



Risk Reduction Measures

While this document refers to dam failure, it is important that Emergency Managers consider the impacts on the community of any dam incident. This includes emergency situations that threaten the integrity of the dam, or its components, and/or that could result in an increased risk to the population. This also includes operational releases from the dam (e.g., principal spillway, emergency spillway, etc.) that may result in flooding major roads, homes or businesses.

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. Working together maximizes risk reduction in every phase of the risk reduction.

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. 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. 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.

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.



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

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 to be better prepared during an emergency.
- Assisting communities on planning and exercising for evacuation procedures

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

Assessing Risk

Emergency managers should work closely with dam owners, federal and state regulators and other relevant stakeholders in preparing risk assessments to evaluate threat, hazard, risk and vulnerability of exposed people and assets as it pertains to dams that impact their jurisdiction.

Risk Assessment

A risk assessment identifies potential hazards and analyzes what could happen if a hazard occurs (www.ready.gov). The information included in the assessment will vary depending on the desired results.

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 www.fema.gov/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 fact sheet 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.

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 1 for specific planning actions.

Zoning and Land Use Planning

Communities should consider the impacts of a possible controlled or uncontrolled release of the dam reservoir 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.

Consequence Assessment and Planning

State, local, and tribal governments should perform a dam risk consequence assessment for their given jurisdictions or areas of responsibility using information obtained from the risk and vulnerability assessment, information provided by the dam owner’s inundation maps and Emergency Action Plan (EAP), state or local hazard mitigation plans, and other information as needed. Dam operators can use the consequence assessment to prepare for potential consequences 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 1: State, County, Local, and Tribal Planning Actions

Type of Planning	Action
Consequence	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Develop security plans—both physical and cyber, if appropriate
Zoning	<ul style="list-style-type: none"> • Review hazard creep regularly • Review and update zoning as needed
Emergency operations	<ul style="list-style-type: none"> • 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

Like 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.

Table 2: Business and Property Owner Planning Actions

Type of Planning	Action
Continuity of Operations Plan	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• Prepare an EOP or continuity of operations plan to protect building tenants and minimize business disruption
Mitigation	<ul style="list-style-type: none">• 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 to “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. The plan should integrate information from the risk and vulnerability plans 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.

Dam Emergency Action Plans

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.

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 EOPs.

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 technical representatives or consultants, 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.

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.

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.

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

FEMA Public Assistance Program

After a federally declared disaster, the Federal Emergency Management Agency (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.