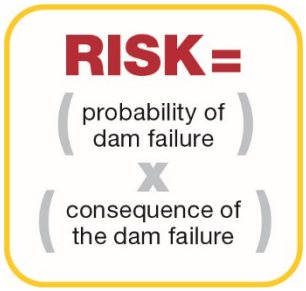
Risk Reduction Measures for Dams

FEMA

Technical Advisory 1 – North and South Carolina DR-4285-NC and DR-4286-SC

Purpose and Intended Audience

The purpose of this Technical Advisory is to help people and organizations better understand the various measures that can be taken to reduce the risks from and improve resilience to dam failure. The intended audience includes federal, state, and local officials; tribal leaders; county and city engineers, planners, and emergency managers; dam owners and operators; building and property owners near or potentially affected by a dam failure; and other interested stakeholders.



Introduction

Numerous measures can be taken both to reduce the risk of dam failure and the effect of a dam failure. The measures can be taken by individuals, dam owners and dam operators, organizations, communities, relevant state and local agencies, or tribes. This advisory provides an overview of the risk reduction measures for consideration and use, based on individual situations, and provides resources with more information.

Risk Reduction Measures

Risk reduction measures can be implemented by any entity that may be affected by or is at risk from a dam failure, including state, local, and tribal governments; communities; dam owners and operators; and individual property and business owners.

The most effective risk reduction occurs when all parties—from the state government to community agencies to dam owners to at-risk individuals—are aware of each other's actions and coordinate them effectively. No entity can act alone and expect to be successful. Working together maximizes risk reduction in every phase of the risk reduction process (pre-event, mid-event/response, and post-event/recovery).

Risk reduction measures aimed at reducing the likelihood of a dam failure and improving the resilience of those impacted by a potential dam failure should be tailored to the needs of all stakeholders. Stakeholders must understand their roles and responsibilities to ensure effective risk reduction and incident management. Strategies, frameworks, initiatives, plans, and procedures must be flexible and adaptable to the unique and dynamic environment created by each disaster. One of the initial critical steps is identifying the at-risk population and understanding each stakeholder's mission, objectives, obligations, and expectations for risk reduction. Ensuring effective communication among stakeholders will improve coordination among the various entities, particularly following a dam failure.

Public Outreach

Effective public outreach is crucial to the success of pre-, mid-, and post-event actions taken to reduce the risks from dam failures and improve resilience. These actions are shown in Figure 1.

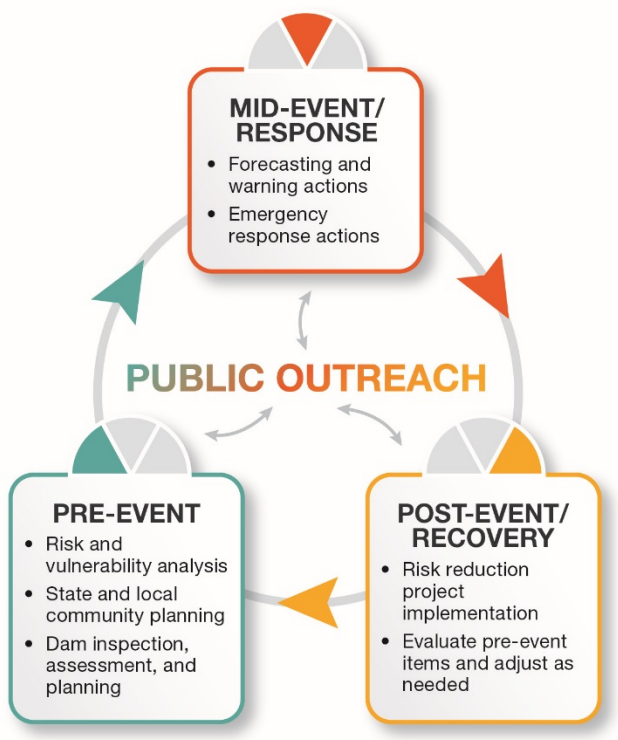


Figure 1: Pre-, mid-, and post-event actions

Public outreach should be undertaken to raise awareness about risk and to disseminate information as needed on improved planning, preparedness, mitigation, and recovery operations. Outreach actions can be performed by dam owners, emergency management personnel, dam safety officials, homeowner associations, and other stakeholders to increase dam risk awareness and facilitate coordination during emergency events.

A coordinated public outreach campaign should be conducted at the federal, state, county, local and tribal, levels using a multimedia, multipronged approach that includes outreach tools such as social media, community websites, Town Hall meetings, seminars, workshops, brochures and flyers distributed by mail or made available at public buildings, and radio announcements.

Public outreach should be used to:

- Raise awareness of dam safety issues, facilitate cooperation, and provide a forum for the exchange of information
- Provide information on the potential risks of living downstream of a dam and what actions have been taken to mitigate the risks
- Help communities upstream and downstream of dams and communities that could be impacted by dam failure (e.g., loss of water for firefighting activities if they rely on a reservoir) to better understand their risk in order to be better prepared during an emergency.

Pre-Event Planning

Pre-event planning is essential for reducing risk and identifying actions that can be performed by appropriate stakeholders. Numerous effective actions can be undertaken. The actions are generally grouped as follows:

- Assessing risk
- Preparing appropriate plans
- Performing mitigation and capital improvements as needed
- Implementing dam-specific preparedness actions
- Conducting public outreach

Terminology

Hazard – Natural, technological, or human-caused source or cause of harm or difficulty (FEMA, 2010).

Threat – Natural or manmade occurrence, individual, entity, or action that has or indicates the potential to harm life, information, operations, the environment, and/or property (FEMA, n.d.)

Vulnerability – Physical feature or operational attribute that renders an entity open to exploitation or susceptible to a given hazard (FEMA, 2010).

Assessing Risk

Any stakeholder affected by a potential dam failure may prepare a risk assessment to evaluate threat, hazard, risk and vulnerability as it pertains to their specific situation.. The results can be used to inform emergency preparedness and the

other pre-event actions described in this advisory, including planning, mitigation, capital improvement, and dam-specific actions. Specific assessments and related actions that can be taken by stakeholders are described in the paragraphs that follow and listed in Table 1.

Risk Assessment

Many types of stakeholders may find it advantageous to conduct a risk assessment. A risk assessment identifies potential hazards and analyzes what could happen if a hazard occurs (https://www.ready.gov/). The information included in the assessment will vary depending on the desired results. For example, local planning departments may want to perform a risk assessment that identifies the interaction of land planning and building zone decisions with dam inundation mapping. Business owners may want to determine whether potential damage to their building could result in a disruption of services to companies outside the at-risk area and whether they rely on services provided by a building within an at-risk area.

Best Practice – Inundation Mapping

It is important for those involved in risk management of dams (owners, regulators, state and local officials, and individuals, among others) to understand the actions that are necessary and the extent of the evacuation for a particular scenario. An evacuation may be triggered by a catastrophic dam failure, but it could also be necessitated by activation of an emergency spillway. Both scenarios may have different inundation and evacuation maps. Details related to different failure scenarios and dam releases should be in the EAP and EOP, and all appropriate stakeholders should be exercised accordingly for the given dam.

A risk assessment has four basic components: identifying the hazard, profiling the hazard event, inventorying potentially affected assets, and estimating the potential for human and economic losses based on the exposure and vulnerability of people, buildings, and infrastructure. For more information on performing a risk assessment, see https://www.fema.gov/hazard-identification-and-risk-assessment.

THIRA

A THIRA is a strategic risk assessment process that helps the whole community, including all levels of government, to help a jurisdiction understand its risks, its vulnerabilities, and estimate its capability requirements. A THIRA provides a standardized, comprehensive approach to identifying and assessing risks, vulnerabilities, and associated impacts and helps jurisdictions understand the resources and actions needed to avoid, divert, lessen, or eliminate a threat or hazard. THIRAs can be used to inform a variety of emergency management efforts, including emergency operations planning, mutual aid agreements, and hazard mitigation planning. For more information on THIRAs, see https://www.fema.gov/threat-and-hazard-identification-and-risk-assessment.

Table 1: Stakeholder Actions Related to Assessing Threat, Hazard and Risk

Stakeholders	Action[1]
Federal, state, tribal	• Prepare a THIRA to assess preparedness • Perform a vulnerability assessment for critical infrastructure and other assets at risk from a dam failure
State and local jurisdictions	• Perform a vulnerability assessment to identify community buildings and other assets at risk from a dam failure • Prepare a hazard mitigation plan to identify location-specific hazards; state and local hazard mitigation plans should include dams and dam risk information for the state or community as appropriate and available
County and city engineers	• Perform a vulnerability assessment to identify hospitals, schools, community buildings, and other assets at risk from a dam failure
Planners / zoning department	• Review inundation maps to identify areas of the community at risk from a dam failure • Review community plans to determine whether newly developed areas are vulnerable
Emergency managers	• Coordinate with dam owners to ensure that dam inundation mapping is correct and current

Stakeholders	Action[1]
Building / property owners near dam	• Evaluate risk from a dam failure, including direct loss from inundation and economic loss from business disruption; a risk assessment should include critical linkages that may result in vulnerabilities to other properties (e.g., damage to a data center within an inundation zone may affect many businesses outside the inundation zone) • Consider taking preparedness actions such as creating a building-specific EAP, improving building resistance to flooding, or purchasing appropriate insurance
Dam owners and operators	• Complete a risk analysis to identify credible potential failure modes[2] • Identify potential mitigation actions • Identify risks that would remain after mitigation • Use results of the risk analysis to prioritize mitigation actions • Re-assess dam risk and potential risk reduction options when hazards, threats, or consequences have significantly changed • Use a vulnerability assessment to inform risk reduction efforts described in this advisory, including before the event, during the event, and after the event

1. This table includes only some of the many actions that can be taken to reduce risk from dam failure
2. For more information on a potential failure mode analysis, see https://www.usbr.gov/ssle/damsafety/risk/BestPractices/Chapters/I-3-20150313.pdf

EAP = Emergency Action Plan; THIRA = Threat and Hazard Identification and Risk Assessment

Planning Actions

Many entities, from federal to local, are involved in dam safety planning activities, and these activities serve a wide variety of purposes, from long-term resilience to short-term emergency response. This advisory presents several planning activities, but is not intended to be inclusive of all planning that could be performed to help stakeholders reduce the risk of a dam failure, prepare for a potential dam failure, and improve response and recovery activities should such an incident occur.

Planning activities that should be performed by dam owners and operators, including developing an Emergency Action Plan (EAP), are described in the "Dam-Specific Activities" section of this advisory.

Terminology

Emergency Action Plans (EAPs) and Emergency Operations Plans (EOPs) are two of the key elements of emergency planning for reducing risks associated with dam failure.

An **EAP** prepared for a dam is a formal document that identifies potential emergency conditions at the dam and specifies actions to be taken to minimize loss of life and property damage. EAPs include inundation maps. EAPs are the responsibility of the dam owner. For more information, see FEMA P-64, *Federal Guidelines for Emergency Action Planning for Dams* (2013).

An **EOP** is a plan that defines the scope of preparedness and emergency management activities for a specific jurisdiction. EOPs are the responsibility of the governing jurisdiction at the state, local, and tribal levels. For more information, see *Developing and Maintaining Emergency Operations Plans: Comprehensive Preparedness Guide (CPG) 101* (FEMA, 2010).

Note: Other organizations such as businesses and nonprofits can also develop EOPs, but this advisory is focused on government EOPs.

State, Local, and Tribal

Planning activities at the state, local, and tribal jurisdiction levels should include long- and short-term risk reduction, emergency response, and post-event recovery. See Table 2 for specific planning actions.

Zoning and Land Use Planning

Communities should consider the possibility of a dam failure when determining their zoning and land use planning policies.

Hazard Mitigation Planning

Hazard mitigation plans are prepared at the state, multi-jurisdictional, or local level. Their purpose is to mitigate hazards before emergencies occur (see the section "Assessing Risk" above).

Consequence Assessment and Planning

State, local, and tribal governments should perform a dam failure consequence assessment for their given jurisdictions or areas of responsibility using information obtained from the risk and vulnerability assessment (see Table 1), information provided by the dam owner's inundation maps and EAP, state or local hazard mitigation plans, and other information as needed. Dam operators can use the consequence assessment to prepare for potential consequences of dam failure and make sure procedures and agreements are in place to facilitate response and post-event recovery. Information from consequence planning should be integrated into the relevant Emergency Operations Plan (EOP), as appropriate, and used to update other plans accordingly.

Table 2: State, County, Local, and Tribal Planning Actions

Type of Planning	Action
Consequence	• Gather information from risk and vulnerability analyses, dam EAP, dam failure inundation maps, and state or local hazard mitigation plans • Ensure that consequence planning is incorporated into relevant EOP
Preparedness	• Develop pre-disaster Memorandums of Agreement and/or Memorandums of Understanding with adjacent jurisdictions • Build partnerships (neighborhoods, businesses, utility service providers, and local government agencies) to strengthen response and recovery
Operational	• Prepare for mass care (sheltering, feeding operations, emergency first aid, bulk distribution of emergency items, and collecting information on victims and providing it to their families) • Test and evaluate pre-disaster plans through exercises (e.g., tabletop exercise, functional exercises)
Mitigation	• Determine whether critical or essential facilities require mitigation and retrofitting such as wet or dry floodproofing • Voluntarily move, remove, or elevate structures and restrict development in the dam failure inundation zone • Relocate critical infrastructure or critical functions outside the failure inundation zone, elevate above anticipated flood levels, or protect infrastructure that cannot be relocated or elevated (e.g., pipelines, water, sewage, natural gas, pump systems)
Security	• Develop security plans—both physical and cyber, if appropriate
Zoning	• Review hazard creep regularly • Review and update zoning as needed
Emergency operations	• Include roles and responsibilities in the EOP. Warning and evacuation planning and implementation are responsibilities of the state and local emergency management personnel with the legal authority to perform these actions. • Indicate in the EOP when to evacuate and when to allow re-entry • Include evacuation maps in the EOP. Evacuation maps are used by emergency management personnel to notify the public and evacuate areas potentially affected by an emergency. Evacuation maps show information such as road closures, detours, and shelters to facilitate timely evacuation of people. Emergency management personnel can also adapt inundation maps to facilitate evacuation procedures by adding features such as highlighted evacuation routes and emergency shelters. Evacuation maps may also show phased zones so the most at-risk populations can be evacuated first. • Integrate information into the EOP from associated EAPs (including inundation maps) as well as vulnerability assessments and consequence planning information

Emergency Response Plans

Emergency response plans should be tactical and focus on personnel, equipment, and resources that would be needed during a dam incident response. Emergency mutual aid compacts, technical assistance, procurement, or other resources should be defined and included.

Emergency Operations Plans

Emergency planning is an important part of risk reduction. EOPs are prepared by state, local, and tribal jurisdictions to define the scope of preparedness and emergency management activities necessary for the jurisdiction. As needed, EAPs, including inundation maps, for each dam affecting the jurisdiction should be integrated into the EOP.

Business and Property Owners

Similar to state and local planning efforts, business and property owners should consider strategies to reduce short- and long-term risk from a dam failure, continuity of operations and emergency response, and post-event recovery. See Table 3.

Table 3: Business and Property Owner Planning Actions

Type of Planning	Action
Continuity of Operations Plan	• Consider whether capital improvements are needed to adequately protect the business or property in the case of a dam failure • Specify dependencies with other businesses
Emergency Operation Plan	• Prepare an EOP or continuity of operations plan to protect building tenants and minimize business disruption
Mitigation	• Voluntarily move, remove, or elevate structures in the dam failure inundation zone • Relocate critical infrastructure or critical functions outside the failure inundation zone, elevate above anticipated flood levels, or protect infrastructure that cannot be relocated or elevated (e.g., pipelines, water, sewage, natural gas, pump systems)

Continuity of Operations

To minimize business disruption, businesses and nonprofit organizations should prepare a continuity of operations plan. The plan should include linkages with other businesses (refer also to the section above on "Assessing Risk").

Emergency Operations Plans

Emergency planning is an important part of risk reduction. Businesses, nonprofit organizations, and building owners may want to consider preparing an emergency operations plan to protect people and property during an emergency. Such a plan should integrate information from the risk and vulnerability plans (see Table 1) and may reference the state or local EOP, including emergency routes, and the dam-specific EAP, including inundation maps.

Dam-Specific Activities

Dam owners and operators are responsible for preparing an EAP for their dams. Dam owners should consider performing periodic dam evaluations regularly and should conduct regular dam inspections and the required operations and maintenance. Dam owners and operators should also undertake preparedness activities such as securing appropriate emergency contracts with specialty vendors and providing a comprehensive and targeted training program to their staff, inclusive of regularly scheduled refresher sessions. Table 4 is a list of activities for dam owners.

Dam Emergency Action Plans

Critical Coordination

It is critical for dam owners/operators to coordinate EAP information with the state and local emergency management agencies that are responsible for developing their EOPs.

It is the dam owner or operator's responsibility to prepare an EAP for the dam. EAPs should be dam specific and contain suggested procedures for protecting the dam and issuing early warning and notification messages to emergency management authorities so they can carry out EOP procedures. For more information about EAPs, see FEMA P-64, *Federal Guidelines for Emergency Action Planning for Dams* (2013). Dam owners and operators should provide relevant EAP information for inclusion in state and local EOPs and especially inundation maps, which are used to develop the evacuation maps included in EOPs. Specific activities are shown in Table 4.

Table 4: Pre-Event Activities for Dam Owners and Operators

Activity	Description
Write an Emergency Action Plan	An EAP should include the following: • Roles and responsibilities. The dam owner is responsible for detecting and evaluating dam safety incidents, classifying the incident, notifying emergency management authorities, and taking appropriate response actions at the dam. Dam owners should not assume or usurp the responsibility of government entities for the evacuation of people.[1] • When to activate the EAP • Emergency protective measures • Monitoring procedures during incidents • Inundation maps, which show the areas that would be flooded if a dam failed. Some inundation maps include travel times for wave front and flood peaks at critical locations or whether there are operational releases during flood conditions. Some also identify critical infrastructure and population at risk that may require protection, warning, and evacuation in the event of a dam failure.
Conduct training	• Train personnel in monitoring and inspection procedures for the dam • Train staff to understand the instrumentation used at the dam, how to interpret the data, and typical seasonal trends so they can notify the dam owner of abnormalities
Conduct dam inspections	• Review the latest inspection report. • Complete a thorough inspection of the dam and appurtenant features to assess their operation and condition. Check for damage and undermining of structural components such as spillways. Diligent inspection and monitoring can help identify minor issues before they become emergencies.
Conduct a dam evaluation	• Review the latest inspection report. • Perform a desktop review of changes in recommended practices. • Determine whether a specific dam evaluation is needed (e.g., seismic). • Evaluate conformance to current engineering standards and dam safety requirements and upgrade the dam to meet the appropriate standards as needed. • Consider evaluating the dam or elements of it, from a vulnerability, liability, or risk perspective, and upgrade the dam if it makes sense to do so even if regulations do not require it. Upgrading will minimize dam owner vulnerabilities, risks, and liabilities; reduce potential consequences downstream; or increase dam and community resilience.
Perform operations and maintenance	• Properly maintain the dam and follow a comprehensive maintenance schedule to ensure that elements are repaired before they become problematic or expensive to fix • Perform needed repairs
Establish an instrumentation program	• Consider installing instrumentation and establishing a corresponding monitoring program when warranted
Perform needed mitigation	Implement mitigation projects that can increase dam resilience and reduce dam failure consequences. Consider: • Adding redundant or improved operational systems for complex dams • Adding interim risk reduction measures to reduce risk until permanent solutions can be funded • Decommissioning and removing the dam to eliminate dam-related hazards if the dam is no longer needed or outlives its benefit

1. There are circumstances, such as when structures are very close to the dam, when the dam owner is in the best position to warn people to evacuate due to lack of warning time. These situations should be closely coordinated with the responsible government entities and included in the EAP and EOP as to how to best carry out the evacuation and who is responsible for what.

Dam Risk Reduction Evaluation

A dam risk reduction evaluation includes (1) assessing the dam and (2) implementing any needed engineering alterations or improvements to ensure that the dam meets current dam safety requirements or making recommendations for rehabilitating the dam if needed. Dam owners may choose to perform a dam risk reduction evaluation in response to specific concerns (e.g., seismicity) or as part of a rehabilitation or capital improvement project.

Dam owners should consider regularly evaluating their dams for conformance to current engineering standards and dam safety requirements. Standards and safety requirements can become more stringent over time, and the gap between current standards and safety requirements and the conditions and performance capabilities of the dam can widen to a potentially unacceptable level. In these cases, upgrading the dam would be prudent to reduce risk, vulnerability, and liability.

If deficiencies are identified, risk assessments can help identify those that might significantly contribute toward adverse risk and provide a basis for prioritizing funding for incremental remedial action.

The dam risk reduction evaluation might consider:

- Changes in watershed hydrology (upstream and downstream conditions)
- Downstream development (hazard creep)
- Updated hydrologic guidance for extreme storms
- Dam stability and performance
- Seismic stability and performance as prescribed for the dam's seismic zone
- Installing instrumentation to aid in assessment

Dam Inspections

Dam inspections should be conducted by the dam owner and his or her technical representatives or consultant, as outlined in the dam's operations and maintenance procedures. Dam inspections should be conducted annually or as required by regulatory agencies. Depending on the dam's hazard classification, state dam safety professionals may regularly update dam records as part of the state's dam safety program.

Operations and Maintenance / Personnel Training

Dam owners and operators should perform routine maintenance and make any needed upgrades or improvements. Additionally, staff should undergo regular training to ensure they are fully prepared for a possible failure event. Trained personnel are crucial in identifying issues before they are critical. Trained staff can also prepare the dam for emergencies.

Planning Ahead

Vendor Contracts
Dam owners may want to consider entering into standing contracts for bulk materials (i.e., aggregates) that may be needed under normal operations and during critical situations. Similarly, dam owners should think ahead about whether it would be advantageous to enter into a contract with a dam contractor that can respond during an emergency situation.

Instrumentation Program
Developing an instrumentation program and training personnel to interpret the data from the program can alert personnel of abnormalities. Staff should also understand seasonal trends in the data.

Mid-Event Actions

Pre-Emergency Forecasting and Watch Systems

Pre-emergency warning systems notify state and local emergency managers and dam owners and operators of potential issues. Some of the forecasting tools that are used in pre-emergency warning systems are summarized in Table 5.

Table 5: Forecasting Tools and Watch Systems

Forecasting Tools	Used By	Description
Flash Flood Watch (NWS)	• Local emergency managers • Dam owners and operators • Potentially affected building and property owners • PAR	The NWS states that "… a dam failure can cause a flash flood, depending on the type of dam and time period during which the break occurs." The NWS defines a flash flood as "a flood which is caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours." Flash flood watches are issued to indicate current or developing hydrologic conditions that are favorable for flash flooding in and close to the watch area, but the occurrence is neither certain or imminent. For NWS definitions, see http://www.weather.gov/bgm/severedefinitions.
Advanced Hydrologic Prediction Service (NWS)	• Local emergency managers • Dam owners and operators	The NWS website hosts the Advanced Hydrologic Prediction Service, which includes graphical products that display the magnitude and uncertainty of occurrence of floods and droughts in hours, days, and months in advance to enable government agencies, private institutions, and individuals to make informed decisions about risk-based policies and actions to mitigate the dangers posed by floods and droughts. For more information about the Advanced Hydrologic Prediction Service, see https://water.weather.gov/ahps/about/about.php.
Quantitative Precipitation Forecast (NWS)	• Local emergency managers • Dam owners and operators	NWS prepares and issues forecasts of accumulating (quantitative) precipitation, heavy rain, and heavy snow and highlights areas with the potential for flash flooding. For more information on Quantitative Precipitation Forecasts, see http://www.wpc.ncep.noaa.gov/qpf/qpf2.shtml.
Instrumentation for dams (various)	• Dam owners and operators	Computer-based data-processing systems evaluate collected data and issue warnings or alarms if certain threshold values are exceeded. Examples of events that can trigger an alarm include when the reservoir level rises above a critical elevation, seepage exceeds a pre-set limit, or piezometer (well) readings exceed specified values. Dam operators should assess abnormal instrumentation warnings before issuing an evacuation notice to emergency management officials.

NWS = National Weather Service; PAR = population at risk

State and Local Emergency Management

Pre-emergency warning systems notify state and local emergency management personnel that conditions in the jurisdiction need to be monitored. If flooding conditions are expected in the region, personnel can begin communicating with all affected dam owners and other stakeholders and preparing resources.

Dam Owners and Operators

Pre-emergency warning systems notify a dam owner or operator when conditions at the dam need to be monitored. Dam owners and operators can use forecasting tools to determine whether a large amount of precipitation or snow melt could result in flood conditions. Forecasting tools give dam operators time to draw down the reservoir to increase storage capacity to accommodate anticipated flood inflows. The dam owner or operator can also use instrumentation at the dam to determine whether conditions are changing and need to be monitored or mitigated.

Emergency and Response Actions

Emergency warning systems notify state and local emergency managers and dam owners and operators of unfolding issues that could rapidly become emergencies. If an emergency situation seems possible or likely, dam owners should evaluate their dams and take action as needed. Table 6 is a list of some of the warning systems used by emergency managers and dam owners and operators. Table 7 is a list of possible emergency actions for dam owners and operators.

Table 6: Emergency Warning Systems

Warning System	Used By	Description
Flash Flood Warning (NWS)	• Local emergency managers • Dam owner and operator • Potentially affected building and property owners • PAR	• Issued to inform the public, emergency management entities, and other cooperating agencies that flash flooding is in progress, imminent, or highly likely. • An example of the dam flash flood warning system is provided in Section 5.10 of the *National Weather Service Manual 10-923* (NOAA, 2017) at http://www.nws.noaa.gov/directives/sym/pd01009023curr.pdf.
Community Warning Systems (city or county officials)	• Local emergency managers • Potentially affected building and property owners • PAR	• Warning sirens can alert people in a local area that an emergency situation is unfolding. Sirens are typically activated by city or county officials (police, fire department, or emergency management personnel). People in the area should be informed of the significance of the warning sirens and their anticipated response. • Automated notification systems, such as Reverse 911 and CodeRED notifications, can be deployed to many people at once over the phone.

NWS = National Weather Service; PAR = population at risk

Table 7: Emergency Actions for Dam Owners and Operators

Actions	Description
Evaluate emergency situation	• Inspect all components of the dam, including the spillway, downstream face, and outlet works. • Conduct situational awareness flyovers for inflows. Drones or helicopters can be used if roadways are inaccessible. • Establish infrared camera operations if the emergency happens at night. • Initiate diver operations if underwater inspections or repairs are needed. • Determine if event-specific inundation models should be used to inform emergency management's evacuation efforts.
Determine appropriate action	Possible actions that can be taken: • Use pumps and siphons to draw down the reservoir • Initiate dam repair • Install sandbags • Cut ditches to provide diversion • Build cutoff walls or levees

State and Local Emergency Management

Emergency warning systems (like flash flood warnings) can notify state and local emergency management personnel that flooding is expected or is occurring in the jurisdiction. State and local emergency management personnel need to communicate with dam owners/operators to determine when it is necessary to initiate community warning systems and begin evacuations.

Dam Owners and Operators

Dam owners and operators must be prepared to respond to unfolding emergency situations. During emergencies, several actions can be taken to gather information about the situation. Once the situation has been evaluated, dam owners and operators can determine which actions are appropriate to try to save the dam or at least postpone failure. Dam owners and

operators should consult their EAP to determine what actions need to be taken and who should be notified (e.g., emergency managers, state dam safety personnel) based on current conditions.

Post-Event Recovery

The funding opportunities described below are available to support risk reduction projects.

FEMA Public Assistance Program

After a federally declared disaster, FEMA can provide funding assistance through the Public Assistance Program for eligible risk reduction projects to state, local, tribal, and territorial governments and certain types of private nonprofit organizations.

Measures considered eligible for funding are those that fall under Category B Emergency Protective Measures. Emergency protective measures conducted before, during, and after an incident are eligible if the measures eliminate or lessen immediate threats to lives, public health, or safety OR eliminate or lessen immediate threats of significant additional damage to improved public or private property in a cost-effective manner.

FEMA may require certification by federal, state, local, tribal, or territorial government officials that a threat exists, including identification and evaluation of the threat and recommendations of the work necessary to cope with the threat.

Other FEMA Programs and Funding Sources

For more information on FEMA programs and funding sources, see:

- FEMA's *2017 Public Assistance Program and Policy Guide*, available at https://www.fema.gov/media-library/assets/documents/111781.
- *Sources of Federal Grant Funds for Dams and Downstream Structures: Technical Advisory Dams in South Carolina* (2016), unpublished, but available from FEMA.
- *FEMA Resources and Services Applicable to Dam Risk Management* (FEMA P-1068, December 2015), available at https://www.fema.gov/media-library-data/1452453732996-ecaca7db5837aba46a7bbece7bc2f17e/DamRiskManagementResources.pdf

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Websites

- Association of State Dam Safety Officials: https://damsafety.org/
- South Carolina Dam Safety: http://www.scdhec.gov/environment/WaterQuality/DamsReservoirs/
- North Carolina Dam Safety: https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permits/dam-safety

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Technical Advisory 3: Dam Awareness

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