres from its location.

The greatest problem with siren systems is the education that is required by the community to understand what the different sirens mean in their area. If the sirens have been installed for multiple purposes, then the siren can only be used as an alert to warn the community to seek further information. In areas where the majority of people are tourists, there is an understandable reluctance to use sirens that may scare the tourists. Even the education program about the sirens may turn the tourist away.

The preferred method is to use the siren to alert the community to seek more information. For this to be achievable, the information systems must be able to handle multiple enquires across all forms of communication. These would include radio, special phone numbers, television , faxstream, public addresses in malls & schools, CB radio, etc.

Community Consultation

The aim of any community consultation is to ensure the community is aware of the existing hazard, any risks that are involved, the benefit of the dam and the risk treatment methods that have been determined.

There is usually a range of techniques employed to consult and receive feedback from a community.

- Information released in the form of media releases, newsletters, brochures, displays and advertisements.
- The gathering of information from written submissions, research and studies.
- Interaction activities such as public meetings, advisory committees, seminars and individual meetings with lobby groups or affected government agencies.

Samples of different forms of information releases are attached at the end of this report.

Community consultation can be undertaken during many forums, but one of the most popular is the public meeting. Public meetings specifically held to discuss risks concerning dams need to have a wide range of expertise in attendance for them to be successful. It is important that if a member of the community asks a question, then an answer is available straight away and it must be an honest answer to maintain credibility.

As mentioned before the Cities of Lompoc, Solvang, and Buellton in the County of Santa Barbara have distributed a brochure to all residents in the inundation area of the Bradbury Dam. Before this brochure was sent out, residents were invited along to a public meeting in the various cities where the risk of the dam failure was explained. The fact that there was funding to reduce the risk certainly helped during this process. The Bradbury Dam has been modified with a birm to stop the wall from sliding down stream and reinforcement of the spillway gates to withstand a significant earthquake.

The Bradbury Dam is located in California where the law (Government Code 8589.4 & 8589.5) states that effected residents must be informed if their property is in the inundation area of a dam collapse or potential flooding from a waterway.

When a property is being sold, the potential buyer must be shown the inundation map for the property. This law has meant that all dam owners have had to supply inundation maps for when the reservoir is at full, medium or low capacity level and emergency action plans for each dam.

Community consultation must make people aware of the existing hazard and the risks associated with the hazard. Risks are always going to be part of living near a dam. Social acceptance of the risk is what should be achieved. Newsletters and brochures have been used on many occasions to keep the community informed. These brochures include avenues for further communication and consultation. Whatever the method of community consultation, they all take considerable time and money to implement.

Many people would know of the Teton Dam collapse in 1976, which killed 11 people and flooded the town of Rexburg.

It is interesting to note that the people of Rexburg are now talking of rebuilding the Teton Dam. In my discussions with the Rexburg Chamber of Commerce it was confirmed that this was currently being considered. The main agriculture in the City of Rexburg and County of Madison is the potatoe, which is a crop that requires a lot of water.

Teton Dam today

Risk Treatment Methods

There are many engineering solutions that may help prevent dam collapse. These include overtopping protection via the use of a concrete overlay, grouting the dam wall or foundations, improved spillway design such as labyrinth, emergency spillways such as fusegates or fuseplugs, supporting birms, cutoff walls to stop leakage, and cable tying to strengthen structures. Emergency managers need to be aware of these methods as many create other associated risks while they are saving the dam.

Overtopping protection for earthen dams often means a layer of material on the dam wall to prevent the wall from erosion when water spills over the entire wall. This protection could be in the form of Roller Compressed Concrete (RCC) layed over the entire or part of the wall.

Emergency spillway made of RCC on the dam wall to prevent overtopping

Risk of this treatment option is that while the dam maybe saved, but downstream will be subject to an extreme flood and it could involve a wave of water.

Other overtopping protection for concrete dams can be achieved by strengthening the top of the dam wall to resist the forces applied by the water as it passes over the dam.

Risk from overtopping of concrete dams includes an increase to the extreme flood and a possible wave of water. People will be drawn to the site to watch the spectacular sight.

Many dams suffer from water leakage problems. This could be due to porous foundation rocks or concrete that has broken down over the years. Chemical grout is injected into the cavities of the rock or concrete to stop the flow of water.

Grout being used to repair an old concrete dam

Spillways design is very important so that the PMF will pass through the dam and not over the top of the dam. On dams that have limited spillway capacity, a labyrinth design will increase the capacity of the spillway without increasing the spillway width.

Other innovations in spillway design include the use of pneumatic assisted gates to raise or lower the spillway height. These gates allow a structure such as a weir or spillway to increase it's holding capacity to prevent excessive flooding downstream.

Single gate showing the bag that lifts the plate.

Spillway height increased by a wall of bags.

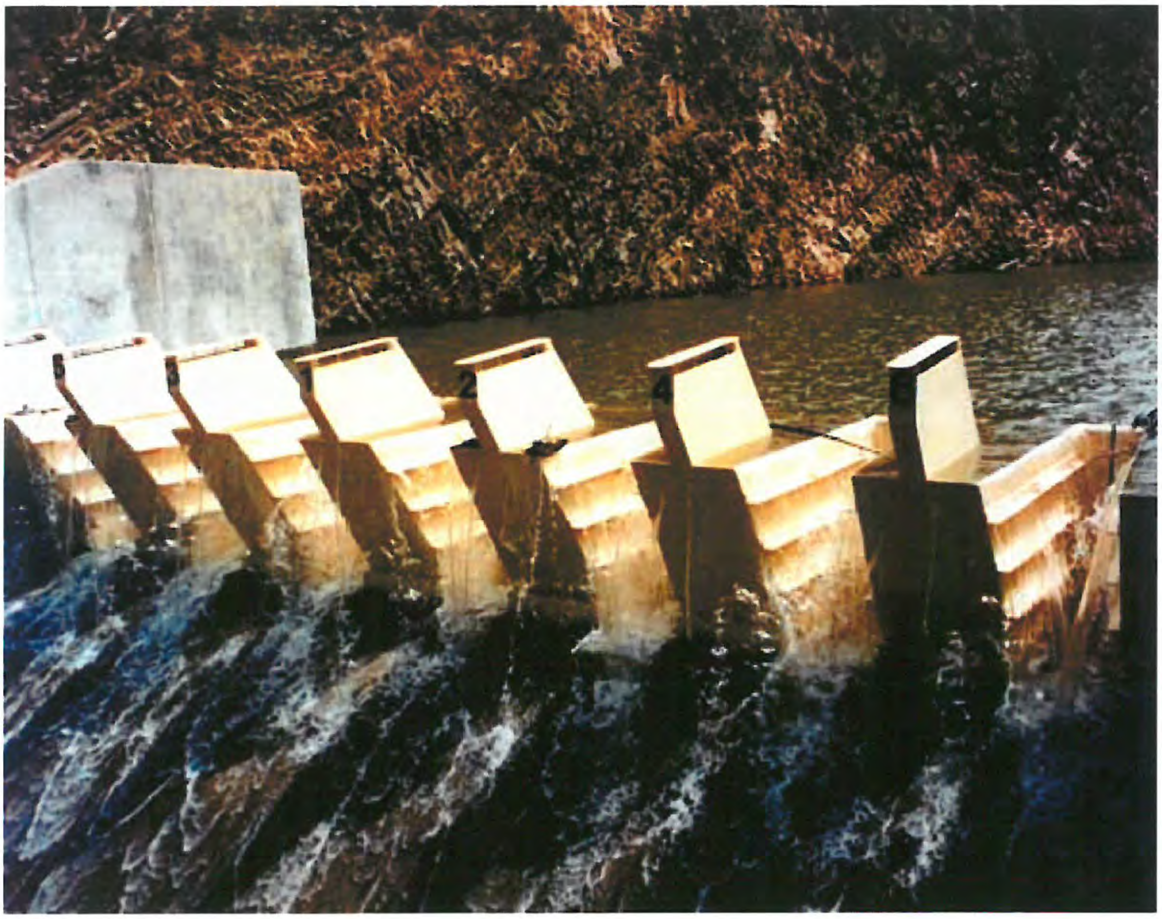
Risk is the sudden deflation of part or all of the airbags that will cause a wave of water to flood downstream. Often used to increase the capacity of the dam to hold more water during flood events, the failure to inflate will also increase the flood.

The use of a spillway fuseplug is another method of increasing the capacity of a dam to cope with the PMF whilst retaining a degree of security. The fuseplug is usually built in the emergency spillway of a dam and is constructed of material that will erode easily when water overtops the structure. When a flood enters the dam, the water level increases until the water overtops the fuseplug. The fuseplug then erodes before the dam wall is overtopped and thus saves the dam. The effect downstream will be usually a significant flood, but not a dam break.

Emergency spillways have been installed on both of these dams using the fuseplug method.

Risk is an increase to the extreme flood levels, but hopefully the dam will be saved.

A spillway fusegate is a gate that is designed to topple over when the water exiting the spillway reaches a certain height. Once toppled, the fusegate allows more water to exit via the spillway so that the dam wall will be saved.



Fusegate spillway using the labyrinth design to increase the water flow.

Risk is the sudden increase and possible wave of floodwater when the gates tilt.

The use of a cutoff wall is a current method to stop leakage or erosion within an earthen dam wall. The cuttoff wall is constructed across the dam in sections and the height of the wall may start at the bedrock at the toe of the dam and be visible on the top of the dam wall. The cuttoff wall is basically, a narrow wall the width of an excavation bucket that provides a barrier to seepage through the dam wall.

The use of a birm can be used to provide support to a dam wall so that the wall does not move downstream due to the weight of the water behind the dam. The birm would also provide support to the wall during an earthquake.

The white material is a birm that is designed to stop the dam wall on the right slipping down stream.

Cable tying can be utilised to tie the dam to the bedrock to stop movement downstream. Large cables are placed in boreholes, fixed to the rock and then tightened to provide tension within the structure.

Dams are designed with the size of the water catchment and the type of terrain in mind. Each design has their own way of coping with emergency situations. Many of the dams are being redesigned to cope with the changes in climate conditions and to cope with earthquakes. The differing dam types are shown below:

Concrete Dam

Earthern Embankment Dam

Concrete Arch Dam

Dam Removal

There has been a growing movement to remove dams where the costs – including environmental, safety, and socio-cultural impacts – outweigh the benefits – including hydropower, flood control, irrigation, or recreation – or where the dam no longer serves any useful purpose. The goal of removal can be multi-faceted, including restoring flows for fish and wildlife, reinstating the natural sediment and nutrient flow, eliminating safety risks, restoring opportunities for whitewater recreation, and saving taxpayer money.

The removal of dams is becoming an increasing issue in the USA. The highly publicised proposal to remove four major dams on the Lower Snake River to allow salmon to spawn has been talked about for some years. The cost to remove these dams would be in the hundreds of million dollars. These dams are only used to generate electricity. Other environmental issues include allowing rivers to flow freely again, hoping to flush out the system and allow regrowth of plant and marine life.




Four dams of the Lower Snake river earmarked for removal

Example of how a dam may look when river is restored

In a recent case, the Federal Energy Regulatory Commission (FERC) ordered the removal of the Edwards Dam to have a free flowing river and the economic benefits of the hydro project did not justify continued operation. The questions are now being raised as to whether FERC has the actual power to order a dam to be removed. This however, is not the first time FERC has ordered dams be removed, but previous cases were on safety grounds. The Edwards Dam was demolished on 12th August 1999.

Edwards Dam prior to removal

Edwards Dam being removed

A total of 121 dams have been removed since 1931, but this is not a significant number considering there are 75,187 dams currently in the USA.

An important part of the risk analysis that should be conducted for each dam is whether the dam is safe enough. With the need for increased spillways to cope with PMF, many dams are being having to undergo expensive remedial work or face removal. Two states of America, Wisconsin and Pennsylvania have removed more than 63 percent of the 121 dams that are listed.

Another dam considered for removal is the Glen Canyon Dam on the Colorado above Hoover Dam. This dam came very close to overtopping on its first fill and still has a lot of water seeping around the dam through the canyon walls as shown below in the photo. The sheer size of Colorado River's Glen Canyon Dam (710 feet high, which impounds 27 million acre-feet of water, and has an installed generating capacity of more than 1,000 megawatts) means that any such proposal will have complications and limited support. Further, the Glen Canyon Dam is a multipurpose project also used for recreation, water supply, and flood control. The cost to remove this dam could be in the hundreds of million. Many of the dams already removed are less than fifty feet in height.

Down stream of Glen Canyon Dam on the Colorado River

Detecting Dam Failures

The electronic systems that can warn of a potential failure are excellent when they are installed at the dam. Regardless of the electronic warning systems, all high-risk dams are usually visually inspected on a regular basis to assess the structure.

There are different types of dam failures. Some of the major ones include: overtopping caused by defective design of the spillway, or the blockage of the spillway with debris; foundation defects like foundation seepage, sliding, and instability; piping and seepage can also cause erosion and cracks.

Contrary to popular opinion, wet areas downstream from dams are not usually natural springs but seepage areas. Even if natural springs exist, they should be treated with suspicion and carefully observed. Flows from ground water springs in existence prior to the reservoir would probably increase due to the pressure caused by a pool of water behind the dam.

All dams have some seepage as the impounded water seeks paths of least resistance through the dam and its foundation. Seepage must, however, be controlled in both velocity and quantity.

Seepage can emerge anywhere on the downstream face, beyond the toe, or on the downstream abutments at elevations below normal pool. Seepage may vary in appearance from a "soft", wet area to a flowing "spring". It may show up first as an area where the vegetation is lush and darker green. Cat tails, reeds, mosses, and other marsh vegetation may grow in a seepage area. Downstream groin areas (the areas where the downstream face contacts with the abutments) should always be inspected closely for signs of seepage. Seepage can also occur along the contact between the embankment and a conduit spillway, drain, or other appurtenance. Slides in the embankment or an abutment may be the result of seepage causing soil saturation or pressures in the soil pores.

At most dams, some water will seep from the reservoir through the foundation. Where a sub-surface drain does not intercept it, the seepage will emerge downstream from or at the toe of the embankment. If the seepage forces are large enough, soil will be eroded from the foundation and be deposited in the shape of a cone around the outlet. If these "boils" appear, professional advice should be sought immediately. Seepage flow that is muddy and carrying soil particles may be evidence of "piping" and complete failure of the dam could occur within hours. Piping can occur along a spillway and other conduits through the embankment, and these areas should be closely inspected.

Sinkholes that develop on the embankment are signs that piping has begun. A whirlpool in the lake surface may soon follow and then likely a rapid and complete failure of the dam. Emergency procedures, including downstream evacuation, must be implemented if this condition is noted.

A continuous or sudden drop in the normal lake level may be an indication that seepage is occurring. In this case, one or more locations of flowing water are usually noted downstream from the dam. This condition, in itself, may not be a serious problem, but will require frequent and close monitoring and professional assistance.

The need for seepage control will depend on the quantity, content, and/or location of the seepage. Controlling the quantity of seepage that occurs after construction is difficult and quite expensive. It is not usually attempted unless draw-down of the pool level has occurred or the seepage is endangering the embankment or appurtenant structures. Typical methods used to control the quantity of seepage are grouting, installation of an upstream blanket, or installation of relief wells. Of these methods, grouting is probably the least effective and it is most applicable to leakage zones in bedrock, abutments, and foundations. All of these methods must be designed and constructed under the supervision of a professional engineer experienced with dams.

Controlling the content of the seepage or preventing seepage flow from removing soil particles is extremely important. Modern design practice incorporates this control into the embankment through the use of cutoffs, internal filters, and adequate drainage provisions. Control at points of seepage exit can be accomplished after construction by using weighted filters and providing proper drainage. The filter and drainage system should be designed to prevent migration of soil particles and still provide for passage of the seepage flow. The bottom layer of the weighted filter should be 6 to 12 inches of sand placed over the seepage area. The sand layer should be covered with a gravel layer of similar thickness. Larger rock should be placed next to complete the berm. This methods will permit the seepage to drain freely, but prevent piping (removal) of soil particles. The weight of the berm will hold the filter in place and may also provide additional stability to the embankment and/or foundation.

The location of the seepage or wet area on the embankment or abutment is often a primary concern. Excessive seepage pressure or soil saturation can threaten the stability of the downstream slope of the dam or the abutment slopes. An abutment slide may block or damage the spillway outlet or other appurtenances. In these cases, not only must the seepage be controlled but also the area must be dried out. This is sometimes accomplished by installing finger drains (lateral drains for specific locations). Seepage control systems must always be free draining to be effective.

Monitoring

Regular monitoring is essential to detect seepage and prevent failure. Without knowledge of the dam's history, the owner or the inspector has no idea whether the seepage condition is in a steady or changing state. It is important to keep written records of points of seepage exit, quantity and content of flow, size of wet area, and type of vegetation for later comparison. Photographs provide invaluable records of seepage.

The inspector should always look for increases in flow and evidence of flow carrying soil particles. The control methods described previously are often designed to facilitate observation of flows. At some locations, v-notch weirs can be used to measure flow rates.

Regular surveillance and maintenance of internal embankment and foundation drainage outlets is also required. Normal maintenance consists of removing any soil or other material that obstructs flow. Internal repair is complicated and often impractical and should not be attempted without professional advice. The rate and content of flow emerging from these outlets should be monitored regularly.

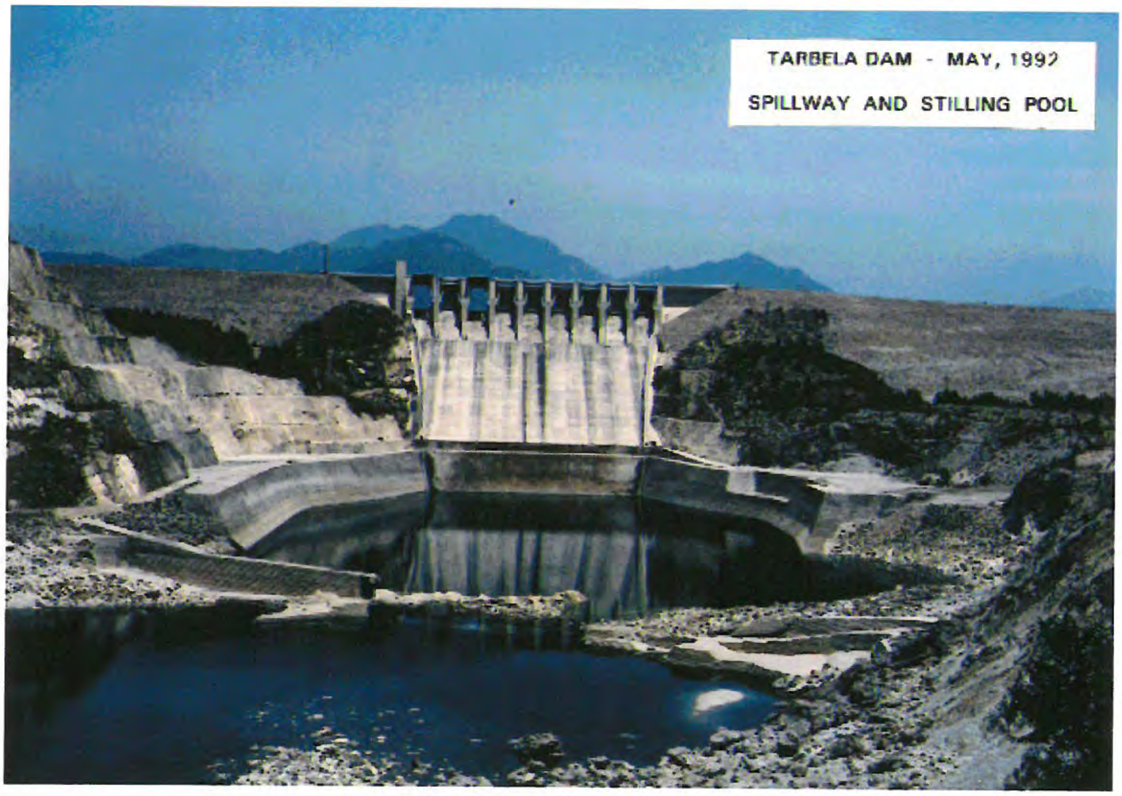
One of the more obvious signs that a dam maybe at risk of collapse is when cracks appear in the structure such as below.

The non-destructive characteristics of geophysical methods are very appropriate for dam assessments. Furthermore, information obtained from geophysical methods is continuous and covers a wide area of investigation compared to single-point data derived from drilling.

The following geophysical methods have been used in different projects related to dam structure investigations.

Ground Penetrating Radar
Radar Tomography
Seismic Tomography
Seismic Reflection
Downhole Seismic
Side Scan Sonar
Electrical Resistivity
Streaming Potential

External erosion at a dam is usually easy to see after a storm event.



There are many tools available to enable inspections at dams to be as thorough as possible. Others that have not been mentioned include theodolite and GPS positioning equipment to assess movement of dam walls.

Emergency Management Planning

All high hazard dams are usually required to have an Emergency Action Plan that details the actions of the dam owner or operator during an emergency at the dam. The municipal emergency management plan will detail the management arrangements that are in place between emergency services and government agencies to respond to, and recovery from any dam incident. The last level of planning is the operational plans that each emergency service or government agency have that deal specifically with each type of dam incident or extreme flood caused by the dam. Sometimes the Dam Emergency Action Plan and the agency action plans are combined into the one document. It is very important that each plan can link into the next plan and to do this they must have similar management arrangements and use the same definitions & terminology.

Operational plans must detail the roles & responsibilities of the agency and in the case of dam break or extreme flood can be very specific in their actions. Interpretation of any inundation maps is vital to the operational planning.

Emergency Action Plan

Suggested section headings for an Emergency Action Plan is shown below;

- Emergency Notification Flowchart and information
  - Who is to be notified, by whom, and in what priority.

- Statement of Purpose
  - Description of dam and area.

- Emergency detection, evaluation and action
  - Early detection or trigger points to initiate action.

- General responsibilities
  - Dam owners responsibilities
  - Responsibility for notification and evacuation.
  - Other agencies responsibilities

- Preparedness
  - Actions to be taken to moderate or alleviate the effects of a dam failure or spillway release.
  - Surveillance, detection and evaluation systems detailed.
  - Access maps, procedures and alternatives
  - Communication systems and alternatives
  - Access to resources
  - Information co-ordination

- Inundation Maps
  - Should delineate the areas that would be flooded as a result of a dam failure.
  - Could include extreme flood conditions when spillway is operating at capacity.
  - Travel time and water depth indication is needed by emergency services.
  - Domino effect on other dams downstream

- Appendices
  - Exercises and updates of plan
  - Definitions

Combined Plans

When a dam is part of a broader river system that also has a flood plan, then a dam failure scenario would become part of that flood plan. However, in some cases, downstream flooding is controlled entirely by the outlet / spillway of the dam and there are no other contributing river systems. For these dams it maybe more appropriate that the Emergency Action Plan is combined with agency action guides, evacuation plans and linked into local emergency management arrangements.

Emergency Evaluation Procedure

Generic procedures to cover most of these incidents:

- Instrumentation readings
- Unusual springs
- Piping
- Slumping
- Sinkhole
- Cracks
- Wet spot or boggy area
- Seismic event
- Obstruction in the spillway
- Damage to structure
- Bomb threat
- Civil disorder
- Aircraft incident
- Chemical incident

Emergency Notification Chart

- Should be generic to cover most of the above incidents
- Dam breach chart
- Possible dam breach chart

Introduction

- General statement about plan

Responsibilities

- Dam owner / operator responsibilities
- Responsibility for notification and evacuation.
- Other agencies responsibilities
- Public warnings and evacuations

Emergency Operation Centre

- Each agency to operate their own

Emergency Co-ordination Centre

- In established municipal centre

Public Information

- Responsibilities and procedures

Warnings

- Dam Failure
- Flood

Maintenance of plan

- Meetings
- Plan review and testing of plan

Prevention Arrangements

- As per risk management treatment options

Response Arrangements

- As per the notification procedures in the flowchart and normal municipal arrangements
- Individual agencies as per their action guides

Recovery Arrangements

- As per municipal arrangements
- Dam owner / operator involved in own asset restoration.

Communications

- Contact arrangements and alternative communications

Emergency Identification, Evaluation and Classification

- General
- Regular surveillance, inspections, instrumentation and monitoring
- Evaluation of incidents
- Flood Operation

Access and Communication Procedures

- Access routes for extreme weather and conditions

Preventative action

- General
- Lowering the storage level

Inundation Area

- Flooded area
- Flood wave travel times
- Water depth

Appendices

- Dam Description and plan of dam
- Action Guide – Police
- Action Guide – Dam Owner
- Action Guide – SES
- Contact List
- Access routes
- Inundation Map
- Earth Tremor Instructions
- Flood Notification Flow Chart

Operational Plan

An operational plan will vary between agency and location, but should follow the basic principles of SMEAC.

Situation

- Brief outline of what is required. (eg: Actions to be taken by SES in the event of a dam break)

Mission

- What tasks are going to be performed. (eg: To undertake the Control Agency role during the event; To provide support to Police during evacuations, public warnings, road closures and traffic diversions)

Execution

- Who is going to do each function and when. (eg: Where each road is to be barricaded; each property for evacuation is listed; where each SES Unit will be staged; respond to rescues)

Administration

- Special resources and equipment
- Staging areas identified
- Forward Control Points established

Command & Communications

- Who is in charge
- Liaison requirements
- Notification to State Duty Officer
- Who is issuing warnings and press releases
- Radio transceiver channels to be used by SES crews

Community Emergency Risk Management

Many dam owners are using use a combination of traditional methods and risk-based analysis to assess the safety and operation of the dam. However, very few dam owners are actually involving the community in the risk analysis. True emergency risk analysis involves all the people at risk and any treatment options will hopefully be owned by all concerned. Many people, who live downstream of a dam, often do so without knowledge of the risk or an awareness of the risk.

Dam Safety '98 Conference

The Association of State Dam Safety Official's conference was held in the Riviera Hotel and Casino in Las Vegas, Nevada and was attended by over 650 delegates. In addition to the many delegates from the USA, there were presenters and representatives in attendance from Canada, China, Slovenia, Brazil, Mexico, South Africa, Switzerland, Australia and New Zealand.

This is the annual conference of the Association of State Dam Safety Officials, which has a worldwide membership of 1868 consisting of local & state & federal government dam safety personnel, engineers, dam owners/operators, emergency planners, contractors and academics.

The conference agenda included the following presentations:

Overtopping of Grassed Embankments

RCC vs Articulated Concrete Blocks for Overtopping Protection

Effects of Compaction on Embankment Resistance to Headcut Migration

A Hybrid Deterministic-Risk-Based Approach to Hydrologic Dam Safety Analysis

Stochastic Modelling of Extreme Floods for A.R. Bowman Dam

Implementation of Risk Analysis Principles into the Bureau of Reclamation's Dam Safety Program Actions

Sedimentation Characterisation for Dam Removal Study

Wisconsin's Abandoned Dam Program

Identification of Underdeveloped Hydropower Resources in the United States, based on Environmental, Legal and Institutional Attributes

Walter F. George Lock and Dam Major Rehabilitation Evaluation Report, Prevention of Potential Structural Failure

Seepage Remediation at Patoka Lake, Indiana

Failure of Centennial Narrows Dam

Performance Parameters for Embankment Dams and Foundations

A Condition Index for Earth and Rockfill Embankment Dams

Televised Inspection of Aging Flood Control Structures to Assist in Prioritizing Maintenance Needs and Funding

The Detailed Method: Using GIS and a Soils Database to Calculate the PMF

A Comparison between HEC-2 and FJDWAV

Five-thousand Men and One Dog: The Human side of Hoover Dam Construction

Summary of the current Dynamic Stability Investigation for Hoover Dam

Linear-Elastic Dynamic Structural Analysis Including Mass in the Foundation for Hoover Dam

Nonlinear Dynamic Structural Analysis of Hoover Dam including Modelling of Contraction Joints and Concrete Cracking

Kinematic Studies to Determine the Stability of Postulated Independent Concrete Blocks Indicated by the Non-Linear Analysis of Hoover Dam during Seismic Loadings

The Underwater Installation of a Drained Geomembrane System on Lost Creek Dam

Dworshal Dam Foundation Grouting

Bloemveld Dam Repair

Spillway Capacity Innovations at Small Dams

Simplified Design Guidelines for Riprap Subjected to Overtopping Flow

Hydraulic Model Evaluation of Tailrace Flow Patterns at the Proposed Summersville Hydroelectric Project

A study of Structural Modifications to the Lower Snake River Hydropower System

Why Gamble with Dam Safety?

Portfolio Risk assessment: A basis for Prioritising and Co-ordinating Dam Safety Activities

Dam Safety and Other Issues Facing Small Watershed Project Sponsors

Georgia's Engineering Guidelines

How Hazardous are Dams of Urban Stormwater Ponds? Findings of a Preliminary Comprehensive Hazard Assessment Study

Dealing with Complex Constraints in Rehabilitation of the Tongue River Dam Spillway System

Sam Rayburn Dam and Reservoir Labyrinth Spillway Design and Construction

Saylorville Dam Unlined Spillway Channel Remedial Actions

Remotely Controlled Vehicles (ROV) – Their Role in Underwater Inspections

A Dam Owner's Tool – The Hinged Floating Bulkhead

So You Think Your Dam is covered by Insurance, Think Again

Recreating the Past: Inspection and Analysis of Spillway Radial Gates

Tainter Gate Testing and Evaluation

California Division of Safety of Dams Spillway Radial Gate Program

Strengthening of Matahina Dam for Fault Displacement

Mine Tailings Disposal in Nevada – The Current State of the Art

Seismic Considerations for Upstream Construction of Coal Refuse Dams

Real-Time Location Methods for Underwater Repair of the Ludington Pumped Storage Plant Reservoir Foundation

Modification of the Baldhill Dam, North Dakota Embankment for Overtopping

Replacement of Duluce Lake Dam

RCC Overtopping Protection Turns 50

Facing Systems for Roller-Compacted Concrete Dams

Combining Function with Aesthetics in RCC Dam Projects

BC Hydro's Emergency Preparedness: An Innovative Approach

Corps of Engineers/Tennesse Valley Authority Cooperative Dam safety Emergency Exercise

Emergency Construction of a New Dam on Pinto Creek, Gila County, Arizona

Probable Maximum Flood and Spillway Adequacy Determination Study of Nacimiento and San Antonio Dams

A Framework for Characterization of Extreme Floods for Dam Safety Risk Assessment

Use of Atmospheric Models and a Distributed Watershed Model for Estimating the Probability of Extreme Floods

Hungry Mother Dam Rehabilitation

Rehabilitation of the Houston Lake dam, Houston County, Georgia

To Siphon or Not to Siphon: That is the Question (Among Others) A Repair History of the Crossgate Dam, Raleigh, North Carolina

Liquefaction Mitigation of a Silty Dam Foundation using Vibro-Stone Columns and Drainage Wicks. A Test Section Case History at Salmon Lake Dam

Arch Dam Geotechnical Exploration and Thermocouple Installation and Monitoring

Similar Dams Different Approaches (A Comparison of Geotechnical Engineering on Two Dams)

New technology for Estimating Plunge Pool or Spillway Scour

Utah Model Saves Texas A Million

Outlet Channel Repairs – Milford Dam, Kansas

Grouting Technologies for Dam Foundations

A Laboratory Simulation of In-Situ Grouting using Portland Cement and Polyurethane Materials with Standard Methods

Tims Ford Dam, Tennesse: Remedial Grouting of Right Rim

Mexican Dam Safety Program

The Dam Safety Program in South Africa

Challenges in Dam Safety: Opportunities in Virginia

Hydrologic Consideration for Safe Dams

Risk! Ignore it?... or Manage It?

Solutions for Freeze-Thaw Deterioration of Concrete Dams

I attended the sessions as highlighted and have the papers on CD if anyone is interested in a particular subject. The conference had the usual mix of very technical presentations from engineers, thought provoking presentations from the academics and practical presentations from dam safety officials.

Interesting issues raised during the conference that are not included in the rest of this report are:

- Widespread use and reliance on divers and robots to perform inspections and repairs.
- Some concrete arch dam designs can withstand overtopping of the dam wall during an extreme flood event. These would form an amazing waterfall when overtopping.

- Contingency plans that utilises concrete highway barricades laid on their sides and joined together to increase the height of the dam wall or levee bank to stop overtopping. Plastic is used to line the barriers on the waterside and it has been used to save some earthen dams from overtopping.

- Risk Management is gaining acceptance by many in the Dam Community but they have a long way to go when considering community risk vs engineering risk.

- It shows just how small the world really is when you travel half way around the world to listen to someone talk about a dam 20 minutes from your home on which some of the latest spillway engineering has been constructed.

- Of note was a report of municipal emergency management planning being driven along and supported by the local power company & dam owner. End result was of benefit to the whole community.

- The complications and legislative redtape encounted when trying to construct an emergency dam to stop toxic silt from a tailings dam collapse entering the waterway during the next storms.

Riveria Hotel, One of the five rooms the conference was held in.

ASDSO banner

Recommendations

I have listed my recommendations in priority order. In the time that I have taken to finalise my report the third recommendation has already been actioned. Thanks to VICSES management for allowing me onto the steering committee to achieve this recommendation.

- **That the Water Act 1989 be expanded to ensure that all property owners are informed if they are in the inundation area of a dam, reservoir or tank.**

- **That SES and other emergency management agencies encourage the dam community to participate in the risk analysis of the community.**

- **That the work undertaken in 1993 on the document "Beyond the spillway" is revised and implemented across Australia.**

- **That current dam emergency action plans are expanded where appropriate to become emergency management plans so they involve the emergency management arrangements of the wider community.**

OES
CALIFORNIA
Governor's Office of Emergency Services

The California Governor's Office of Emergency Services (OES) plans the state emergency response to disasters resulting from all natural and man-made risks, including attack or invasion. OES is responsible to guide local government, special districts, business and industry in the development of emergency management plans in response to all risks. OES also prepares State resources & staff to assist local government during emergencies and informs the public on emergency preparedness through public education campaigns, films and presentations.

OES trains the State, local and private sector emergency planners/coordinators and responders in emergency response operations and writes exercises to test State and local emergency management plans.

The Federal funded programs for emergency planning, emergency operations centre support and communications systems development & maintenance are all administered by OES. This includes support for the Title III; SARA Hazardous Materials Planning Commission.

OES has the following functions and duties;

- Provide intelligence reports to the Governor on the emergency and advice on state response.
- Inform impacted government of the resources available to combat the emergency
- Coordinate mutual aid requests and the application of State & federal resources in response to local needs
- Directs (during a State of Emergency) state agencies to respond in support to local government
- Assists local government and citizens by providing access to and assistance with obtaining appropriate state and federal disaster recovery assistance and funds

OES also has the power to regulate compliance with provisions of the Government Code 8589.3 (Dam Evacuation Planning) and A.B. 2189 (Hazmat Planning).

The general terms the California Office of Emergency Services performs some of the roles of the Victorian State/Regional Emergency Response Coordinators, the emergency management role of the Victoria State Emergency Service and the risk management functions of the Country Fire Authority.

The main difference between Victoria and California is that the OES take over control of state or regional emergencies. Each OES Region has a coordinator for Fire, Law and OES. This layer is necessary to control emergencies that are beyond the duristriction of the local authorities. These juristriction areas maybe very small as each County, City and Federal Agency in the State will have their own Fire and Law enforcement services.

The OES is divided into three administrative regions with the head office based in the State capital of Sacramento. OES being part of the Governor's Office is usually located with the National Guard (each state Governor has their own National Guard to protect the state) and therefore maintains close liaison at all times.

In the last two years, OES has been very busy ensuring that dam owners comply with Government Codes 8589.4 & 8589.5. These codes mean that every dam and reservoir in California over 8 metres high requires flood inundation maps for sudden dam collapse. Dam owners submit inundation maps to OES for review and approval in accordance with guidance issued by OES. Inundation maps represent the best estimate of where water would flow if a dam failed completely and suddenly with a full reservoir. However, later downstream changes, such as major land contour alterations, may affect the actual inundation pathway. Copies of the approved inundation maps are sent to the city and county emergency services coordinators of affected local jurisdictions. Three maps have to be produced to show inundation at full, half and lowest capacities of the dam. These maps are assessed by OES and if there is the possibility of injury or death from the dam collapse, then an emergency evacuation plan must be prepared by the dam owner and local authorities. The completed plan is then assessed by OES.

The OES was established as part of the Governor's Office in 1950 as the State Office of Civil Defence. In 1956, the agency became more involved in natural disaster operations, and the name was changed to the California Disaster Office. Adoption of the state's Emergency Services Act in 1970 changed the agency's name to the Office of Emergency Services.

The Governor's Office of Emergency Services coordinates overall state agency response to major disasters in support of local government. The office is responsible for assuring the state's readiness to respond to and recover from natural, man-made, and war-caused emergencies, and for assisting local governments in their emergency preparedness, response and recovery efforts.

During major emergencies, OES may call upon all state agencies to help provide support. Due to their specialised capabilities and expertise, the California National Guard, Highway Patrol, Department of Forestry and Fire Protection, Conservation Corps, Department of Social Services, Department of Health Services and the Department of Transportation are the agencies most often asked to respond and assist in emergency response activities.

OES may also call on its own response resources to assist local government. For example, four communications vans are available to send to disaster sites. Portable satellite units are available to provide voice and data transmission from remote locations. OES also maintains caches of specialised equipment, principally for use by local law enforcement agencies. One hundred and twenty OES fire engines ("pumpers") are stationed with fire districts at strategic locations throughout the state and can be dispatched when needed. OES staff members are on call 24 hours a day to respond to any state or local emergency needs.

The OES Warning Centre is staffed 24 hours a day, 365 days a year. From this centre, warning controllers speak with county OESs and the National Warning Centre in Berryville, Virginia on a daily basis.

OES also maintains a 24-hour toll-free toxic release hotline, and relays spill reports to a number of other state and federal response and regulatory agencies, as well as local governments.

OES coordinates the statewide Fire, Law Enforcement, and Telecommunications Mutual Aid Systems based on the "neighbour helping neighbour" concept. OES also coordinates the state's Urban Search and Rescue and Safety Assessment Volunteer programs.

Regional Operational Centre in Los Angeles

Communications for REOC

During emergencies, OES activates the State Operations Centre (SOC) in Sacramento and the Regional Emergency Operations Centres (REOCs) in impacted areas to receive and process local requests for assistance. OES and other state agency, public information officers, staff the OES Emergency News Centre to provide emergency information to the public through the news media.

OES is the "grantee" for federal disaster assistance, principally from the Federal Emergency Management Agency (FEMA). During the recovery phase of a disaster, OES helps local governments assess damages and assists them with federal and state grant and loan applications to repair damaged public property.

Individuals and families suffering losses may apply for federal and state assistance through a toll-free, tele-registration phone line. Individuals may also apply for other assistance programs administered by local and volunteer agencies such as the American Red Cross. The OES public information effort continues in this phase in cooperation with other state and federal agencies.

OES maintains the State Emergency Plan, which outlines the organisational structure for state management of the response to natural and man-made disasters. OES assists local governments and other state agencies in developing their own emergency preparedness and response plans, in accordance with the Standardised Emergency Management System and the State Emergency Plan, for earthquakes, floods, fires, hazardous material incidents, nuclear power plant emergencies, and dam breaks.

The OES Earthquake Program provides specialised earthquake preparedness planning and technical assistance to local governments, business, schools, hospitals, the public and other groups.

In addition, OES manages the state's annual public awareness campaigns to help California residents become better prepared for emergencies. Each winter, a Winter Weather and Flood Preparedness campaign is held. Also, the California Earthquake Preparedness Month Campaign is conducted each April and includes related events throughout the year.

OES coordinates search and rescue missions through its Law Enforcement Branch's search and Rescue program to locate individuals lost in the mountains or wilderness. Through its Fire and Rescue Branch's Urban Search and Rescue Task Force program, OES coordinates missions for those trapped by collapsed structures or in other high-risk situations. OES also provides search and rescue task force training for local fire personnel, governments and volunteers.

OES' training arm, the California Specialised Training Institute in San Luis Obispo, provides training programs for city, county, and state emergency services personnel on the latest techniques in disaster planning, response, recovery and management.

The Santa Barbara County Fire Service runs a section called the Office of Emergency Services (OES) that is responsible for emergency management on behalf of the County. Headed by a Battalion Chief as the Director, the section is managed by a civillian deputy director and staff.

Santa Barbara OES assists other agencies and organisations with emergency planning, training and exercises.

Because of the extensive dam safety program in California at the moment, Santa Barbara Fire OES has been working with the people from the Cities of Lompoc, Buellton and Solvang on warning strategies in the event of a failure of Bradbury Dam. More detail regarding this program is in the community consultation part of this report.

Bradbury Dam is currently being updated with work on the spillway and a birm has been installed downstream to prevent the dam wall from sliding during an earthquake.

Divers boat and barge at spillway.
Cofferdam used on spillway in foreground.

Picture of the birm

Santa Barbara County has the distinction of having the only dam in the United States to fail during an earthquake. The dam was built in 1917 and failed in 1925 during the Santa Barbara earthquake.

Rexburg is the closest City to the Teton Dam site and the township was flooded by the dam collapse in 1976. Rexburg was not part of my original itenary and we chose to stay in Rexburg as a centre for day trips into Yellowstone National Park and Teton National Park. I did however, know that Rexburg had a flood museum which was marked on my touring map and had seen the Teton Dam collapse video many times, but didn't put the facts together until I met with the local Fire Chief.

The Rexburg City & Madison County Fire Department look after a population of 40,000 and have their only station in Rexburg. They have the usual pumpers, tankers, ambulances and rescue vehicles. I also met with the executive officer of the Rexburg Chamber of Commerce and was informed that the people of Rexburg are now considering whether they should rebuild the Teton Dam again.

The flood museum is part of the Upper Snake River Valley Historical Society and it has a large section dedicated to the Teton Dam Collapse. This includes models of the dam, newspaper articles, videos and publications.

The construction of the Teton Dam began in 1972 and was finished in October 1975. The dam was allowed to fill up to three times faster than normal because of excessive snow thaw making its way down stream. It took only five hours from the time of the first observed seepage in the immediate proximity of the dam until the dam failed.

Teton Dam collapse 1976

Teton Dam 1998

Idaho State Bureau of Disaster Services is responsible to the Idaho Governor. Their mission is to save lives and limit injury to people, reduce the damage to property, the environment and the local economy by coordinating the state and federal response to emergencies and disasters in support of local jurisdictions.

The Bureau of Disaster Services state headquarters is located with the National Guard at Boise. There are also six Area Field Offices. The operations section is responsible for coordinating emergencies/disasters with local, state and federal agencies and private industry. The Area Field Offices work directly with the local emergency manager and act as the eyes and ears for the ECC and EOC operations officer.

They also provide a valuable tool to the counties and cities by using their technical expertise to assist in emergency/disaster operations.

The Planning Section provides planning and technical assistance to state agencies and local government and agencies in the areas of mitigation, preparedness, response and recovery regarding all-hazard disasters and emergencies. This assistance is accomplished by:

- Preparing, maintaining and updating a state disaster plan based on the principle of self help at each level of government.
- Promulgating standards and criteria for local and inter-governmental disaster plans.
- Periodically review local and inter-governmental disaster plans.
- Providing assistance to local officials in designing plans for search, rescue, and recovery of persons lost, entrapped, victimised or threatened by disaster.
- Coordination of the state disaster plan with the disaster plans of the federal government.
- Identifying areas particularly vulnerable to disasters.

The Resource Management Section manages support activities for the agency, which includes information/automation management, communications, facilities, logistics, budget, finance, and personnel administration.

BDS does not have a specific dam safety program even though this is the state where the Teton Dam collapsed. Most of the dams are owned and operated by Idaho State Department of Water Resources, Bureau of Reclamation, US Army Corps of Engineers and/or Federal Energy Regulatory Commission.

BDS Emergency Coordination Centre (ECC)

During smaller scale incidents, where activation of the EOC is not required, the BDS operations personnel work out of the Emergency Coordination Centre (ECC). The ECC is equipped with four work-stations for operations and liaison personnel. The ECC was designed so that operations personnel can gather, interpret, display and disseminate information in an efficient manner. As a situation develops, operations personnel coordinate the response efforts of state and federal agencies. This approach ensures that state and federal agencies responding to emergencies and disasters coordinate their efforts and assets are used to their fullest potential.

STATE OF IDAHO EMERGENCY OPERATION CENTER (EOC)

The state EOC is fully automated. There are 17 work-stations located around the perimeter of the room. Each work-station consists of a computer connected to the BDS network and an in/out phone system. Also located in the EOC, is a digital video projector, 4- 35" colour televisions with cable to receive the news and to display disaster information. 17 more phone line drops stored in the ceiling providing BDS the ability to expand the phone system, a cork board display to hang maps and two 3'x6' white boards.

As the states support centre during large-scale emergencies, the EOC is manned by state, federal and volunteer agency representatives 24 hours a day. EOC personnel identify solutions to disaster-related problems communities are facing and facilitate the best use of state assets.

Ada City-County Emergency Management (ACCEM) is a local government agency responsible for disaster preparedness. ACCEM represents Ada County, Ada County Highway District, Boise, Eagle, Garden City, Kuna, Meridian and Star.

ACCEM is a division of the Ada Planning Association that works closely with other local, state, and federal agencies to help the community mitigate, prepare for, respond to, and recover from disasters and emergencies.

Staff consist of three full time emergency management planners who look after a population of 354,457 and have offices in the Ada County Sheriff & Boise Police Complex. This also where the Municipal Emergency Coordination Centre and law enforcement computer aided dispatch is located.

Boise is the State Capital of Idaho and also home to the National Wildfire Coordination Centre.

ACCEM lists the risks for the area as:

- Earthquake — Ranks 5th highest state in US at risk of major earthquake
- Flooding — Boise River runs through the State Capital and has flows that allows white water rafting to be a viable business in the town.
- Flash Flooding — Wildfires in the nearby hills have destroyed the vegetation, this risk has increased to such an extent that seven Outdoor Warning Sirens are installed in Boise foothills sirens to warn residents.
- Hazardous Materials
- Wildfire — Recent wildfires have devastated large acreages near the City

Dam safety is handled as part of the flood plan for the area and is also rated as a major concern for the emergency management planners. Even though the risk is lower than the emergencies mentioned above, there are three major dams on the Boise River that flow through the Capital City. If for any reason any of the dams should overtop or collapse, then the City of Boise would be devastated.

The middle dam is a concrete arch dam that was built in 1915 and it is in the early stages of concrete decay. The water from the first dam actually helps hold this dam in place when the water level is half way up the wall of the second dam. The first dam is owned and operated by the US Army Corps of Engineers. The Second and third dams are owned and operated by the Federal Bureau of Reclamation.

Arrowrock Dam full

Arrowrock showing full wall when Lucky Peak Dam is low

Lucky Peak Dam

ACCEM has introduced a warning system to warn residents of flash flooding near the hills. Approximately 15,000 people can hear the warning sirens. The supervisor at the Boise Police and Ada County Sheriff's dispatch centre activates the system after receiving information from the National Weather Service. The sirens could be used to warn the residents of a dam failure but the area is only a small proportion of the city.

The Oregon Office of Emergency Managerment is based in Salem, captial of Oregon and located in their own office complex. They are a department of the State Police and have a control room that monitors incidents across the state.

OREGON EMERGENCY MANAGEMENT

The purpose of the Office of Emergency Management is to execute the Governor's responsibilities to maintain an emergency service system by planning, preparing and providing for the prevention, mitigation and management of emergencies or disasters that present a threat to the lives and property of citizens and visitors to the State of Oregon.

The agency is responsible for coordinating and facilitating emergency planning, preparedness, response and recovery activities with the state and local emergency service agencies and organisations.

In order to achieve this they:

- Coordinate statewide all-hazard emergency planning and technical assistance among state agencies and local jurisdictions;
- Coordinate the development of a survivable network of emergency operations facilities;
- Develop and maintain the state emergency management plan;
- Assist with hazard identification in local jurisdictions;
- Develop all hazard emergency management plans;
- Provide technical assistance in emergency management operations.
- Direct the Earthquake Hazard Reduction Program, develop and implement program and support Seismic Commission.
- Increase tsunami awareness and preparedness in cooperation with the Department of Geology and Mineral Industries and the academic community.

- Coordinate Hazardous Materials Planning requirements of Superfund Reauthorization and Amendments Act (SARA) Title III serving as point of contact for the Oregon State Emergency Response Commission (SERC) and the Local Emergency Planning Committee (LEPC) and for the US Department of Transportation Hazardous Materials Emergency Planning (HMEP) grants.

- Develop, coordinate, and conduct local and state emergency management training programs and professional development classes;

- Conduct Public Officials' Conference for emergency program managers and elected officials;

- Develop, conduct, and evaluate emergency management exercises for state and local jurisdictions.

The OES consists of 33 staff in the State Headquarters without any regions. There are 813 dams in Oregon. High hazard dams must have an emergency action plan. If there is a problem at a private dam the various State Departments cannot take control of the dam but they can issue an order to breach the dam or have the outlets opened.

Any dam safety incidents are usually reported via the Oregon Emergency Response System.

The purpose of the Oregon Emergency Response System (OERS) is to coordinate and manage state resources in response to natural and technological emergencies and civil unrest involving multi-jurisdictional cooperation between all levels of government and the private sector.

Oregon Emergency Response System Control Centre in Salem

OERS is the primary point of contact by which any public agency provides the state notification of an emergency or disaster, or requests access to state or federal resources.

OERS was established in 1972 by the Governor of Oregon to improve communications and coordination between government agencies responding to hazardous materials incidents across the state.

This was the first state plan of its type in the country.

Since that time OERS has become an "all-hazards" system, responding to other types of emergencies: Natural Hazards such as floods, wildfire and earthquakes and Search and Rescue missions.

OERS is the cornerstone of the State Emergency Services System.

The Association of State Dam Safety Officials is a national, non-profit association dedicated to the improvement of dam safety through research, education and communication.

The Association of State Dam Safety Officials was formed in 1983 in response to several massive dam failures in the late 1970s (see below) and subsequent national concern over the state of dam safety in this nation. In the 16 years since it was formed, ASDSO has made great strides toward improving dam safety in the states and is constantly initiating new efforts and placing higher demands on itself as the major supporter of state dam safety programs.

ASDSO was formed to serve these initial functions:

1) Provide a forum for the exchange of ideas and experiences on dam safety issues
2) Foster interstate cooperation
3) Provide information and assistance to state dam safety programs
4) Provide representation of state interests before state legislatures and Congress
5) Help improve state dam safety programs
6) Foster public awareness of dam safety

In its fulfillment of these goals, ASDSO maintains many programs to heighten public awareness, to train state personnel in technical areas of interest, and to maintain channels of communication between states, between government levels, and between the public and private sectors. ASDSO produces research documents to keep the dam safety community abreast of current technical and policy issues and ideas.

Facts About Dams

Dams are a vital part of a country's infrastructure

Operation, maintenance, and rehabilitation of existing dams can range in cost from the low thousands to the low millions.

Communities and individuals reap benefits in the millions of dollars through increases in water supply for drinking, irrigation and recreational activities; and for hydropower energy and flood control.

Failures can be devastating. Property damage can range in the thousands to billions of dollars.

No price can be put on the lives that have been lost or could be lost in the future. Failures know no state boundaries; inundation from one dam failure can affect several states.

Catastrophic Dam Failures Can Kill

In the past several years, approximately 273 documented failures have occurred across the nation (this includes 250 during the Georgia Flood of 1994). Lives were lost in Georgia as an indirect result of dam failures. Dam and downstream repair costs resulting from failures in 23 states reporting in 1994 totalled $54.3 million.

Georgia--November 5, 1977--Kelly Barnes Dam failed killing 39 students and college staff and causing about $2.5 million in damage.

Idaho--June 5, 1976--Teton Dam failed killing 11 people and caused an unprecedented amount of property damage totaling $400 million.

West Virginia--February 26, 1972--Buffalo Creek Dam failed killing 125 people.

Pennsylvania--In 1889, the South Fork Dam, about nine miles above Johnstown, Pennsylvania broke without much warning sending a deadly rush of water and debris into the city of Johnstown. The flood killed 2,209 people.

The bottom line is that while more and more U.S. dams start to age and deteriorate, more and more are at the same time being classified as high-hazard because of changing design standards and uncontrolled downstream development. State dam safety programs are not given the authority and funding needed to attack this problem, while the federal government fails to take aggressive action on this issue of national significance.

Dam Safety: Still an Unrecognized National Concern

Hundreds of thousands of citizens in every state are dependent on dams for water supply, power, flood control, irrigation, and recreation. High safety standards for these dams can keep them from failing causing devastating environmental and property damage, economic hardships, and, in the worst case, loss of life.

High-hazard dams, some of which are unsafe, exist in every state and affect the lives of thousands downstream. About 9,000 of the nation's 74,000 dams inventoried in 1994 were determined to be high-hazard* with about 1,800 dams deemed unsafe. *(High-hazard is a term used by a majority of state dam safety programs and federal agencies. While the definition varies slightly from place to place, it generally means if failure of a high-hazard dam occurs, there is a potential for loss of life and hundreds of thousands of dollars worth of property damage. Unsafe dams have been found to have deficiencies which leave them more susceptible to failure.)

Deterioration of the infrastructure is a major concern. Decay of existing dams, coupled with an increased lack of direction on the part of developers who are building downstream of dams, causes more high-hazard determinations and potential victims below unsafe dams. State and federal funding to keep up with these problems is not receiving appropriate recognition in the budget process. Additionally, the lack of funding for dam rehabilitations is becoming a serious national problem in the public and private sectors.

Deterioration problems increase as dams age. It has been determined that the life of a dam is 50 years. The majority of dams in this country are quickly approaching this age and rehabilitation of these structures is a major concern.

Recent ASDSO studies show that about half the states have shown program improvement progress while half have either remained constant or regressed in the last 10 years. With the recent economic climate, even those state programs showing improvement are struggling to keep up with growing responsibilities, cuts in staffing, and increased workloads.

Regulatory Facts

State governments regulate or inventory 95% of the approximately 74,000 dams within the National Inventory of Dams. The other 5% are regulated or owned by the federal government.

Forty-eight states and Puerto Rico have dam safety regulatory programs although these programs vary in adequacy from state to state.

A newly-enacted law entitled the Dam Safety Act of 1996 was signed into law on October 12, 1996 (as part of the Water Resource Development Act of 1996). The law codifies a national dam safety program and authorized funding to support the following programs:

1) grants to state dam safety programs;
2) dam safety research;
3) state dam safety inspector training; and,
4) the National Inventory of Dams.

Funding has been appropriated for FY99 totalling $3.9 million, the full authorization.

The Emergency Alert System (EAS) is the long awaited 1997 upgrade to the 1964 Emergency Broadcast System (EBS).

The EBS was originally created to enable Federal authorities to warn the American public of a national emergency via the nations broadcast stations and other communications resources. It was subsequently expanded to enable the National Weather Service and local civil defence authorities to warn the public of any threat to the public health, safety, and welfare. The EBS was never used for an actual National emergency but it has been used thousands of times to warn of local, natural, or manmade threats.

The old EBS required that an official call the primary EBS station with the warning message. That primary station, in turn, would activate special EBS tones that would unlock EBS alert decoders in every radio and television station tuned to that station. The FCC required every broadcast station to buy and maintain such equipment.

There were several problems with the EBS that grew over the years:

* First, the threat of a national emergency diminished.
* Second, many states didn't utilise the benefits of the EBS for local emergencies.
* Third, more and more broadcast stations were allowed to operate unattended thereby making the relay of any warning message impossible. Even if a station was attended, if the control operator stepped out of the room when an alert came in, the operator was not there to manually handle it.
* Fourth, the long, obnoxious EBS tones used in the weekly tests served to drive listeners away to other stations.
* Fifth, listeners could have a false sense of security about a system that local officials never planned to use or failed to use.
* Sixth, and perhaps one of the most important weaknesses, was that the EBS depended upon the domino theory; i.e., if the primary station failed for any reason, none of the other broadcasters could receive and retransmit the warning.

1997 heralded the upgrade of the venerable EBS into the digital communications age and automation. In other words, there will still is the verbal warning message but it will be accompanied by digital bursts that do many things. The digital header contains the type of warning, for what county or counties, a date/time stamp, and the issuing authority. The FCC regulations require that every broadcaster receive a minimum of two radio signals. Many stations are equipped for four or six or more. This means that a warning message may be relayed from several sources-no more "dominoes." The EAS becomes a web. The "smarts" within an EAS decoder rejects duplicates so that there should be no danger of multiple activation's for the same event.

Equally important is that the EAS enables any radio station to automatically put that warning message over the air without any human intervention. This means that, whether the station is attended or not, that warning will be broadcast to its audience. It is predicted that over 80% of the nation's broadcasters will opt for this automatic "loop through" for EAS warning bulletins.

Because the EAS has the ability to provide the message digitally, this enables it to be carried by television stations and cable television companies. Television stations are not required to place additional text or instructions on the screen for the hearing impaired, but the State of California has facilitated this with a cooperative joint industry-government supported system called the EDIS (Emergency Digital Information Service.) The EDIS complements, but is not a part of, the FCC-mandated Emergency Alert System.

CATV companies will become FCC-required participants in the EAS.

There is a new requirement in the EAS regulations-a coordinated, monthly test that includes every AM, FM and TV station. The broadcasters are given the option to automatically relay or delay the monthly broadcast but by no more than 15 minutes. To best test the system end to end, it is recommended that the Required Monthly Test originate from time to time from an Emergency Operations Centre. Thus all participants are trained: the county emergency management people, all of the broadcasters and CATV firms, and the public.

The FCC requires all new EAS Plans. Every state is divided into one or more Local Areas. The larger a state's geography, the more Local Area plans must be accomplished. The Plan should be simple, accurate, and easy to follow. Together, the Local Plans constitute the State Plan. There are several formats; some are simple and some are not. We support a format for a State EAS Plan that has two parts. Part I is the introduction, general description, glossary, and other non-perishable information. The standard operating procedures, any perishable, changeable information, and data always goes into Part II. Part II is comprised of separately numbered Communications Operations Orders or COOs.

GENERIC SCRIPTS

"This is a coordinated monthly test of the broadcast stations and cable systems of your area. Equipment that can quickly warn you during emergencies is being tested. If this had been an actual emergency such as [INSERT TYPES OF EMERGENCIES THAT MAY OCCUR IN THE GEOGRAPHIC AREA), official messages would have followed the alert tone. [INSERT STATION CALL SIGN OR CABLE SYSTEM NAME] serves the [FCC LOCAL AREA NAME]. This concludes this test of the Emergency Alert System."