



Model State Dam Safety Program Manual

September 2022



FEMA



Association of State
Dam Safety Officials

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Acknowledgements

The Board of Directors of the Association of State Dam Safety Officials wishes to extend its appreciation to the 2019–2022 Model State Dam Safety Program Update Task Force. Significant contributions to this update were made by:

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We would also like to thank the Fernandes Family Charitable Trust, a Donor Advised Fund of the U.S. Charitable Gift Trust for a generous monetary donation that helped fund this update.

The Model State Dam Safety Program was originally developed by FEMA in 1987 and was amended in 1997, 2007, and 2022 (with the present document) to reflect the current experiences and expertise of state program officials.

Publication Date:

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Introduction

1. Purpose and Audience Focus

The overall purpose of the Model State Dam Safety Program (Model Program) is to enhance national dam safety. The objective is to encourage progressive safety standards in the promulgated practices and procedures state agencies use to regulate dam site investigation, design, construction, operation and maintenance, and emergency planning and preparedness. The Model Program is meant to outline the key components of an effective state dam safety program. It does not mirror any state program, nor does it supplant any state's existing criteria. It is intended to provide guidance on the development of more effective and sustainable state programs that will mitigate major risks facing dams across the nation. The Model Program is a collaborative effort between the Association of State Dam Safety Officials (ASDSO) and the Federal Emergency Management Agency (FEMA) National Dam Safety Program. The Model Program supports ASDSO's mission to improve the condition and safety of dams through education, support state dam safety programs, and foster a unified dam safety community.

The target audience for this document includes state dam safety program managers, their management, and legislators, with dam owners, engineers, and dam safety staff as a secondary audience.

2. Description

The document contains six chapters, organized as follows:

1. Authorities
2. Communication, Coordination, and Outreach
3. Existing Dams
 - Introduction
 - Dam Information
 - Dam Inspections
 - Risk Evaluation and Management
 - Public Safety and Security
 - Compliance and Enforcement
4. Dam Construction, Modification, and Removal
5. Emergency Planning and Incident Response

6. Program Administration and Management



Model State Dam Safety Program Resources

This Model Program contains applicable references, web links, and technical summaries. These and other information can be found on the [Model State Dam Safety Program Resources](#) reference page on the ASDSO website.

Significant changes to the Model Program from the previous version (2007) include a revised chapter organization and an increased emphasis on existing dams. Other changes include:

- A chapter on public, stakeholder, and owner outreach instead of a public relations plan
- A chapter dedicated to existing dams, with subsections describing inventory, hazard potential, inspections, safety and security, risk evaluation, and enforcement
- A periodic comprehensive review inspection, in addition to routine periodic inspection
- Risk evaluation
- Additional guidance for construction, modification, and removal and deregulation of dams
- Incident response as an essential dam safety program role
- A separate chapter about program administration and management (earlier editions had elements of program administration and management throughout the various chapters)

Many elements of this model provide several options for state programs to achieve model objectives. There are other areas in which the use of consistent terminologies or processes across state programs are essential, including:

- Hazard potential classifications, especially the terms “high” and “significant”
- Consistent evaluation of potential loss of life and/or damage to property, infrastructure, or the environment for those hazard potential classifications
- Two different levels of periodic inspections: routine and comprehensive review inspections
- Use of both deterministic and risk-informed analyses

Chapter 1 – Authorities

Key Takeaways

1. Dam safety programs can only do what they are authorized to do
2. Support is needed from state legislature to change dam safety program authorizations
3. Dam safety officials must know how the system works within their state’s government and what state agencies are involved with dam safety

Checklist

Dam Safety Law Authorities

- Administration of the dam safety laws in one agency
- Jurisdictional criteria for dams that are regulated by that agency
- Duty to adopt rules and establish standards for construction, modification, and removal
- Qualified engineer must oversee construction, modification, and removal
- Permit or application approval required prior to construction, modification, and removal
- Second approval required prior to impoundment, after construction or modification
- Inspections during construction and periodically during the life of the structure
- Agency personnel permitted to enter private lands for inspections
- Actions for unsafe or neglected conditions or operations, with penalties for violations
- Liability disclaimer for the agency personnel and actions
- Sufficient funding from the state and from fees to support all program activities
- Dedicated funds for emergencies and rehabilitation
- Require the dam owner to be fully responsible for safety, follow rules and approval or permit conditions; inspect and monitor; operate and maintain; demonstrate financial capability; retain records; develop an Emergency Action Plan; and take necessary actions in an emergency

Minimum Dam Safety Rules

- Definition of terms, including the national definition for hazard classification potential
- State specific design review criteria, including design flood and earthquake events by dam classifications
- Permit or application approval process clearly described, with required notice for beginning construction, agency approval of major changes, as-built records, a project completion report, and a filling and monitoring schedule submitted by the engineer
- Approval of operations and maintenance plans or specific operating conditions
- Requirement of Emergency Action Plan, with exercises and updates, for high and significant hazard dams
- Routine and comprehensive review inspection requirements and frequencies
- Fee structures and processes
- Enforcement procedures including notice, hearings, and civil and criminal penalties
- Owner financial responsibility and ongoing duty to maintain, rehabilitate, and/or remove the dam, consistent with current dam safety criteria

Definitions

Law – legislation passed by the state legislature and signed by the governor

Rule – explains a law and how the agency will administer the law, filling in administrative and technical details left out of the law

Policy – provides even more detail than rules about how the agency carries out program functions and critical decisions

1. Introduction

The Model Program recognizes that the foundation of any state dam safety program is the legislative authority and accompanying administrative regulations. Drafting periodic revisions to laws and regulations is essential. State statutes will provide authority for dam safety to a single agency to provide consistent oversight. If other agencies have dam safety authorities, they will coordinate with the lead dam safety agency for the state.

2. Law

State legislation will provide state dam safety programs with comprehensive statutory authority and sufficient appropriations to regulate the design, construction, modification, removal, deregulation, inspection, operation, monitoring, repair, and maintenance of dams in the state.

The following best-practice dam safety program activities should be described in state law.

Dam Construction, Modification, Operation, and Removal

- Define dams under state dam safety program jurisdiction
- Require promulgation of rules to establish standards and definitions for inspection, design review, construction, modification, maintenance, operation, repair, and removal and deregulation of dams
- Require a permit or formal approval in writing prior to the start of any non-maintenance-related activities
- Require that the design of new construction, reconstruction, enlargement, alteration, repair, operation, breach, and removal of dams and supervision of construction be in the charge of a registered professional engineer
- Require proof of financial capability for a person proposing to build *or purchase* a dam
- Prohibit water impoundment until project completion documents, including a refilling plan, have been approved

Dam Inspections, Reviews, and Analyses

- Define authority to conduct periodic engineering inspections and comprehensive review assessments of dams; inspect dams during construction and periodically during the life of the structure, with authority for dam safety program personnel to enter private lands to inspect dams
- Define authority to set the “safe storage level” of a dam as part of the periodic inspection and condition assessment rating

- Require the inspection and comprehensive review assessment of dams by a registered professional engineer experienced in the design, construction, and operation of dams
- Order corrective action, including storage restrictions, dam repairs, modification, or operational changes, if necessary, for the safety of a dam

Emergency Planning and Incident Response

- Require dam owners of high and significant hazard dams to have a complete emergency action plan (EAP) and to exercise the EAP periodically
- Require coordination of the owner and state with local emergency managers and first responders to establish roles and responsibilities for EAP maintenance, exercise, and emergency response
- Authorize the dam safety program to respond to incidents in which there is risk to people, property, infrastructure, or the environment, including actions at the dam if the owner is absent or unwilling to take action, and to access private property, as necessary
- Authorize the state program to accept volunteer support from public and private sources during dam safety emergencies

Program Implementation and Administration

- Prescribe the state dam safety program's role, if any, in dams owned by a federal agency
- Describe the state dam safety program's role, if any, in co-regulation of hydropower dams regulated by the Federal Energy Regulatory Commission (FERC)
- Authorize enforcement actions, including financial penalties for non-compliance with laws, regulations, or orders from a dam safety program
- Include a liability disclaimer for state dam safety program personnel
- Provide sufficient funding to support the program from any combination of general funds, special funds, and fees as needed to administer state dam safety laws and rules and regulations

The state law must specify that the safety of the dam is the dam owner's responsibility and describe dam owner liability for non-compliance. The law will require each dam owner to:

- Be responsible for the safety of their dams, including directing sufficient resources toward dam safety
- Comply fully with state dam safety laws and regulations
- Monitor, operate, and maintain the dam in a safe condition and make necessary repairs
- Comply with operating and permit conditions and with safety orders

- Conduct periodic inspections and analyses as may be required
- Submit reports on the condition of the dam
- Notify the dam safety program and responsible authorities of any unusual condition or high flow releases and take all necessary actions in accordance with an EAP or agency order
- Retain records

The state laws need to provide specific legal requirements for dam safety. Laws also authorize adoption of dam safety regulations or rules. State programs will strive to obtain the legal authorities outlined above by working with the executive and legislative branches after official agency approval for changes. Since laws can be difficult to change, it is especially important to exclude specific engineering methods from dam safety law because best practices for dams are continually evolving. When changes are anticipated in a state's dam safety laws, the dam safety program will review the Model Program and will also consider the model dam safety law at the Model Dam Safety Law (Appendix B).

Definitions of regulations versus rules vary by state, and states may use the term rule or regulation, or both. Regulations or rules should be written with a balance of clarity, specificity, and technical detail to be understood by the regulated community, including dam owners and their engineers. The following sections describe dam safety program best practices to be included in regulations, rules, and guidance.

3. Regulations and Rules

Regulations and rules are developed by the agency housing the dam safety program and require significant dam safety technical input. Effective rules explain the law and how the agency will administer that law and fill in administrative and technical details left out of the law. Some laws specifically require rules to address specific topics. The agency must develop rules if statutes so direct. In addition, some states have their jurisdictional criteria in rule or policy rather than in the law. Rules need to define all terms not already defined in statute. Rule development will also include a legal review to verify the agency is authorized by the law for any specified rule requirement. The administrative requirements for promulgation of rules are defined by each state, and each states' requirements must be followed.

Rule development can result from the adoption of a new law or a change to an existing law. In addition, the dam safety program may identify a need to make changes to align with modern best practices. Rule development or modification considers examples in the Model Program. Rules are normally developed with an advisory committee that includes members of the affected community, including dam owners, engineers, and emergency managers. Rules will be clear and specific and written so that dam owners and engineers can understand them. States may consider objective-based rules, which state what the rule is trying to achieve rather than mandating a specific design or other method. An example of objective-based rule is a listing of an event standard such as probable maximum flood or maximum credible earthquake. Rules that are specific to a methodology that may be subject to change should be avoided, as changes in methodology will require promulgation or amendment of the rules.

4. Policy

Dam safety programs will maintain policies consistent with the law and agency policies. Having a formal policy in writing is advised. Reviewing Chapter 6 may help with policy development. Elements of policy include public information, outreach, and awareness; collaboration; various methods of enforcement; target compliance time frames; and initiation of legal actions.



Issues Addressed by Policy

- Dam safety program administration of its dam safety laws and regulations
- The effect of other non-dam safety laws on the dam safety program, with particular importance placed on state and federal public information laws
- The program's use of support from other programs within the parent agency, including information technology and public information
- Dam safety program approaches to supporting its parent agency to achieve its mission
- Program coordination within the agency and with other agencies
- Dam safety program priorities if resources are limited, especially in emergency situations
- Requirements for maintaining professional and adequately trained technical staff

5. Standards, Procedures, and Guidance

Standards and procedures are developed with less external review than rules but still must comply with dam safety laws and all other state laws. Standards and procedures include all design and review standards not specified in rules. Standards and procedures provide more details than are provided in rules. Examples of items found in standards include procedures for hazard potential classification review, application submittal checklists, and administrative details for permits, orders, violations, and appeals of violations. The other chapters of this Model Program are intended to provide information a state dam safety program can use in developing standards and procedures appropriate for its state.

Chapter 2 – Communication, Coordination, and Outreach

Key Takeaways

1. Communication and outreach need to be at the forefront of every interaction between dam safety program staff and stakeholders
2. Informing dam owners, the general public, and other stakeholders can help reduce risk from dam failures and better advocate actions that support safer dams
3. Transparent sharing of information about state-regulated dams and coordinating with federal, state, and local emergency managers are critical activities for effective and efficient response to dam incidents and failures

Checklist

- Communication strategies in place for outreach (e.g., publicity campaigns, awards programs, brochures, and fact sheets)
- Regular formal and informal meetings with stakeholders
- Dam owner education and workshops
- Annual state activities to educate the public about the need for dam safety programs with sufficient resources to find and take actions on safety issues
- Policy on public information, including release of inspections and EAPs

Definitions

Stakeholders – a portion of the public and agencies or organizations with a specific interest in dams or a specific dam or the effects of dams or a specific dam

Dam owners – those legally responsible for the safety of the dam and for consequences from unsatisfactory dam performance; may be public, private, or an intermediate organization or district

General public – citizens and communities living below dams and within limits of dam failure inundation zones

1. Introduction

Dam safety programs must communicate clearly and efficiently to promote dam safety awareness and educate the general public about the safety of dams. These efforts include both day-to-day communications and outreach to affected parties. Dam safety programs will frequently engage with the stakeholders, including a portion of the public and dam owners. It is essential to communicate and provide critical information in a way the specific audience can understand. Different audiences have different needs and abilities to understand critical information. Model state dam safety programs need a written communications plan and strategies in place to meet the objectives of the plan. This chapter provides guidance on effective communication and outreach with stakeholders.

“Stakeholders” includes a portion of the general public and agencies or organizations with a specific interest in dams or a specific dam or the effects of dams or a specific dam. Stakeholders may include but are not limited to:

- Dam owners
- Citizens and communities potentially affected by dam-related flood and safety risks
- State and local officials
- Emergency management partners
- Media and journalists
- Consulting engineers involved with dams
- Contractors involved with dams
- Municipal water suppliers
- Industrial water users
- Agricultural water users
- Conservation and environmental organizations
- Realtors
- Local flood plain management officials
- Federal dam owners and regulators
- State and federal natural resource agencies
- Lobby or other organizations representing any of the above

“Dam owners” are the most critical stakeholder group, as they are ultimately responsible for actions to keep their dams safe. The owner is legally responsible for the safety of the dam and for consequences from unsatisfactory dam performance. Dam owners are a very diverse group. A dam owner may be public, private, or an intermediate organization or district. A dam owner may have large technical and operations staff or may be a single individual who owns property that includes a dam and reservoir. Although the term dam owner generally includes any technical staff (caretakers)

working for the owner, it is important to have an official dam owner point of contact. Typically, formal correspondence from the state dam safety program will be directed to that official contact.

The **“general public”** includes citizens and communities living below dams and within limits of dam failure inundation zones, i.e., the population that is at greatest risk from dam failures and incidents.

1.1. General Communications

Dam safety program policy will address information policy. State programs will follow their policies for all communications. It is advised that all formal communication, especially to dam owners and owners’ engineers, be in writing. Dam safety programs will decide communication policies based on state statutes governing public and non-public information. Dam safety program managers will provide direction to staff on roles in providing information outside of the dam safety program.

Informing dam owners, the general public, and other stakeholders can help reduce risks from dam failures and better advocate actions that support safer dams. Proactively preparing, practicing, and providing information, including through outreach and awareness initiatives, will provide secondary benefits during stressful events and incidents. These initiatives will establish messages and materials that can be used and be widely understood by public information officers (PIOs), stakeholders, and the general public. Further, dam safety program staff will develop experience in delivering consistent answers when asked tough questions.

1.2. Public Information Officers

Many state agencies will have specific PIOs (often not solely for the dam safety program) who conduct most direct contact with members of the media. Experienced dam safety staff are used as subject matter experts, and they will take part in determining public information messages. Dam safety program staff will meet with the agency PIO to understand their respective roles in providing information. Roles will be based on the skill and experience of the PIO and on the dam safety engineer’s ability to talk to non-engineers. Of critical importance are pre-defined roles and responsibilities and planning for dam safety incidents or emergencies.

Accurate information is essential when there are information requests from media individuals or organizations. This is an important part of raising public awareness of dams and dam safety, but communication will extend far beyond working with the media. The public information lead will be informed of all media questions. In all cases, and especially during an emergency, all relevant information will be researched for accuracy and vetted before a response is provided. Dam safety staff will coordinate with their PIO and be factual in all conversations with media.

2. Information for the General Public

State programs will normally share information that is in the public interest and will not share information that could lead to harmful actions at a dam. How to categorize information will vary by state as determined by state law and administrative policies and procedures. It will also vary based

on whether the dam is considered critical infrastructure, on the hazard rating, and on population at risk (PAR) below the dam. Information will be shared in the manner described in the state’s public information laws and policies.

In consultation with local and state emergency managers, dam safety programs will develop an internal policy on what records and EAP information can be made public. The decision-making process will discuss and weigh the benefits of an informed and aware population within a dam failure inundation zone versus any potential security risk(s) of making the information public. The current trend is for information on dams and dam failure inundation mapping to be made publicly available, as dam safety programs are determining there are more benefits to a having a knowledgeable public during an emergency event than there are risks resulting from the release of this information.

Public information requests will be addressed consistent with state legal standards for such requests. If the law provides dam safety program discretion as to what the release may contain, programs may release any or all information that would not put the dam or dam owner at risk. Per current guidance, specific information to share publicly includes inspection documents, inundation maps, information on general dam condition, and almost all general statistics that are not dam-specific. Per current guidance, information not to share includes design drawings, security vulnerabilities, any item meeting a critical infrastructure communication designation, and most dam owner personal information.

3. Information for Stakeholders and Dam Owners

The information for stakeholders will be tailored to the needs of those stakeholders. The information can include details about dam safety program objectives and limitations, and facts may be delivered through topic-specific presentations or tours to observe dams and dam operations. Stakeholders are often interested when there are changes proposed to state laws or regulations. They will be informed and sometimes participate in these processes. Details on specific communication strategies are described later in this chapter.

Dam owners and their engineers are the most important information contacts for dam safety programs. Dam safety program staff will make direct and frequent contact with owners of state-regulated dams. Dam safety programs will share all information that helps the owner keep the dam safe. This includes all inspection documents, drawings, and completed analyses in the state program records. Unless state law or a court action directs otherwise, all file information should be provided to the owner as that information is requested.

Because dam owners are incredibly diverse, their needs for information and ability to understand that information will vary greatly. As discussed later in this chapter, dam owner workshops are strongly advised. These workshops will also invite engineers who work on dam-related issues in the area to attend. At all workshops, owners must be reminded that the safety of their dams is their legal and ethical responsibility.

4. Information Sharing and Coordination with Emergency Managers

Sharing information about state-regulated dams and coordinating with federal, state, and local emergency managers are critical activities for effective and efficient response to dam incidents and failures.

Coordination with the state office of emergency management can start with simple information-sharing meetings. At such meetings, the dam safety office can share its organizational team structure, the team’s capabilities, geographic location, and typical workload. The office can also ensure that the emergency managers have up-to-date information on state-regulated dams, including locations, hazard classifications, and EAP status. Ensuring the state office of emergency management has access to the latest EAPs for high and significant hazard dams is also part of information-sharing meetings.

For their part, the state emergency managers share their organizational structure, which can include various sections: logistics, planning, operations, and emergency operations center (EOC) mitigation and recovery. Dam safety officials should get to know section chiefs and where various sections reside within the organizational structure. Understanding the roles and responsibilities of the sections through interaction with the chiefs is an effective way to build trust and connections. Relationship-building establishes trust and familiarity with emergency management partners before dam failures and incidents, which is key to an effective real-time emergency response. Knowing who to reach out to in an actual emergency builds confidence and speeds up response time.

Coordinating between dam safety program and the state EOC is another important preparedness-building activity. Dam safety officials can learn their roles in the state EOC during emergencies through participation in regular EOC exercises. State dam safety officials can learn the language of emergency management through training and exercises on the National Incident Management System (NIMS) and Incident Command System (ICS). Dam safety officials can also learn their roles and dam safety emergency support functions through regular participation in EOC exercises.



FEMA Incident Response Reference Documents

- [National Incident Management System](#)
- [Incident Command System](#)
- [National Response Framework](#)

The dam safety program should also coordinate with the state-level mitigation section and the state hazard mitigation officer (SHMO). The SHMO in each state is responsible for updating the state hazard mitigation plan (HMP) every five years. It is critical that dam safety hazards are identified in each state’s HMP. The SHMO also manages FEMA Hazard Mitigation Assistance (HMA) grant programs. FEMA provides federal matching grant funds that states can use to reduce hazards. FEMA

HMA comes through a variety of programs, many of which are appropriate for supporting state dam safety program improvements and measures to reduce dam safety risk in each state.

Each state dam safety program is encouraged to become a member of the state's emergency management association and to participate in annual conferences. Most states have such associations, and membership raises the visibility of dam safety hazards across state and local levels. Conference space is generally free for non-profit and governmental entities and provides an opportunity for dam safety officials to interact with all levels of emergency managers across a given state in a single location annually.

At the local emergency manager level, the most effective way to communicate, coordinate, and share information may be through regular participation in local multi-agency coordination (MAC) group meetings. MAC group meetings are a FEMA requirement if counties are to receive grant funding. MAC meeting organizers are usually receptive to adding discussion of new and relevant hazards as topics for their meeting agendas. By providing introductions and short (15- to 30-minute) presentations on introductory dam safety topics, dam safety officials can raise awareness and understanding of dam safety hazards, which counties can then add to their all-hazard knowledge and capabilities. This activity also builds familiarity and trust between dam safety officials and local emergency managers.

County HMP updating is another area for coordination between state dam safety officials and county emergency managers. Counties must have county HMPs to receive FEMA HMA grant funding. Dams and dam hazards are increasingly being added to county HMPs, and information sharing is critical to making those updates accurate and effective. The SHMO in each state can help coordinate which county HMPs are being updated at any given time.

State dam safety program officials should also share information and coordinate with the FEMA representatives for that state. Before emergencies occur, it is critical to coordinate dam safety with both the FEMA National Dam Safety Program and FEMA regional representatives. Educating FEMA regional personnel on dam safety can be done through presentations at regional offices or virtually. Participation in FEMA regional offices' annual consultations with their states is also an important opportunity to share information and develop big-picture understanding of how dam safety risk reductions can fit within FEMA hazard mitigation programs.

5. Outreach and Awareness

This section describes outreach and awareness initiatives. These initiatives include a wide range of activities that engage, educate, inform, and build positive relations with the general public, dam owners, engineering practitioners, emergency management officials, and other stakeholder audiences, both external and internal to the agency. Dam safety outreach and awareness initiatives attempt to raise awareness within the general public, motivate others to conduct safety improvement activities, involve members of the public in their own safety preparedness, and involve the public in the development of policies, programs, and projects. Outreach and awareness initiatives include providing specific information during a dam safety incident and follow-up information after the incident. Outreach and awareness initiatives will bring a balance to both

proactive and reactive communication. Because information technology is changing very rapidly, it is likely that dam safety programs will need to understand and adapt to these changes, such as the use of social media. However, the key messages will be similar, regardless of the platform.

An outreach and awareness mindset will be developed in all staff and become part of doing day-to-day business. Managers will discuss outreach and awareness roles with their staffs. Dam safety programs will occasionally conduct formal outreach and awareness events. These events may take the form of half-day or day-long dam owners' workshops, EAP exercises, or awareness workshops for first responders or other stakeholder groups. Serving as a guest speaker at regularly occurring events planned by stakeholder groups can also provide opportunities for formal outreach, without requiring as significant a time commitment from staff. These events are often organized by technical societies, regional and state real estate associations, and groups providing continuing education opportunities.

ASDSO is a principal resource that provides example messages and informational documents. While state-specific messaging is important, aligning with national messaging is also necessary.



Key Messages to Include

- Dams have many benefits but can pose large and costly responsibilities to their owners
- Inspections alone do not make dams safe
- Dams need inspection and repair, and they must be built to withstand extreme events; there are standards and guidelines for these critical dam safety actions
- Dam owners must routinely maintain their dams, or small issues will grow into major and expensive problems
- Small dam safety incidents must be addressed quickly before they grow into emergencies
- If not quickly identified and corrected, incidents can lead to dam failure and catastrophic flooding
- All owners' high and significant hazard potential dams need to create, update, and practice EAPs
- A professional engineer, experienced in dam safety, is necessary for evaluation of dam safety and for any construction or modification of dams; complex projects require a team of engineers

5.1. Developing an Outreach and Awareness Plan

A carefully developed approach to conducting outreach and awareness will result in a strategy for making others aware of the organization's activities, why the activities are conducted, and how the activities contribute to the welfare of the community.

Objectives for an outreach and awareness plan may include:

- Raising program awareness for the general public and stakeholders
- Educating dam owners (ASDSO’s Dam Owner Education Program Workshops webpage provides an example)

 [Dam Owner Education Program Workshops](#) webpage

- Involving the general public in the dam safety reviews and approvals
- Coordinating with other affected state and local agencies
- Advertising workshops, seminars, or hearings to potential attendees
- Raising community awareness of potential dam failure inundation areas
- Understanding roles and necessary actions during and after dam safety incidents

The outreach and awareness strategy will likely include developing short, topic-specific presentations covering topics such as:

- Dam owners’ responsibilities
- Dam safety basics
- Inspecting dams
- Dam maintenance
- State requirements for construction, modification, and removal of dams, and associated permitting or approval requirements
- EAP development, updates, and exercises

A single awareness presentation will not fit all audiences. Different presentations should be developed for each intended audience. Parts of smaller pre-developed presentations can be quickly combined to create audience-specific talks for various stakeholder groups. Dam incidents in the news and lessons learned from case histories will also be documented in presentations. If state-specific case histories are not available, there are many national and international failure case histories with substantial documentation, photos, and relevant lessons learned. These studies provide great learning opportunities for stakeholders. For example, the South Fork Dam failure near Johnstown, Pennsylvania, is a historically significant event for the dam safety profession in the United States and is an appropriate beginning point for presentations. More recent dam failures highlight the relevance of dam safety currently and into the future. Each incident provides for new understanding of threats to dams and how dam safety activities remain critical in reducing risks.

Dam safety programs will search for pictures visualizing common topics. The photos will be categorized and saved by safety subject for quick and easy future use.

Specific outreach activities may include workshops, seminars, continuing education venues, conventions, stakeholder group gatherings, publicity campaigns, online and social media opportunities, and awards programs. General topic brochures and fact sheets that are related to the safety of dams are available from the FEMA and ASDSO websites. Materials that can further the objectives of the program include brochures, fact sheets, displays, slides, media kits, newsletters, questionnaires, frequently asked questions and answers, and news releases. A good way to summarize objectives, audiences, and strategies is with a table. Table 1 below provides an example.

Table 1: Sample Dam Safety Outreach and Awareness Initiatives

Objectives	Audiences	Strategies	Timetable	Cost
Raise program awareness	<ul style="list-style-type: none"> ▪ Elected officials 	<ul style="list-style-type: none"> ▪ Hold informational meetings ▪ Develop exhibits 	<ul style="list-style-type: none"> ▪ During legislative session 	Budget to develop display and informational materials
		<ul style="list-style-type: none"> ▪ Copy elected officials regarding specific issues with dams in their district 	<ul style="list-style-type: none"> ▪ As inspections identify safety deficiencies 	
Raise program awareness and trust	<ul style="list-style-type: none"> ▪ Media ▪ General public 	<ul style="list-style-type: none"> ▪ Issue news releases 	<ul style="list-style-type: none"> ▪ As needed 	Funding of public information office, entrance fees, budget for printing, graphics services
		<ul style="list-style-type: none"> ▪ Exhibit display at public events 	<ul style="list-style-type: none"> ▪ Conventions ▪ Fairs ▪ Youth events 	
		<ul style="list-style-type: none"> ▪ Develop media contacts 	<ul style="list-style-type: none"> ▪ Ongoing 	
Raise program awareness	<ul style="list-style-type: none"> ▪ Dam owners 	<ul style="list-style-type: none"> ▪ Conduct an ASDSO “Dam Owner Education Program Workshop” 	<ul style="list-style-type: none"> ▪ As needed 	Budget for meeting expenses
Raise program awareness	<ul style="list-style-type: none"> ▪ Emergency managers 	<ul style="list-style-type: none"> ▪ Attend and present dam safety topics and county MAC group meetings 	<ul style="list-style-type: none"> ▪ Monthly, rotating periodically across the state 	Free, travel expenses

Objectives	Audiences	Strategies	Timetable	Cost
		<ul style="list-style-type: none"> ▪ Become members of state emergency manager associations and attend annual conferences ▪ Have a dam safety program booth at the conference 	<ul style="list-style-type: none"> ▪ Annually 	<p>Free booth space, membership fees of \$250–\$500 for the organization (payable with FEMA National Dam Safety Program funds)</p>
<p>Obtain public input to the permit process, if public comment affects permit issuance</p>	<ul style="list-style-type: none"> ▪ Affected public ▪ Regulated community ▪ Engineering firms 	<ul style="list-style-type: none"> ▪ Publish public notes ▪ Issue news releases ▪ Hold public hearings/meetings 	<ul style="list-style-type: none"> ▪ Within specified number of days or as law requires 	<p>Budget for newspaper advertisement, public service announcements, meeting rooms</p>
<p>Provide information about program activities and promote two-way dialogue</p>	<ul style="list-style-type: none"> ▪ Regulated community ▪ General public ▪ Elected officials ▪ Emergency managers 	<ul style="list-style-type: none"> ▪ Develop questionnaires and newsletters ▪ Hold public meetings about program activities ▪ Hold an open house 	<ul style="list-style-type: none"> ▪ Short-term: print newsletter ▪ Long-term: solicit feedback, conduct public meetings 	<p>Budget for graphics artist, printing, newsletter cost, room and meeting expenses</p>
<p>Be prepared for a dam incident</p>	<ul style="list-style-type: none"> ▪ Media ▪ General public ▪ Elected officials 	<ul style="list-style-type: none"> ▪ Ensure the agency’s public affairs office maintains a program facts summary and EAP that can be coordinated with the PIO at the site 	<ul style="list-style-type: none"> ▪ Short-term: prepare press kit ▪ Long-term: Prepare type and amount of emergency information in advance 	<p>Budget to assemble press kit, public announcements</p>

5.2. Methods of Outreach

Below are several recommended materials a dam safety program may develop for public outreach and awareness programs. Materials should be available in electronic format, and most should be in a format that can be easily printed for sharing in public settings such as conferences or public meetings.

Dam safety administrators should maintain background information materials with a **program summary and specific facts**. Information contained in these materials includes:

- The number and hazard rating of dams regulated by the state
- The number of dams inspected in the last year
- Detail on dams not meeting state safety standards
- An organizational chart and contact information for dam safety program staff
- Copies of recent newsletters, photographs of program activities, and/or editorials or articles that demonstrate the benefits that the program brings to the community

Fact sheets are an excellent way to provide in-depth information on specific issues and to present topics that are subject to frequent questions. Topics may include dam ownership, explanation of permit processes, classifications of dams, size of dams, clarification of technical topics, aspects of incident and emergency planning, and the roles of external agencies during incidents and emergencies.

A well-designed **webpage** that is kept current is perhaps one of the most effective methods of presenting useful information on the dam safety program and raising public awareness and status of the program. Most states have a webpage as part of the larger department website. Websites must be mobile-device friendly and consistent with changing technology. As with printed brochures, the information presented must be accurate, descriptive, and clearly written. Information to consider for the webpage includes:

- Links to legislation and regulations
- Current news and/or newsletter
- A PDF of the dam safety program brochure
- Program history
- Frequently asked questions and answers
- Organization chart

- Technical guidelines and references used or recommended by the dam safety program
- Permit application forms
- Emergency action planning information and templates
- Awareness information
- Informative photographs
- Grants and loan program information
- State dam safety inventories in tabular and map views
- Copies of recent dam safety inspections (if consistent with state dam policy)
- EAPs (if consistent with state dam safety policy)
- Links to the National Inventory of Dams (NID), FEMA dam safety program, and ASDSO websites
- List of dam safety program contacts, emails, phone numbers, etc.

A **newsletter** can improve public understanding and participation in the dam safety program. The publication will serve as a means of direct communication to inform and update audiences regarding organizational developments, regulations, concerns, and goals. A newsletter can reach dam owners, engineering consultants, emergency services personnel, legislators, media contacts, agency administrators, agency field staff, and other interested persons.

A basic element of any public information plan is the **news release**, which discusses program activities such as dedication of new dams, repair of popular dams, new or revised regulations, public comment periods, or awards. A news release should stick to the facts, use complete names, emphasize community benefits, and be timely. The PIO needs to work closely with the program in developing and distributing news releases.

A **display** can be an effective and flexible tool to draw attention to a dam safety program. Displays can be set up at trade shows, legislative halls, libraries, and other public events. Display materials may be found in existing files and materials. For example, if the display is to be set up at a construction-related exhibition, before and after pictures of dam safety construction projects may be found in existing files.

Chapter 3 – Existing Dams

Key Takeaways

1. There are two basic types of periodic inspections for existing dams, routine inspections, and comprehensive inspections, which are critical for identifying problems and confirming that dams are safe throughout their life cycle
2. Maintaining an accurate and current dam inventory database helps dam safety programs set program priorities and goals, conduct essential dam safety activities, and understand the number, range of sizes, and risks of the dams they regulate
3. Risk evaluation and management can be a complex but rewarding process that requires careful attention to details to establish credibility in the assessment and outcomes

Checklist

- Maintain inventory and files, and move these to an electronic system
- Maintain dam design and inspection information permanently
- Use hazard potential to classify dams
- Review hazard potential classification periodically
- Ensure dams are routinely inspected by the state or a consulting engineer
- Routine inspections by hazard potential: High-annual; Significant-2 years; Low-5 years
- Provide a state-specific and approved inspection form
- Inspections reviewed to ensure action recommendations made as needed
- Begin a program of comprehensive review inspections
- Evaluate dams with both deterministic and risk-informed analysis
- Determine probable modes of failure for dams
- Begin a program to take safety actions based on risk evaluation
- Require owners to conduct safety assessments and prepare public safety plans
- Follow guidelines for implementation of a dam security program
- Identify unsafe and non-compliant conditions and situations
- Take effective enforcement actions

Definitions

Hazard creep – change in hazard classification as the result of downstream development

Risk – the product of the likelihood (probability) of a sudden dam failure and the consequences of that dam failure or uncontrolled release of water.

Risk-informed decision making (RIDM) – a method of dam safety evaluation used to determine whether risks are tolerable or unacceptable, using the likelihood of loading, dam fragility, and consequences of failure to estimate risk

Potential Failure Mode (PFM) – a specific chain of events leading to a dam failure or uncontrolled release of water.

1. Introduction

The workload for dam safety programs has shifted over time, from design review of new dams to actions necessary for the safety of existing dams. Most dams are decades old, often designed and constructed when there was limited understanding of dam-related hazards and risks. Therefore, it is essential to conduct and maintain a current inventory of dams in the state, allowing for quick access to the accurate and current information that is necessary to manage essential dam safety actions. Dam safety programs are also responsible for confirming the safety of existing dams by conducting or ensuring dams are properly inspected, including routine inspections, comprehensive reviews, and specialized inspections, as needed. Evaluating dam safety also involves the ability to identify, assess, and manage any risks associated with a dam, including the populations and areas surrounding that dam that could be affected by an incident. A thorough understanding of risk enables optimal planning and decision-making. In the event that inspections or risk assessments reveal that a dam is unsafe or not compliant with safety statutes and regulations, dam safety programs must be prepared to take enforcement actions to bring the dam back into compliance.

2. Dam Information

2.1. Dam Inventory

State dam safety programs will maintain a dam inventory database of basic information necessary to set program priorities and goals and conduct essential dam safety activities. Having accurate and current data helps dam safety programs understand the number, range of sizes, and risks of the dams they regulate. This information is critical for dam safety program use, for information requests, for reporting, and for prioritization of program tasks. Without a good inventory and good records management practices, it is not possible to manage essential dam safety actions.

For each dam regulated by the program, the inventory must include the dam name, owner information, geographic location, height, storage capacity, hazard potential classification, purpose, condition assessment, and inspection dates. Consideration should be given to including all data fields found in the NID. Certain NID data fields may be required to qualify state programs for FEMA National Dam Safety Program funds. Staff must have the ability to export selected data to update the NID, which is maintained by the U.S. Army Corps of Engineers (USACE), and to respond to inquiries from the public. The state dam safety program must also be able to easily add new fields to the database as necessary and to accommodate future USACE data requirements and the needs of the state dam safety program.

Each state must establish the classification criteria of dams that it regulates by size, hazard potential, and purpose. Many states have adopted the NID criteria, which consists of dams meeting at least one of the following criteria:

- High hazard potential classification – loss of human life is likely if the dam fails

- Significant hazard potential classification – no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns
- Equal to or exceeds 25 feet in height and exceed 15 acre-feet in storage
- Equal to or exceeds 50 acre-feet storage and exceed 6 feet in height

Guidance for dam hazard potential classification is provided in Section 2.3.



USACE [National Inventory of Dams](#) webpage

2.2. Dam Inventory and Database Requirements

Dam safety programs must also maintain permanent records of all essential design, construction, modification, approvals, permits, inspection, analysis, and other information. Over time, all available paper files must be scanned and saved as electronic documents. Such documents include, but are not limited to, design drawings, as-built drawings, design reports, reports of investigations and analyses, construction records, photographs, repair records, operational records, inspection reports, transcribed conversations with the dam owner/engineer, and enforcement actions. The virtual files must be organized into standard file storage on a computer server or cloud storage system, with back-up file storage that must be available if file servers are down or staff require access from outside the office (e.g., if the brick-and-mortar office space is unavailable). In addition to being accessible by staff in the office, the data must be accessible in the field via cell phone, laptop computer, or tablet for use in an emergency. Use of proprietary records management systems must be avoided, as the companies that developed such systems may not be available in the future to make system updates.

Files must be named using a standard convention so that users can easily find the information. The state agency's file retention policy must clearly identify all dam records as permanent files to be retained in the dam inventory for the life of the dam (as opposed to allowing for disposal after a defined period).

2.2.1. EXPORT OF RECORDS FROM THE DATABASE

Staff must have the ability to create reports of selected fields from the database to periodically provide the data to USACE for the NID. States may use a geodatabase (a large, complex file that can contain points, lines, shapes, images, and other spatial data) or rely on traditional database files to manage information and then periodically export the data to geographic information systems (GISs) for generating maps. Dam safety programs may consider developing an interactive map of inventory dams on its webpage and consider publishing dam failure inundation zones for the areas below the dams, showing the areas that would be flooded in the event of dam failure.

2.2.2. DATABASE STRUCTURE

The NID provides an inventory database structure for dams. Additional fields are recommended to store data needed to manage the state dam safety program. As they deem necessary, states may add additional fields to support local regulatory functions. Appendix C provides a tabular list of additional fields to consider.

2.3. Hazard Potential Classification Process

Guidance for hazard potential is published in FEMA Publication 333, *Hazard Potential Classification System for Dams*. This classification system ranks a dam as “High,” “Significant,” or “Low” hazard based on the damages or consequences that would occur if the dam failed. The definitions for hazard potential classification, as accepted by the Interagency Committee on Dam Safety, are as follows:

- **High Hazard** potential dams are those where failure or mis-operation will cause probable loss of human life. Significant economic, environmental, and lifeline losses are possible, but not necessary, for this classification.
- **Significant Hazard** potential dams are those dams where failure or mis-operation results in no probable loss of human life. Dam failure can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with significant population or infrastructure.
- **Low Hazard** potential dams are those where failure or mis-operation results in no probable loss of human life and few economic and/or environmental losses. Those losses that do occur are principally limited to the dam owner’s property.

FEMA [Hazard Potential Classification System for Dams](#)

Different elements of a dam may need evaluation to determine the proper hazard potential classification for the project. However, there is only one hazard potential classification assigned to the entire project. Individual elements are not assigned separate classifications. Some states include additional terms in the classifications, such as adding “extreme” to “high” if the loss of many lives would be expected. States sometimes use other terms, such as negligible, for smaller dams far from developed areas and busy roads.

It is important to note that the number of persons identified in the population at risk (PAR) does not directly equate to a high hazard potential classification. Determining the hazard potential can involve many uncertainties and may require judgment by the analyst. Dam breach flood flow depths and velocities where people are likely to be present will normally be used to guide determination of hazard potential. For the purposes of hazard classification, most states only include life loss calculations to the first “critical structure.” A life loss of one (1) typically results in a high hazard classification. Risk-informed approaches typically use ranges of life loss for decision making. The

United States Bureau of Reclamation (USBR) publication ACER- 11 *Downstream Hazard Classification Guidelines* provides guidance that can help with determination of hazard potential. Risk-informed approaches can be analyzed using the USBR *RECM – Reclamation Consequence Estimating Methodology*. Risk-informed approaches are further described in Section 4 below.



Resources for Determining Hazard Potential of Dams

- USBR [Downstream Hazard Classification Guidelines](#)
- USBR [Reclamation Consequence Estimating Methodology](#)

2.4. Hazard Creep and Classification Review

The hazard classification of a dam may change as the result of downstream development (hazard creep) or improvements in dam failure modeling. It may also be that the original determination of hazard potential was based not on analysis (see Section 2.5) but on judgment alone. Appropriate hazard class re-evaluation occurs periodically, at least every five years. Even if dams are not currently regulated, downstream hazard potential can change, and re-evaluation may be needed in the future. Dam safety programs must conduct hazard classification reviews and dam breach inundation analyses, as evidence indicates the impacts to people, property, or infrastructure may change after the hazard classification is first determined. The need for periodic re-evaluations underscores the importance of keeping permanent records for all dams, as the classification process requires historical documents.

2.5. Dam Breach Inundation Analysis

Dam breach inundation analysis is the means for determining or revising the hazard classification of a dam. Any simplified and conservative hydraulic model may be used for the dam breach inundation analysis to show that a dam will be rated low hazard. An accepted and hydraulically consistent computational model is needed to conduct the inundation analysis for significant and high hazard dams. The reservoir level at breach is a critical factor for the inundation analysis. States may use a full dam or a dam at high inflow (at least 0.2% annual exceedance probability flood).

The principal factors calculated by a breach analysis are depth and velocity of water at potentially vulnerable locations. Vulnerability depends on the presence of and types of structures such as homes (including mobile homes), schools, businesses, hospitals, roads, vehicles, recreational areas, and other infrastructure. Where people are likely to be present in the inundation areas, a high hazard rating is generally appropriate, especially if the incremental difference between flooding with and without a dam breach is significant. Several references provide guidance for depth and velocities likely to cause loss of life or property damage at different types of structures.

Inundation analysis includes:

- The specific proprietary model or method used for the analysis
- Details regarding the model geometry
- The specific mode of failure and any assumptions made in the selection of the mode of failure
- A list of dam breach parameters and any assumptions made in the selection of the breach parameters, which are based on dam material and thickness and any other factors that would influence the time it would take for the dam to breach from internal erosion, overtopping, or displacement
- A list of all boundary and initial conditions and any assumptions in the selection of these conditions
- A map indicating the inundation boundary, areas inundated by a depth greater than two feet, and all frequently occupied structures that fall within or are immediately adjacent to the inundation boundary
- A sensitivity analysis evaluating the variability in model inputs (likely needed when the dam breach inundation analysis results indicate the hazard classification is on the border between two classifications)

It is important to distinguish between the potential for loss of human life and PAR. Estimating “loss of life” involves many uncertainties and often requires the analyst’s judgment. Variables include distance below the dam, amount of warning time available, time of day, flood wave travel time and DV (depth x velocity), and human factors such as evacuation routes or ability for the elderly, children, or injured persons to evacuate. Currently, there is not one definitive method for precise determination of hazard potential. Whatever methods are used by a dam safety program, they must be clear, defensible, and repeatable.

A report summarizing the model information and results must be developed by a qualified engineer. A state program may require or accept inundation analysis conducted by the owner’s engineer to determine a hazard rating. Regardless of whether the state or owner’s engineer conducts the analysis, the state program makes the final determination of hazard potential classification.

Dam safety programs must provide dam owners with formal notification if hazard potential changes.

3. Dam Inspections

Dam inspections are a critical function of an effective dam safety program and are necessary to identify problems and confirm that dams are safe. Inspections at dams can be performed for many reasons, ranging from maintaining a dam inventory to performing comprehensive safety evaluations. Dam inspections are essential to determining dam condition, operability, maintenance, and repair needs and to identifying unsafe conditions. This chapter contains a discussion of issues related to

the inspection of existing dams. Inspection of dams under construction or removal is discussed in Chapter 4.

There are several types of periodic inspections for existing dams, including: routine inspections and comprehensive review inspections. All inspections must be led by experienced engineers, with a team of engineers and specialists as needed. Routine inspections involve engineers familiar with the design and construction of dams and include general assessments of the dam's condition. Comprehensive reviews are performed less frequently but involve a much more detailed inspection of the dam, as well as thorough review of the dam's design, construction, monitoring data, and operational history. Inspections are performed by a state or consulting engineer, while surveillance is performed directly by the owner or owner's representative. Both routine and comprehensive inspections can be enhanced with the continued use of remote sensing techniques as technology evolves.

3.1. Inspection Process

State dam safety programs must ensure that dams are inspected periodically. There are three approaches to ensuring state-regulated dams are properly inspected:

- A state-responsible program, in which state dam safety agency staff perform the periodic inspections
- An owner-responsible program, in which the inspections are conducted by private consulting engineers hired and paid for by the dam owner, with specific qualifications required by the dam safety program
- A program in which both of the above apply

If states use dam safety program staff for inspections, the state must ensure staff are qualified and prepared to conduct these inspections safely. Using this approach requires state programs to:

- Train their personnel on inspection protocols
- Develop annual inspection plans
- Assign staff to complete inspections
- Ensure staff contact the dam owners and access the property legally
- Develop safe working standards and ensure they are followed
- Track progress and adjust the inspection plan if urgent issues arise
- Expedite inspection schedules for dams with developing conditions
- Have authority to require corrective action of safety deficiencies identified

If the state requires the dam owner to procure the services of a consulting engineer to conduct dam safety inspections, the state program must:

- Identify the jurisdiction of each dam, inventory the dam, and assign the hazard potential classification
- Have the authority to make inspections and inspect records and manuals with state dam safety program staff
- Set inspection intervals for the dam owner's inspections
- Make selected field inspections of dams inspected by the owner's engineer to verify the findings of the owner's inspection
- Require that inspections by the owner's engineer be submitted to the state program
- Review all submitted inspections, with a focus on recommended actions
- Require follow-up inspections by the owner's engineer if conditions indicate
- Ensure that the owner's engineer has adequately documented deficiencies and provided suitable time frames for maintenance, repair, or other actions
- Document deficiencies in a letter to the dam owner, with specified time frames for abating the deficiencies consistent with recommendations of the inspection report
- Have enforceable regulations related to the performance of owner inspections and be prepared to take enforcement actions if dam owners do not complete necessary work

3.2. Inspection Standards and Templates

To help ensure quality and consistency among inspectors, the state must use or develop inspection standards and must require the use of standard inspection forms and correspondence or report formats. Each state must provide a template and standards for routine inspection in that state. State programs may consider other states' templates when developing or updating their templates.

Minimum Required Elements to be Included in Inspection Forms

- Reservoir level, including the level on the day of the inspection and minimum recent freeboard (staff gage or automatic water level readings)
- Spillway(s), including auxiliary spillways, noting especially any changes in the spillway control section, debris near the spillway, and deterioration of the spillway channel
- Penetrating conduits or penstocks, including trash racks and outlet works
- Conduit controls and operability
- Surveys and observations of deformations and alignment

- Instrument readings from piezometers, weirs, gages, monuments, etc.
- Measurements or estimations of seepage locations and flow rates
- For embankment dams, identification of any deformations or defects, including settlement, other slope movement, cracks, sinkholes, animal burrows, woody vegetation, and vegetation that obscures the inspection
- For concrete dams and concrete appurtenant structures, identification of any potential change in alignment, evaluation of conditions in galleries, changes in cracks and leakage through cracks, and if available, uplift pressure at the base of the dam
- Seepage or movement at the dam abutments
- Any other components and appurtenances that, if nonfunctional or damaged, could increase risk of an uncontrolled reservoir release
- Access and access control
- Hazard creep, such as development or other items that may result in a hazard classification change

All dam safety inspections must be led by engineers with prior dam inspection experience. For routine inspections, the engineer must use the inspection form provided by the state dam safety program. The engineer must have experience or training in the use of the state form and have experience in general dam inspection techniques. When determining the inspection team size, dam complexity and risk and the safety of the inspectors may be considered. It is recommended that each inspection team comprise at least one engineer and one technician, although for simple embankment dams, it is possible for the engineer to inspect a dam with a competent dam owner or owner's representative onsite.

3.3. Routine Inspections

State programs must set the frequency for routine inspections of dams under their jurisdiction. Annual inspections of high hazard potential dams, biennial inspections of significant hazard potential dams, and inspections of low hazard potential dams every five years are recommended. Using the form developed by the state dam safety program, the engineer conducting a routine periodic inspection must perform the following:

- Review conditions of approval or permits as applicable, recent past inspection(s), operation and maintenance plans, and EAPs
- Review instrumentation data to identify trends and unusual readings
- Observe and take measurements as needed to complete the form provided by the state dam safety program
- Take photographs of all critical elements of the dam and of specific elements or locations needing maintenance, repair, or special inspections

- Determine whether conditions of approval/permit are in compliance
- Review records to determine whether the dam has been subjected to any new or unusual loading conditions
- Determine whether prior inspection recommendations or requirements have been satisfactorily completed
- Determine whether additional development has occurred within the downstream area that may change the hazard potential classification or require amendments or additions to the EAP

Inspections must be specific to the size and complexity of the dam. Inspections must focus on items that are more likely to affect dam safety and operation, including the spillway, defects (especially near the crest), seepage, and conduit and controls deterioration and operability. Inspectors must carefully review prior inspection(s) to evaluate any significant changes at the dam. The lead inspector is responsible for providing recommendations for all deficiencies identified and for directing specific attention to conditions reported in previous inspections and status of corrections required by the dam safety program.

3.4. Comprehensive Review and Inspection

Comprehensive reviews and inspections are beneficial because most existing dams were designed and constructed when the understanding of risks to dams was significantly different from current knowledge. Additionally, routine inspections typically look only at the dam's condition at the time of the inspection, whereas comprehensive reviews consider the dam's performance history through time. The comprehensive review and inspection involves a team of specialist engineers, potentially including hydrologic, hydraulic, geotechnical, engineering geology, structural, mechanical, and/or electrical engineers. The team needs expertise on all potential modes of failure for that dam and needs a team leader. Team composition can depend on the type of dam and the design information available for the dam, as well as the complexity of the dam and dam site. The comprehensive review and inspection team leader must not be a person who has developed a sense of security about the dam's safety from past inspections or observations.

All dams classified as high or significant hazard potential need periodic comprehensive review inspections. These can happen less frequently than routine inspections. Dam safety programs should consider setting at least a 10-year comprehensive review inspection frequency for high hazard potential dams and at least 15 years for significant hazard potential dams. This detailed inspection includes all elements of routine inspections. In addition, the more rigorous inspection must include review of all original design documents, as-built construction documentation, all inspection reports to evaluate past performance including deficiencies and corrective actions, and any prior studies. These detailed inspections must always include an evaluation of spillway capacity and stability, review of drain system design and layout, identification of drain outlets that could be impaired by flowing water, and evaluation of possible access problems for conducting camera inspections. For embankment dams, this inspection must evaluate the potential for internal erosion

and the effectiveness of soil filters, if any. Special inspections not performed as part of routine inspections, like TV inspections of conduits and drains or subsurface explorations, may be needed if records do not exist. In these cases, the comprehensive review inspection is used to fill data gaps. Other items needing comprehensive inspection can depend more on regional vulnerabilities, and may include seismic analysis, embankment stability, or the potential for landslides to impact the dam or reservoir.

State programs may consider consulting engineers hired by the dam owner for completion of these comprehensive reviews and inspections. State programs may also choose to use a mix of state-conducted and owner-engineer-conducted comprehensive review inspections. The comprehensive review and inspection must compare the design and construction standards at the time of the dam's design and construction to current design and construction standards.



Questions to Consider During Comprehensive Reviews

- Does the inflow design flood and spillway capacity meet current safety standards (probable maximum flood or risk-informed flood frequency for high hazard dams)?
- Did the original designer understand geologic and geotechnical issues (e.g., rock structures, discontinuities, soil variability) and have qualified experts make these interpretations and investigations?
- Do previous inspection reports identify resolved or unresolved deficiencies that could be indicators of potential failure mode initiation or progression?
- Is there a soil filter(s), and do filters have gradations meeting current filter criteria standards?
- Are concrete wall and chute thickness, and the use of reinforcing steel or other materials, adequate?
- Does a concrete spillway chute have functioning underdrains and do all joints meet modern design standards?
- If there are piezometers, are pore water pressures consistent with original design assumptions?
- Were conduits or penstocks originally constructed of durable materials, and are they still of sufficient durability that they are not prone to leakage?
- Are all necessary parts of the dam accessible in an incident or emergency?
- Is the dam secure from damage by malevolent parties?

If underwater or confined spaces have been inspected recently, the comprehensive review and inspection must evaluate the findings from these inspections. If such inspections never took place or

are outdated or the engineer determines they are inadequate, such inspections must be performed as part of the comprehensive review and inspection.

Comprehensive reviews and inspections may be tailored to the region and the specific dam and dam site. Region-specific content may include seismic site characterization, liquefaction potential, seismic deformation, landslides above the dam or reservoir and, for some western locations, potential for debris from wildfires as well as large debris flows down channels to the reservoir.

Comprehensive reviews and inspections must include the slopes above the reservoir and dam, the interior of conduits, and the full length and width of the spillway, with indirect methods, or concrete coring as necessary if there are questions as to actual thickness. Subsurface explorations may also be included. The emphasis must be on areas where design standards have changed since construction and areas where the original design team (or single engineer) lacked expertise. There must also be a focus on significant risks not well understood when the dam was constructed.

A comprehensive review and inspection report must be completed and submitted to the owner and regulator(s). This report must include determination of failure modes for the dam and must form the basis of risk evaluation and management (Section 4 of this chapter).

3.5. Other Inspections

Other specialized inspections, such as the following, may be performed outside the normal routine inspection cycle:

- Interior inspections of confined space conduits or other penetrations
- Underwater inspections of the upstream face, trash rack and inlet, or any other submerged element of the dam
- Complete review of instrumentation function and data
- Post-event inspections, such as immediately after floods, wildfires, or earthquakes, to determine event-caused damage and the need for more detailed inspection
- Inspections in response to identifications of potential dam failure situations

3.6. Correspondence with the Dam Owner

The lead inspecting engineer is responsible for correspondence with the dam owner. Dam owners must be contacted and invited to participate in all dam inspections. The inspection must document, in writing, important discussions with the dam owner or the owner's representative.

After the inspection, it is essential that a written inspection report or summary be prepared and submitted to the dam owner. The state must have a standard report format for both periodic and comprehensive reviews and inspections. This document must describe all visual observations of the

embankment, spillway, outlet, appurtenant structures, and reservoir conditions at the time of inspection. All safety deficiencies, maintenance and repair needs, and items that were obscured or were not otherwise inspected must be described in this correspondence. Selected electronic photographs of the dam, showing specific observations or problem areas, must also be included.

The summary or report of an inspection must specifically describe maintenance or repair work needed and may provide a maximum time frame for completion of that work. Correspondence accompanying the report must include the urgency of recommended actions, including actions needed immediately, actions needed prior to the next inspection, and/or longer-term actions that require planning and budgeting. Such inspection correspondence provides the basis for any follow-up repairs and, if necessary, enforcement action. Both state program and owner–engineer inspections need review by the state program. Those conducting the review must determine whether additional actions are needed, what time frames are for necessary actions, and whether enforcement is appropriate (Section 6 of this chapter). The review must also determine whether specific elements of the dam were not inspected and why, and provide recommendations on how those inspections will be completed in the future.

3.7. Dam Owner Surveillance

A state inspection program depends on dam owners and/or their consultants to provide complementary and necessary inspections and surveillance. The owner is solely responsible for the dam’s ongoing operation, maintenance, surveillance, and periodic inspection. The state must evaluate whether the dam owner is doing the following:

- Maintaining surveillance of the dam in relation to the size, condition, and hazard classification
- Training dam personnel (including all personnel who regularly visit or work at the dam) in the basics of visual inspection techniques, including the reporting of observed problems
- Recording instrumentation data at specified time frames and reporting anomalies to the state program
- Notifying the state program of any unusual observations (possible indications of distress)
- Ensuring the dam is inspected during and after any unusual loading, including but not limited to significant storm/runoff events or earthquakes
- Maintaining records for the dam, including but not limited to construction plans and documents, engineering studies, inspection reports, monitoring records, photos, the EAP, and the operation and maintenance manual
- Obtaining the services of an engineer and/or coordinate with the state dam safety program to inspect the dam at least as frequently as required by state regulations

4. Risk Evaluation and Management

There are two general approaches to safety assessment of dams:

- The standards-based approach (SBA), which is the long-standing traditional methodology for dam engineering and evaluating dam safety
- The Risk Informed Decision Making (RIDM) approach, which has a long history in the process industries but has only recently been applied to dams

Under the SBA, safety is assessed by following established rules for design events and loadings, safety coefficients, structural capacity, and defensive design measures. Over the years, the SBA has developed from recognized effective practices that have been identified from theoretical considerations and empirical evidence. Unfortunately, the SBA is poorly suited for evaluating some important dam safety issues, such as internal erosion, spillway gate reliability, human factors, and operational issues. SBA is also conservative by necessity, so by itself SBA often fails to provide a direct way to quantify risk of failure.

Understanding and reducing risk drives all dam safety programs actions. Integrating risk-informed approaches provides a rigorous, systematic, and thorough process that improves the quality of decisions about the safety of dams. The most common risk related tool currently utilized by state dam safety programs is the assignment of dams into hazard classification categories. State dam safety programs put more resources toward the regulation of High Hazard dams. However, the magnitude of potential consequences varies within a given hazard classification category and hazard rating provides no information on the condition of the dam, therefore, the use of a hazard classification system is only a screen for dams needing further evaluation.

Nationally, the USBR and USACE have both implemented risk-informed processes and decision making into their dam safety programs. Recognizing the importance of having a consistent federal approach to managing dam safety risks, several federal agencies (USBR, USACE, FERC, FEMA, and the Tennessee Valley Authority) began collaborating and developing general dam safety risk guidance. This work culminated with the 2015 FEMA publication *Federal Guidelines for Dam Safety Risk Management*. State dam safety programs must understand these guidelines.



FEMA [Federal Guidelines for Dam Safety Risk Management](#)

Risk, in the simplest terms for dam safety applications, is the product of the likelihood (probability) of a sudden dam failure and the consequences of that dam failure or uncontrolled release of water.

Risk-informed decision making (RIDM) is a method of dam safety evaluation used to determine whether risks exceed generally accepted safe levels. RIDM uses the likelihood of loading, dam fragility, and consequences of failure to estimate risk. Risk estimates and analyses are used along with standards-based analyses to decide whether risk reduction actions are required and whether dam safety investments are justified or warranted. This approach has many benefits, including a

greatly improved understanding of the safety of the dam and identification of dam safety vulnerabilities that may not be possible using standards-based evaluation techniques.

The essential elements of risk analysis which state dam safety programs must be proficient at and begin to use are:

- Determining potential failure modes (PFMs)
- Estimating probabilities
- Consequence analysis

When combined, these three elements become risk analyses. Risk analysis for state dam safety programs can be conducted in two ways. **Screening-Level Risk Analysis** (SLRA) allow for identification of the “riskiest” high hazard dams within a state. **Semi-Quantitative Risk Analysis** (SQRA) should be used to further analyze risk and identify and justify potential risk reduction measures to be taken at high hazard dams identified through the SLRA process.

4.1. Potential Failure Modes

A **Potential Failure Mode** (PFM) is a specific chain of events leading to a dam failure or an uncontrolled release of water. Identifying the specific potential failure modes that are most likely at a given dam is the critical first step in evaluation of risk. Once the failure modes are identified, the frequency of occurrence of the loadings (reservoir load levels, floods, earthquakes, etc.) that could initiate potential failure and then result in adverse consequences would be estimated and considered as part of a risk analysis.

Model state dam safety programs must require determination of potential failure modes on high hazard potential dams, either with state program staff or by engineers working for the dam owner, or both. Based on historical records, most dam failures involve a small number of common failures modes. For risk evaluation work, potential failure modes or otherwise unsafe releases for dams can include (as a key process in a chain of events):

- Overtopping and breach of structure by erosion or undercutting
- Spillway failures, including but not limited to chute erosion, slab jacking, gate malfunction, and blockage from debris or ice
- Mis-operation due to human error or equipment malfunction
- Internal erosion including backward erosion piping (embankment dams)
- Seepage or leakage from outlet conduits
- Headcutting erosion in earthen or rock unlined spillway channels

In addition, the following modes of failure may be regionally or locally relevant and, where applicable, need to be included in the analysis.

- Seismic deformation or liquefaction
- Landslide-induced wave, causing overtopping and erosion
- Static slope failure of embankments
- Unusual susceptibility to malevolent actions (vandalism/terrorism) if not assessed by a security agency

Additional modes of failure for concrete dams include:

- Sliding at base or overturning, related mostly to uplift pressure
- Severe concrete deterioration and cracking
- Rock discontinuities in abutments (arch dams)
- Sliding instability due to abnormal loads (silt and ice)

PFMs that are determined to be reasonably possible and potentially driving risk of failure are carried forward to risk analysis. States may use lists or libraries of potential failure modes that include the most common modes listed above, or for more complex dams or dams with very high consequences may need to require a **Potential Failure Mode Analysis (PFMA)**.

A PFMA is an exercise to identify all potential failure modes under a range of loading conditions, including static loadings (normal operating water levels), floods, and earthquake loadings on a dam. Event trees are established for each potential failure mode. The PFMA process uses facilitated “expert elicitation” to review and reach consensus on potential failure modes being considered. The findings are based on a review of existing data and information, firsthand input from field and operational personnel, a site inspection, completed engineering analyses, identification of potential failure modes, event tree development, and likelihood and confidence determinations. A risk assessment begins with a PFMA and extends to considering the consequences.



Resources for Risk-Informed Decision Making (RIDM)

Guidance for performing PFMA and risk assessments is available from several sources, including the FERC Engineering Guidelines [Risk Informed Decision Making \(RIDM\)](#), the USBR Dam Safety [Risk Management Best Practices](#) documents, and Colorado Dam Safety’s [Comprehensive Dam Safety Evaluation tools](#).

4.2. Screening-Level Risk Analysis

A screening-level risk analysis is typically performed for multiple dams. State dam safety programs should perform screening-level risk analyses on state regulated high hazard potential dams. The goal of this screening level risk analysis is to develop relative risk estimates for each dam in a way that enables the relative risk among the dams to be evaluated and priorities for further study or remediation to be established. A screening-level risk analysis is a useful tool for prioritizing inspections, compliance, and other activities. Information on loadings, consequences, and analyses that relate to potential failure modes may be very basic and limited, typically consisting of data already available or prepared just in advance of the screening effort. Screening-level risk analyses can help identify uncertainties related to potential failure modes and dam safety issues. These analyses can be used to prioritize additional studies and initiate modification studies and the need for more detailed semi-quantitative risk analysis. One big advantage of a state program performing the risk analysis with state program staff is consistency in risk ratings across different dam owners.

Typically, an individual or a small team of individuals can perform screening-level risk analyses in a short duration, taking from less than a day to a few days per dam. The results of a screening-level risk analysis do not provide absolute values of risk. In a screening-level analysis, the risk of the potential failure modes may be rated as much above average, above average, average, low, and negligibly low.

For a screening level analysis, risks may simply be rated by categories similar to the 5 qualitative categories, very high to remote. To assign a quantitative probability of failure requires additional analysis.

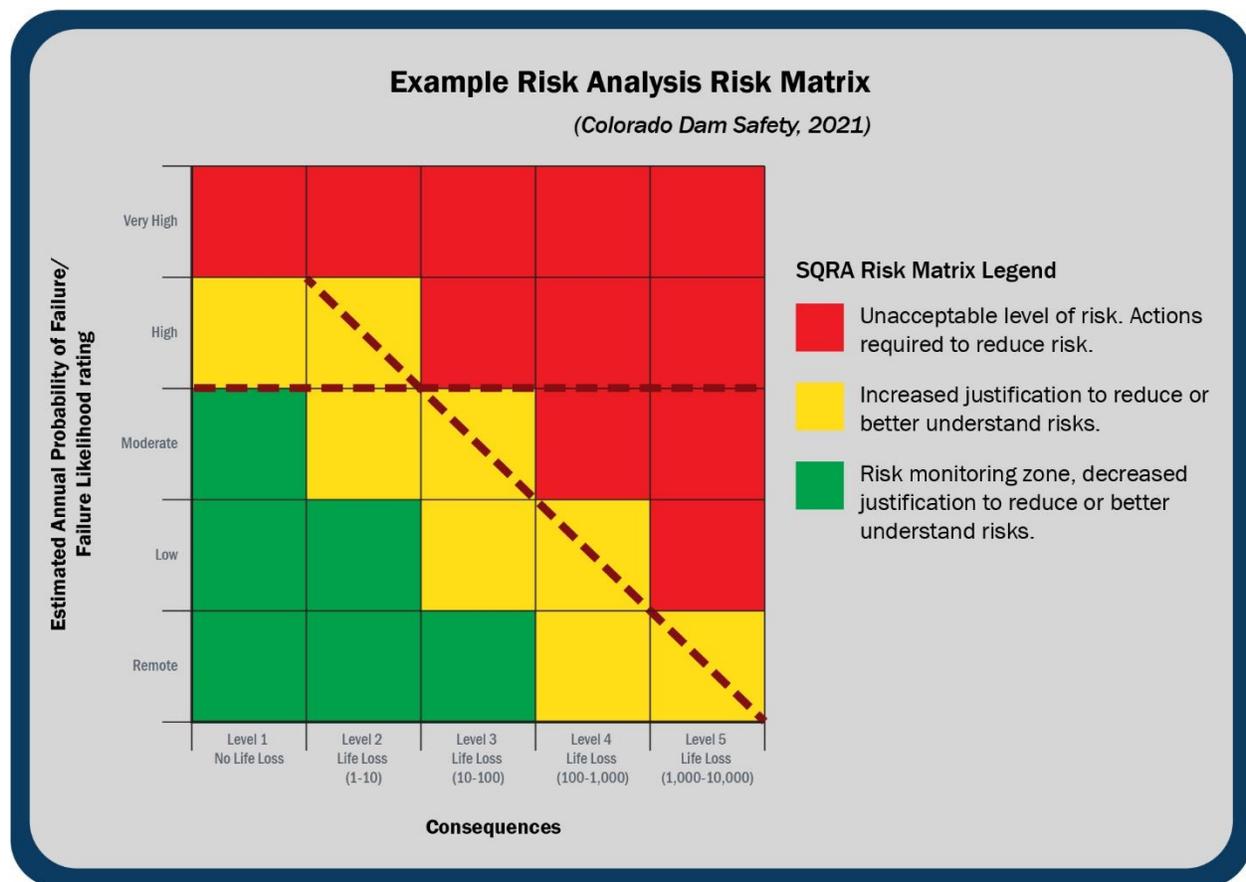


Figure 1. Example risk analysis risk matrix.



Resources on Screening- or Portfolio-Level Risk Analyses

More detailed information on screening- or portfolio-level risk analyses is available from several sources, including the FERC [Risk-Informed Decision Making \(RIDM\) Guidelines for Dam Safety](#) and the USACE [Safety of Dams – Policy and Procedures](#) documents.

4.3. Semi-Quantitative Risk Analysis and Risk Assessment

Comprehensive review inspections that determine the condition of the dam through time also need to incorporate a risk analysis to enhance the value of the effort. Significant effort is required to prepare for these comprehensive reviews and inspections. This effort includes reviewing all project information, studies, analyses, performance and monitoring information, and other key project data. Through the course of these efforts, much project knowledge is amassed and evaluated. Additional engineering analyses and studies may be performed as part of the risk analysis, which generally relies mostly on existing information. SQRA focuses on all potential failure modes to determine which

ones are considered credible and significant at the dam. Risks are commonly portrayed on a risk index or risk matrix chart, by potential failure mode.

Semi-quantitative risk analyses require determination of event recurrence and magnitude for those that might result in dam failure. These events are typically infrequent recurrence floods and earthquakes and evaluating these with the potential for overtopping or internal erosion and other risks as identified as credible during the evaluation of potential modes of failure. More information on these higher-level risk analyses can be found in *Best Practices in Dam and Levee Safety Risk Analysis*, issued jointly by the USBR and USACE.

 USBR and USACE [Best Practices in Dam and Levee Safety Risk Analysis](#)

4.4. Risk Assessment

Risk assessment is the process of examining the safety of a specific structure and making specific recommendations on a given dam or project using risk analysis, risk estimates, and other information with the potential to influence decision making. Risk assessments are advised for dams in poor or unsatisfactory condition and for all dams with a PAR. The risks are assessed by the dam owner and the regulator and, as applicable, the owner's engineer and/or other stakeholders. The assessment may consider all factors (likelihood, consequences, cost, environmental impacts, etc.) and may also use evaluation factors established by the owner or regulator. Recommendations may include additional or enhanced monitoring; additional investigations, evaluations, or analyses; remedial actions; abandonment of the dam; or no additional actions. Note that a risk assessment is not a means to justify less costly safety upgrades of dams than those required by an SBA. Such a view seriously misunderstands the true aim of risk assessment, which is to achieve more informed decision making than would be possible from reliance on the SBA alone.

Additional information on risk assessment can be found in Chapter 4.1 of FEMA *Federal Guidelines for Dam Safety Risk Management*.

 FEMA [Federal Guidelines for Dam Safety Risk Management](#)

4.5. Risk Management and Decision Making

The benefits of a risk-informed approach are extensive and well documented. Risk has been used to inform dam safety decisions for a range of purposes:

- Identifying and better understanding potential failure modes (i.e., the causes of dam failure)
- Developing and prioritizing risk reduction measures
- Identifying and understanding risks that exist through normal operation, if any
- Identifying cost-effective options for more rapidly achieving reduced dam safety risks

- Providing a greatly improved understanding of the safety of a dam
- Improving EAPs and identifying critical monitoring and surveillance needs
- Analyzing and assessing risks in areas where traditional standards are not established
- Understanding the potential liabilities of dam ownership

All these activities relate to management of risks, which involves dam safety actions to reduce risk and activities to identify issues early before potential failure modes can initiate.

The primary goal of risk management is to implement actions to accept, further monitor or evaluate, control, or reduce risk, while considering the costs and benefits of any actions taken. Consideration must be given to the level of risk reduced compared with the costs of risk reduction.

4.6. Risk Communication

Risk communication is a critical component of an effective risk-informed decision process. State dam safety programs need risk communication plans. Risk communication is not a separate component of the process; rather, it must be integrated into all aspects of the process. Communication about the work associated with risk is particularly important because of the fears, sentiments, perceptions, and emotions surrounding the word risk and the use of risk analysis in engineering. Risk communication provides many benefits, including enhancing communication with the public, internally within dam-owning and -regulating organizations, and with emergency management agencies; the purpose is to improve the chances that dam safety decisions will be supported within and outside of the organization. Good communication practices better prepare the organization and the public to take action in the event of an emergency and instill confidence in the organization's dam safety office. In this sense, risk communication is essential for all agencies, organizations, and individuals that have a stake in the dam or would be impacted by its failure.

5. Public Safety and Security

5.1. Public Safety Around Dams

According to the *Federal Guidelines for Dam Safety Risk Management*, “public safety is of paramount importance at all dams and reservoirs. Specifically, public safety on the reservoir, in areas adjacent to the reservoir, and below the dam should be considered, particularly in recreational areas. Safety measures should include identification of high watermarks to indicate past or probable reservoir levels and stream flows, posting of safety instructions at highly visible and key locations, and providing audible safety warnings upstream of and below outlets as appropriate.” Public safety measures can include physical barriers, operating controls, warning systems, buoy systems, signage, enforcement actions, remediation construction, decommissioning projects, portage development, and public education and outreach.

While dam owners maintain the ultimate responsibility for the safe operation and maintenance of their dams, remedial construction projects should be reviewed through dam safety program permit application processes. It is also prudent that every dam safety organization be able to periodically require owners to conduct public safety assessments and prepare public safety plans, as discussed below, to minimize risks to the public and to share openly with the public.

5.2. Public Safety Assessments

A public safety assessment is a process used to identify the locations and types of hazards that may exist at or around a dam. The public safety assessment process should include all areas upstream or downstream of the dam that could be affected by its operation, even if those areas extend beyond the owner's property. For hazards identified outside of the owner's property, the dam owner should make owners of at-risk property beyond the dam aware of these hazards and work with these owners accordingly to implement appropriate public safety measures.

5.3. Public Safety Plans

Once a public safety assessment is conducted, a public safety plan should be developed to address the specific hazards associated with the dam. These measures may include, but are not limited to, physical barriers, operating controls, warning systems, signage, and public education and outreach. The dam safety organization should develop a process to require routine periodic re-assessments of public safety and have minimum requirements and procedures developed for public safety plans.

5.4. Security at Dams

Dams are one of the Nation's 16 critical infrastructure sectors. Dams deliver critical water retention and control services. The Dams Sector also has interdependencies with other critical infrastructure sectors, most notably the water and energy sectors. Dam security is vital to protecting the project function and the downstream areas from damage or loss caused by criminal or terrorist acts. Dams present unique security challenges due to the open nature of project sites and the associated recreational aspects of certain facilities. Dam owners must identify security risks in order to provide safe, proper, and adequate service to their customers and develop risk mitigation practices through the implementation of physical security and cybersecurity practices.

To assist state dam safety offices throughout the country with the implementation of security programs, ASDSO has developed the *Guidelines for State Dam Safety Office Implementation of a Dam Security Program*. An effective security program has many considerations and components, which all begin with an awareness of security issues affecting the Dam Sector.



ASDSO [*Guidelines for State Dam Safety Office Implementation of a Dam Security Program*](#)

While physical security considerations to prevent or protect against damage or mis-operation of a dam have not evolved significantly in recent years, the cybersecurity world has changed greatly. A cyberattack on a dam may involve attempts to manipulate the operations of gates, valves, and other

flow control devices at dams that are remotely operated or can be remotely accessed; the attacker's aim is to initiate an uncontrolled release of water or otherwise adversely affect project function. Cybersecurity involves the prevention of and/or protection against such attacks.

The dam safety organization should have the ability and authority to maintain awareness of security and potential security threats to dams by engaging in the activities below, identified in the *Guidelines for State Dam Safety Office Implementation of a Dam Security Program*:

Developing Awareness of Dam Security Issues and Responsibilities by:

- Staying informed and developing a basic understanding of security issues
- Encouraging information sharing and outreach

Collaborating with State, Federal, and National Organizations with Dam Security Responsibilities by:

- Encouraging state and local coordination and collaboration
- Encouraging federal and national coordination and collaboration

Identifying, Prioritizing, and Evaluating Security Risks on State-Regulated Dams by:

- Identifying high-priority state-regulated dams
- Conducting security risk assessments for high-priority state-regulated dams
- Supporting and coordinating development of security plans
- Monitoring status and progress

Conducting Security Exercises and Participating in Related Activities by:

- Participating in security exercises for high-priority state-regulated dams
- Participating in related exercise activities relevant to dam security

6. Compliance and Enforcement

A core function of a dam safety program is to identify unsafe or noncompliant situations and to require appropriate corrective actions to be taken to protect downstream lives, property, and the environment. Compliance is the process of agreeing to and then completing corrections in an appropriate time frame. Enforcement is an action taken to compel a noncompliant actor into compliance. States must use their statutes and policy, recognizing that the desired outcome is a safe dam and not an enforcement action. Since enforcement can be very time-consuming, working in a manner to gain the dam owner's cooperation is typically the optimum way to achieve safe conditions at a dam. All states, however, must have and use enforcement authority when the owner is not taking actions toward bringing the dam into compliance. Compliance with dam safety standards is the goal of any formal dam safety program action. Achieving compliance cooperatively normally reduces the amount of time and other resources a dam safety program must spend.

State dam safety programs must use their enforcement statutes and corresponding regulations quickly, uniformly, and fairly. Such enforcement authority must be addressed specifically within the dam safety legislation and regulations and may also be within general state enforcement procedures. An essential feature of any enforcement program is clear and well-defined procedures that are to be followed by the dam safety program. The compliance and enforcement process must convey to the affected party the action that is formally taken. There must be a defined appeal process for any person or entity subject to this enforcement action. This process is usually set out in the state administrative procedures act.

For most state agencies, the compliance and enforcement process often begins with a periodic or annual inspection or a comprehensive review and inspection. The process may also result from a comprehensive risk assessment. The inspection or assessment must identify non-compliance with state safety standards or conditions of a permit. Periodic onsite inspections are the single most important means by which an agency can determine the level of compliance by dam owners in the maintenance and operation of their dam. Onsite inspections provide the agency, on a regularly recurring basis, with an opportunity to evaluate the safety of a dam and are most useful in identifying short-term issues. Risk evaluations may be necessary for longer-term risk, including safe passage of extreme floods and high internal erosion or seismic risk.

Emergency situations need to be resolved immediately, with enforcement procedures taken subsequently as required. Non-compliance or other safety inadequacies are normally started with a formal notice of the non-compliance and request for actions the owner must take to attain compliance. If an owner does not comply in a reasonable timeframe, or when a clear and willful violation exists, an enforcement order for compliance is issued, with clear actions and time frames for compliance. This order or other action must be written to allow appeal by the dam owner. If the owner does not comply by the date specified, legal action for compliance must be initiated.

If the dam is determined to be unsafe under normal or full conditions, the order or legal action may require actions such as:

- Draining the reservoir and keeping all valves open
- Establishing a maximum (restricted) water level
- Safe breaching of the dam by the owner
- Safe breaching of the dam by the state if the owner fails to comply

Model dam safety programs must apply civil or criminal penalties as consistent with program statutes and regulations. In the administration of enforcement actions, dam safety programs will likely discover minor or inconsequential non-compliance issues that are of lesser severity. State programs may deal with such cases in manners not involving formal hearings or litigation, such as consent orders. However, other violations will require more rigorous enforcement procedures, including the state's attempt to assess civil and/or criminal penalties. An appropriate monetary judgment must cover the cost of the enforcement procedure and penalize the owner appropriately; monetary penalties or consequences must be sufficient to deter violations.

Monetary penalties typically range from \$500 to \$25,000 assessed for each day that the violation goes unaddressed. These moneys often go into the state’s general fund, although it is recommended that they go into a fund specifically earmarked for dam repairs. In addition, it is recommended that the statute indicate that violations of any part of the dam safety statutes, rules, or regulations or failure to comply with orders, directives, or permits constitutes a misdemeanor.

In an emergency, a model dam safety program must have the authority and funding mechanisms to immediately take control of a dam and take appropriate actions toward making the dam safe. The state needs the ability to charge the owner for compensation for taking such actions and to levy liens against the owner or property for failure to reimburse the state.

State programs must have clear administrative procedures for compliance and enforcement actions. These procedures must closely follow dam safety laws and state administrative procedure acts. These must include a clear appeal process for the dam owner or other entity that is subject to the dam safety compliance or enforcement action. Model state programs need to coordinate with the state department of justice and/or agency attorneys on enforcement actions.

Chapter 4 – Dam Construction, Modification, and Removal

Key Takeaways

1. The review and approval process is most effective when the dam safety program, engineer, and dam owner work collaboratively throughout the process
2. Regulators need to be clear and transparent about the review process
3. Dam owners are financially responsible for maintaining dams throughout their life cycle

Checklist

- Communication between the owner's engineer and the state dam safety program prior to submittal of design information
- Review and evaluation of an application and all design submittals including reports, drawings, specifications, operations plans, emergency plans, and all other supporting documents
- Determination of necessary changes to the documents as submitted by the owner and the owner's engineer
- Approval of the design documents and/or applications if compliant with state standards and denial of all non-compliant applications
- Monitoring and or inspection of the approved project's construction
- Review of project completion documentation
- Monitoring and/or inspection of the completed project

Definitions

Construction – includes building of new dams and modifications to existing dams

Modification – any construction or repair activity that changes a design element of a dam or otherwise requires engineering analysis

Removal – all actions needed to eliminate risk of dam-failure-related inundation below the dam and may include partial or complete structure removal

Deregulation – safe removal/permanent stabilization of a dam so that it no longer poses downstream risks and is no longer subject to state dam safety program jurisdiction

1. Introduction

Review and sufficiency determinations of design documents for new dams was the original focus of most of the long-standing dam safety programs. Design review is essential for determining whether dams are to be built to meet or exceed minimum state and current-practice design and operating standards. Dam safety programs may use either a permit-based process or a regulatory review and approval process, or a combination of both. Model state dam safety programs must regulate construction approval, modification, and removal through the following activities:

- Communication between the owner’s engineer and the state dam safety program prior to submittal of design information
- Review and evaluation of an application and all design submittals including reports, drawings, specifications, operations plans, emergency plans, and all other supporting documents
- Determination of necessary changes to the documents as submitted by the owner and the owner’s engineer
- Approval of the design documents and/or applications if compliant with state standards and denial of all non-compliant applications
- Monitoring and or inspection of the approved project’s construction
- Review of project completion documentation
 - If the project is complete, formal written permission to impound water and/or to place the dam into service
 - If the project is not complete, formal written request of actions to properly complete the project or to remove the dam
- Monitoring and/or inspection of the completed project

For the purpose of the Model Program, **construction** includes building of a new dam and may include some or all modifications. **Modification** is any construction or repair activity that changes a design element of a dam or otherwise requires engineering analysis. **Modification** includes any activity that increases the height of a dam or might increase or reduce the normal operating reservoir level of a dam. State programs must determine which specific modification actions, such as rehabilitation and certain repairs, will require state review and approval and/or permitting.

Removal includes all actions needed to eliminate risk of dam-failure-related inundation below the dam and may include partial or complete structure removal. **Removal** may include stabilization and drainage of materials in tailings dams and other storage lagoons and, in some cases, removal of some or all of these materials. **Removal** includes permanent stabilization of the project site to prevent movement of waste materials and to prevent rapid erosion of natural stream sediments.

State programs must determine specific actions necessary for **removal**. The term **deregulation** is used for safe removal/permanent stabilization of a dam so that it no longer poses downstream risk and no longer requires state dam safety program inspection and other actions. Some dam safety programs may also evaluate environmental impacts or risks.

The permitting or design review process includes actions and input from dam owners, the engineer of record, and construction contractors. The **engineer of record** is the lead engineer responsible for overall implementation of all approved permit design and application documents. Design documents and application review compare the proposed project to state regulatory criteria, accepted technical standards, and/or compliance with the state of practice.

Permitting/review and approval is the essential tool that dam safety programs use to require that proposed dam projects are designed and constructed to minimize risks to life, property, the environment, and infrastructure located downstream of the dam. The graphic below shows the typical permitting life cycle of dams.

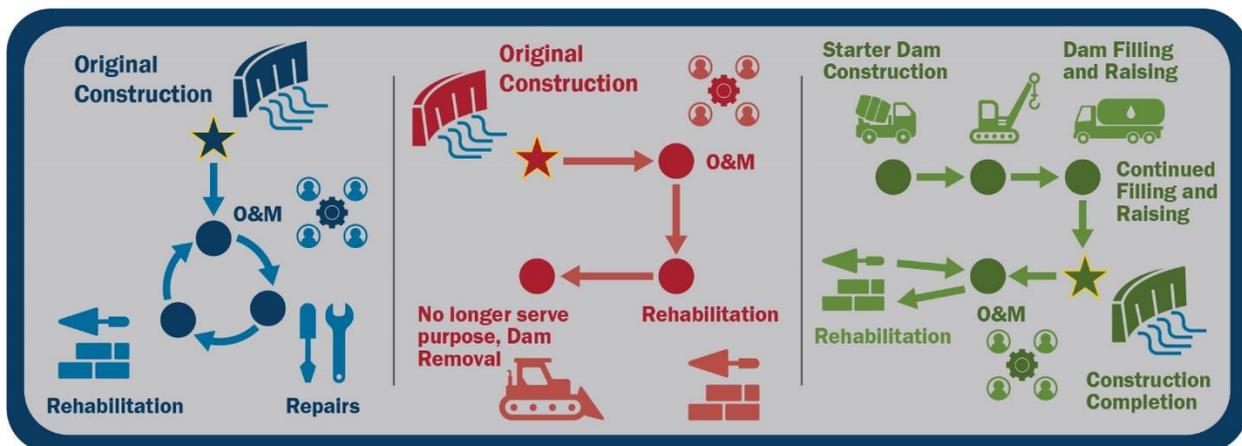


Figure 2. Life cycle of a dam. Typical in-service dam (blue), dam that has reached the end of its service life and will be removed (red), tailings dam (green). Inspections are performed throughout the life cycle of a dam, and they often identify potential risks and/or deficiencies.

2. General Responsibilities

The dam safety design/approval process typically includes the dam owner, engineer, construction contractor, and dam safety program. The general responsibilities of each of these entities is discussed below. These responsibilities will vary based on the complexity and risk associated with a project.

2.1. Dam Owner

Dam owners are responsible for:

- Operating and maintaining the dam safely, as required by the permit/conditions of approval and laws or regulations
- Having sufficient financial resources to maintain and repair the dam, as needed, over the life of the structure
- Selecting an engineer with dam safety project experience to perform the design and monitor the construction/rehabilitation
- Screening and contracting with the construction contractor (with dam construction experience) to perform/complete construction/rehabilitation
- If necessary, screening and contracting with an independent/specialized review team or board of review
- Obtaining all necessary federal, state, and local permits and approvals
- Overseeing and participating in design, permitting, and construction

2.2. Engineer

Engineer responsibilities include:

- Designing a new dam, repairing or rehabilitating an existing dam, or decommissioning and removing an existing dam no longer needed for its original or modified intention; these services are performed on behalf of the dam owner
- Managing the design process, including facilitating necessary communication and meetings with the owner and state or federal dam safety program
- On behalf of the dam owner, completing and submitting application packages, including a signed/sealed design report, plans, and specifications
- Responding to and addressing dam safety program comments and concerns
- Performing direct oversight and monitoring during construction to make sure the project is completed in compliance with the design and permit conditions
- Working with the other entities to address any construction-related issues that potentially affect the safety of the completed project
- If there is a team of engineers, appointing one to be the engineer of record
- Ensuring that details of the construction monitoring/inspection program demonstrate an adequate and qualified force for inspection of construction, reconstruction, enlargement, repair,

alteration, maintenance, operation, or removal of dams; the dam safety program cannot accept quality control monitoring/inspection by the contractor

- Notifying the dam safety program of any significant change in condition encountered, with proposed design modifications to be agreed to by the state program
- Providing construction records and a construction completion statement to the dam safety program; overseeing the dam's post-completion/first filling/placement into service and related monitoring

2.3. Construction Contractor

Construction contractors are responsible for:

- Reviewing and understanding the permit conditions/approved plans and specifications
- Completing construction in compliance with the design and permit conditions
- Providing safe access to the site for inspection/observation
- Identifying constructability issues or site conditions that differ from those in the design and communicating them to the engineer and dam safety program
- Providing and maintaining construction site safety and security throughout construction

2.4. State Dam Safety Program

A model state dam safety program must:

- Establish appropriate standards and guidelines to be used in the permitting and/or approval process
- Participate in meetings and communications with the engineer, dam owner, and construction contractor; require an engineer of record and engineer retained by a dam owner to analyze, plan, and design a dam to current safety standards and to oversee safe construction
- Provide clear guidance on the application and review process, indicating how the review will be conducted
- Review applications and designs for compliance with dam safety rules/regulations of the state and/or consistency with current industry and national practices
- For large or complex high-risk projects or projects that use new or non-standard technology, require that the engineer and dam owner hire an independent specialized review team (board of review), which must be approved or agreed upon by the dam safety program

- Perform independent calculations as needed based on project complexity and risk
- Provide clear and concise comments or concerns to be addressed to the dam owner and engineer
- Provide the opportunity for public input in accordance with statutory requirements
- Approve design documents and issue permits, as appropriate, if the design complies with regulations, rules, and guidelines; deny the application if the design is not in compliance
- Perform periodic site visits/inspections during construction to check for project compliance with the permit conditions
- Receive and review construction inspection reports and proposed technical changes
- Perform final project inspection
- Receive and review construction records
- Prior to (re)filling the reservoir, authorize placing the dam into service or back into normal operation, or provide confirmation that the dam has been correctly and suitably removed so it can be deregulated

3. Dam Construction

For new construction, reconstruction, or modification of an existing dam, the following minimum items must be required and signed/sealed by the engineer, as applicable. Construction must not be approved or permitted until the state dam safety program determines all required analyses, designs, and plans meet state program regulations or standards.

The Following Must be Submitted and Reviewed:

- Construction plans and specifications
- Hazard potential identification or classification
- Statement of ownership
- Hydrologic and hydraulic design computations
- Structural design computations
- Geotechnical data and design computations
- Evidence that existing critical drain systems were constructed without defects and are performing properly or design computations and data documenting suitability of proposed critical drain systems
- Instrumentation plan
- Operation and maintenance plan

- EAP (for high and significant hazard potential dams, at a minimum)
- Proof of ownership or easement and identification of impacts to flowage area upstream under normal pool and maximum pool/top-of-dam elevation
- Statement of the dam owner’s financial capability/performance bond in accordance with statutes and regulations
- At the end of the project, the submission of as-built plans, construction records, construction record drawings, and a statement by the engineer that the project was completed in compliance with the design and permit conditions

Construction and operations of tailings dams are significantly different from other water and wastewater dams. Tailings dams are frequently enlarged, and upon stabilization or deregulation, the tailings remain in place.

4. Dam Modification

Plans and other documents for the modification of existing dams need to be reviewed and approved by the dam safety program prior to modification activity. The current condition of the dam, the hazard rating, the type of modification, and the proposed means to achieve the modification all dictate the timing and detail of review needed. Emergency repairs must be addressed on a case-by-case basis. Major pre-planned repairs must be reviewed and approved prior to the initiation of the activity. Repairs may be ordered in accordance with risk prioritization. In all cases, the owner and the dam safety program must maintain record or as-built records of the completed repair.

State dam safety programs must determine what activities require review and must always review all changes that increase height or storage or that modify any designed safety element of the dam. Submittals must be required for any other change that could reasonably affect the safety of the dam. A state dam safety program may require design submittals for any repair activity the program deems necessary. A separate process may be used for maintenance and minor repair issues.

While perhaps not as preferred as a single-phased project from a dam safety prospective, a multi-phased project is often necessary because of the high costs associated with dam design and construction. It is important that dam safety programs recognize the viability of multi-phased projects and encourage dam owners and engineers to develop a risk-informed approach to prioritizing and phasing the work. In this way, a project schedule can be developed that addresses the highest risk deficiencies first, with the long-term goal of bringing the dam into full compliance. At the end of the day, dam safety programs do not want to discourage dam owners from addressing safety deficiencies.

5. Dam Removal and Deregulation

The following items shall be required and approved prior to initiating a dam’s removal:

- Method of dewatering, including any necessary testing for environmentally sensitive discharges and justification for proposed flows
- Method of breaching or removal
- Means to control erosion and sediment transport during and after the breach (in some cases, another agency may be performing this evaluation; the model dam safety program may need to share the removal plan with other agencies as appropriate)
- An EAP that is applicable for all phases of the dam's removal
- Time schedule and sequence of construction
- Completion plans
- Notification whether it is necessary to re-map downstream floodways

6. Dam Safety Program Review Process

The model dam safety program must familiarize itself with all state legal requirements for review, including with respect to public participation, if applicable. Inter-agency review of all permit applications may be necessary, especially where the dam safety program is not the lead for water quality or floodplain management.

The review and approval process is most effective when the dam safety program, engineer, and dam owner work collaboratively throughout the process, with the common goal to construct a project that properly provides for public safety while meeting project performance goals/uses and needs. For the project to be most successful, clear and open communication between these entities is necessary throughout all elements of a review and completion of permitted activities. The model dam safety program must ensure rule and guidance criteria used for the review are made available to the engineer.

A critical element of review is to understand and to review the design engineers' assumptions. Are the site geologic issues adequately investigated and interpreted? Are current information and procedures used to determine the inflow design flood and routing of that flood through the spillway(s)? Are critical parameters based on field measurements or only average properties? Is the dam breach inundation analysis for the dam safety program suitable to determine the hazard potential classification?

The review process may be scalable so that the same general process is followed for every project, from a small, low-risk project to a large, complex, high-risk project. The number of program staff working on the review will depend on project complexity, although a minimum of two reviewers is typically recommended, as is a full, in-depth review complete with comments (if applicable).

Pre-application meetings with the dam owner and engineer are advised. Ideally, the first meeting would occur prior to finalizing the engineer’s scope of work for the project. This step is important for understanding the project, its constraints, and the application and design submittal requirements. Documentation of these meetings may be important, as it can serve as guidance for the project.

Dam safety programs must clearly communicate how the permit or design review will be performed and set clear expectations for application submittals. The required standards, rules/regulations, and guidelines against which the application will be compared must be made available to dam owners and engineers. It can be helpful for state programs to develop an application checklist that is shared with the dam owner and engineer. While it is not up to the dam safety program to tell an engineer how to design a dam, the program is obligated to tell engineers how their applications will be reviewed. After documents are reviewed, the state program may advise the engineer if all documents have been completed or more documents are needed. More detailed technical review will result in clear correspondence and communication with the owner and engineer.

6.1. Design Objectives for High Hazard Dams

Table 2: Design Objectives for High Hazard Dams

State Dam Safety Programs should develop design objectives for dams of all hazard potential classifications within their regulatory jurisdiction based on Federal Dam Safety Guidance and industry best practices. Below is a table that provides recommended design objectives for High hazard potential dams.

Design Objective	Description
Inflow Design Flood and Spillway Capacity	The Probable Maximum Flood is considered the design flood by most dam safety organizations. State programs may choose to use a very infrequent annual exceedance probability flood (10^{-5} to 10^{-6} exceedance). States may also consider incremental consequence analysis or risk-informed decision making to evaluate the potential of selecting a different design flood.
Earthquake/Seismic Design Criteria	The Maximum Credible Earthquake is now considered the design earthquake in western states and earthquake-prone eastern states.
Internal Erosion for Embankment Dams	Defensive soil filters and drains are needed to prevent internal erosion and safely collect and transmit seepage out of the dam structure.
Foundation Drains for Concrete Dams	Uplift pressures due to seepage through the dam’s foundation must be addressed.
Conduits	Conduits for all dams must be durable and include drainage provisions based on the hazard potential classification and relative risks of the dam.
Concrete Spillway Chutes	Concrete spillway chutes must be designed specifically to withstand, structurally and hydraulically, the forces of the spillway discharge from the inflow design flood.

Design Objective	Description
Construction Materials	Construction materials must be inspected for defects and tested, as necessary.

6.2. Financial Responsibility

It is essential that dam owners be able to afford all elements of dam construction, operation, and maintenance for the lifetime of the dam structure, including its removal. There are many ways for state programs to determine financial responsibility. One effective technique requires that dam owners secure bonds for the continued operation, maintenance, or removal of the dam. Other states have set up funds to assist dam owners with obtaining bonds. Whichever instrument is used, it must hold up to legal scrutiny.

6.3. Conditions of Approval or Permit

When the design documents and associated plans are approved, a formal permit or written approval document must be provided to the dam owner and the engineer. The document must include conditions under which the work must be conducted. For efficiency, states may consider developing general conditions that apply to every dam project and a catalog of project-specific conditions that can be included in the permit when warranted.



Typical Permit or Approval Conditions

- Notification to dam safety program of planned start date of construction
- Valid time frame of the permit, including seasonal requirements/winter work requirements, if applicable
- Requirements for pre-construction and final completion meetings with the dam owner, engineer, construction contractor, and dam safety program
- Construction monitoring/supervision requirements
- Notification prior to certain construction aspects, such as backfilling of a spillway pipe trench
- Providing state program staff access to the project site to perform construction inspections
- Notification of necessary deviations from the approved design and written approval from the dam safety program of these proposed changes to the design
- Requirement that the engineer provide, upon project completion, construction records, including record drawings or as-built drawings; photo documentation; material testing reports; and construction reports
- Statement from the dam safety program after final inspection that the completed project has been constructed in compliance with the approved design and permit conditions and that the program affirms that the dam can safely impound water or water-borne material,

that the dam can be safely placed into service, or that the dam has been completely decommissioned and removed

- Requirement that the dam cannot be used to impound water or otherwise placed into service until the dam safety program provides written authorization following confirmation of compliance with all other permit conditions

6.4. Application Denial or Permit Revocation

The permit application must be denied if (1) the application is administratively incomplete, (2) the application fails to meet minimum application requirements, or (3) the project fails to meet minimum safety standards. The model dam safety program must provide a denial letter to the applicant detailing the reasons for the denial. If the conditions of a permit are not followed, compliance and enforcement may be necessary. If compliance cannot be achieved, the permit may be revoked, and enforcement will be pursued, as necessary.

6.5. Construction Inspections

A model dam safety program must perform construction inspections to ascertain whether the engineer of record is monitoring the project sufficiently to determine whether the project is being constructed in conformance with the approved plans, specifications, and permit or approval conditions. Dam safety programs need not duplicate the frequent inspection and design implementation work of the engineer (of record). Dam safety program construction inspections must evaluate dam construction at critical times, such as when the footprint has been cleared and the cutoff trench is excavated, when the conduit is being installed, and during construction of concrete spillway chutes. If a dam safety program finds inconsistencies, the program must notify the engineer that the work must be corrected to ensure proper construction. If the engineer fails to do this, enforcement actions must be taken against the construction contractor, engineer, or owner, as appropriate. Dams must not be allowed to store water or water-borne materials until all necessary construction review has been completed and the dam safety program concurs with the engineer's final submittals.

6.6. Other Agency Requirements

In addition to state dam safety permitting, it is likely that other permits for dam projects will be required, such as state environmental permits, federal environmental permits, and local permits.

6.7. Project Completion

Dam safety programs make the final determination of project completion and must inform the owner in writing of the decision that all necessary documents have been submitted and accepted. Similarly, in the case of dam de-regulation and removal, written confirmation that the dam has been satisfactorily removed is necessary. The following items must be submitted and approved:

- The engineer’s construction completion statement indicating the project has been performed in compliance with approved plans and specifications and permit conditions
- Construction records including record/as-built plans, photographs, material testing reports, and field reports
- Filling/post-construction monitoring schedule prepared by the engineer
- Engineer’s statement of completion

The owner or engineer must request a dam safety program final construction inspection. After that inspection, and upon receipt and review of the material listed above, final inspection by the dam safety program shall be completed. Based on this, the dam safety program will decide whether to provide authorization to impound water or water-borne material and place the dam into service or to confirm that the dam has been satisfactorily decommissioned and removed.

It had generally been common practice for dam safety programs, as part of the project completion process, to require that the engineer certify or provide a project certification for the completed work. State programs are advised to stop using the term “Certification” for project completion, as it indicates a higher level of certainty than can reasonably be ascertained and elevates the engineer’s liability beyond the normal standard in engineering practice.

What can be provided is a statement of opinion based on sufficient observation. The engineer responsible for construction inspection must provide a statement such as, “I, _____, was onsite for sufficient time to observe construction and confirm that the project was constructed in general accordance with the approved plans, specifications, and permit conditions.”

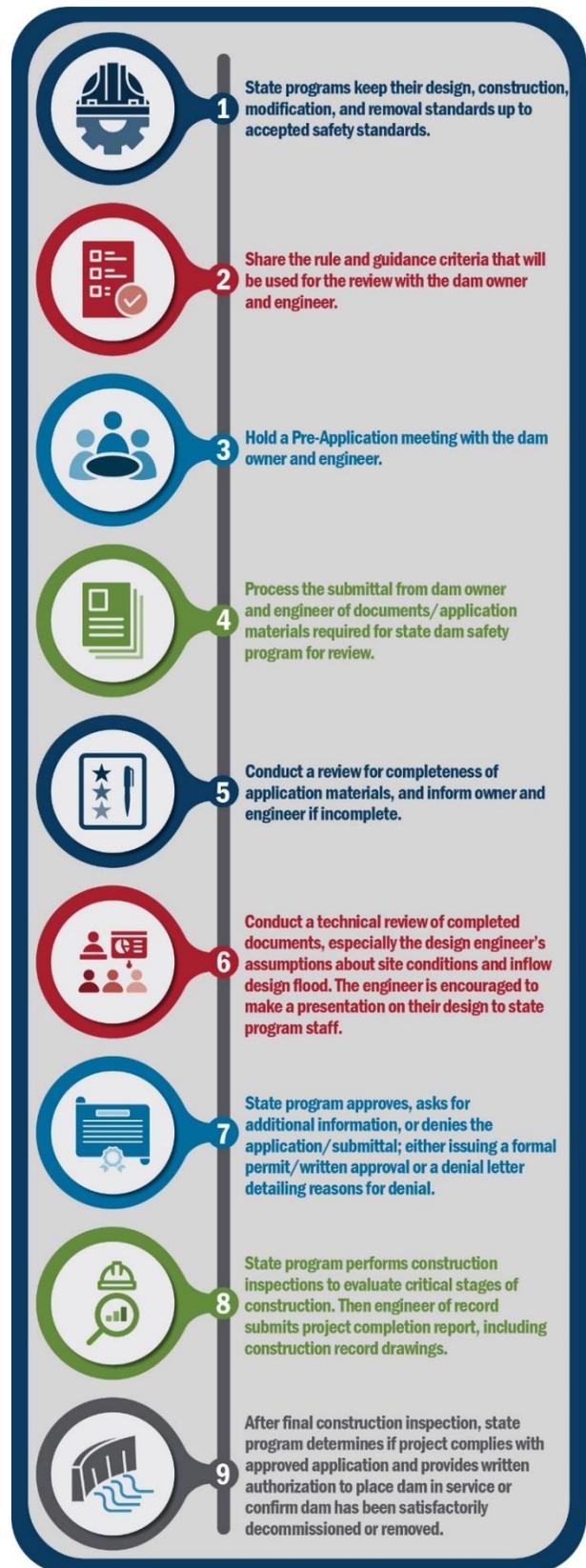


Figure 2. Project completion process.

Chapter 5 – Emergency Planning and Incident Response

Key Takeaways

1. Model state dam safety programs must require EAPs for high and significant hazard potential dams; EAPs must be periodically updated and exercised to ensure that all stakeholders and emergency response team members are fully prepared
2. All members of the emergency response team must know their roles and responsibilities to ensure an effective and efficient incident response
3. Forensic investigations of all failures of high and significant hazard potential dams must be conducted, and forensic inspections of low hazard dam failures should be considered

Checklist

- State standards for EAPs or a state template, consistent with FEMA 64
- EAPs developed for high or significant hazard potential dams
- Dam owner knows to immediately notify the program and emergency managers when incidents identified
- Dam owners aware of necessary emergency actions to prevent dam failure
- Program able to respond to dam emergencies and take necessary actions if owner cannot or will not
- Staff prepared to coordinate with the emergency managers during emergencies
- Staff prepared to assist in incident communication
- Program prepared for multi-dam emergency inspections, including completed Emergency Management Assistance Compacts
- Program investigates failures of high and significant hazard dams

Definitions

Dam safety incident – any changed or changing condition at a dam that, if left unattended, poses an elevated risk of damaging flooding downstream or could progress to dam failure

1. Introduction

This chapter describes what a state dam safety program needs to understand and address in order to create and foster a culture of preparedness for dam safety incidents and failures. This chapter is broken into activities associated with emergency action planning and activities associated with incident response. Dam safety incidents require detection and categorization, followed by an appropriate response that includes timely actions of the dam owner, first responders, the dam safety program, state and local emergency management agencies, the National Weather Service, and others. The groups tasked with responding to dam safety incidents are collectively referred to as the Emergency Response Team. The response must be scaled proportionately to the likelihood of dam failure as a result of the observed condition and to the downstream consequences.

Dam safety incidents include any changed or changing condition at a dam that, if left unattended, poses an elevated risk of damaging flooding downstream or could progress to dam failure. Dam incidents can be classified into categories, including unusual condition, high flow, potential failure, and imminent failure. Unusual conditions are changes at the dam that do not pose an imminent risk (non-failure at the present time) but do require additional monitoring or inspection. Unusual conditions include much higher-than-normal reservoir levels, changes in seepage, small slides, and many others. Unusual conditions are sometimes referred to as non-failure conditions but should be considered serious, as they may be a sign of initiation or progression of a potential failure mode.

Any incident may in time become an emergency that could pose an immediate and imminent threat to people or property. Incidents can be triggered by specific events such as major floods, earthquakes, or intentional acts of vandals or terrorists. Incidents can also be initiated by progressive failure mechanisms such as internal erosion or piping. Mis-operation of outlet and spillway valves and gates can also lead to dangerous high-flow conditions in the channels below dams. Any unusual or high-flow condition must be assessed with urgency, as such conditions can quickly progress to dam failure if left unattended. Incidents categorized as potential failure or imminent failure require immediate action to evacuate those within the dam failure inundation zone to reduce the potential for loss of life.

2. Roles

2.1. State Dam Safety Program

The state dam safety program must set standards for its role in incident response and planning. State programs must evaluate dam owner preparations for identifying and responding to incidents and emergencies. In cooperation with state and local emergency managers, the dam safety program must also set standards for EAPs, review and approve the EAPs, require, review, and approve updates of the EAPs, collaborate with the owner on periodic EAP exercises, and provide or collaborate on EAP training sessions for stakeholder groups.

2.2. Dam Owner

The dam owner is ultimately responsible for all actions at the dam in an incident or emergency. The dam owner may also be responsible for initial notifications if dam owner staff make the observations, or for confirming and verifying the observations of others. Owners of dams classified as high or significant hazard potential must develop EAPs for their dams, in coordination with the state dam safety program and emergency management authorities. Dam owners must have the necessary tools and training to identify the level of an incident, make appropriate notifications, and respond appropriately to incidents and emergencies, as detailed in the EAP.

2.3. Emergency Management Officials

Emergency management officials include federal, state, and local emergency managers. All dam incidents and failures start as “local” events, with local emergency managers having primary responsibility. As an incident escalates, local jurisdictions will work with state emergency managers, and once the local resources are expended, a state disaster declaration will be made, and state resources will then be utilized in the response. If the incident escalates further still, a national or presidential disaster declaration will be issued, and federal resources, including FEMA and the National Guard, can be used in the response. Local emergency managers have the primary responsibility and statutory authority for mass notifications, evacuation, security, shelter, and care.

State and local emergency managers need to be knowledgeable regarding the location and ownership of high and significant hazard dams. To ensure this knowledge, state dam safety officials should work closely with state and local emergency managers as they each develop hazard mitigation plans (HMPs) for their jurisdictions. As discussed above in the “Information Sharing and Coordination with Emergency Managers” section, HMPs are a FEMA requirement if states and counties are to receive FEMA funding. Since high and significant hazard dams clearly represent a hazard, it is appropriate for state dam safety programs to work with emergency managers to ensure the locations, hazard classification, ownership information, and other pertinent information about dams in each state are included in county and state HMPs.

Local officials also decide whether it is necessary to ask for a state or federal emergency declaration and whether additional resources are needed for the emergency or post-emergency response and recovery efforts. State emergency managers must be involved if additional resources are needed and can also help facilitate discussion at all levels.

2.4. First Responders

First responders are responsible for road closures and evacuations. First responders are typically local police, fire, sheriffs, and transportation departments. In some cases, they could be volunteers. First responders may have no prior experience with dam emergencies. First responders take direct actions to protect people and property below the dam, using the inundation maps in the EAP.

2.5. National Weather Service

The National Weather Service is notified of imminent or ongoing dam failures, in accordance with EAP procedures, and will issue official public warnings for these incidences and failures. The National Weather Service Weather Forecast Offices (WFOs) may be offered the opportunity to be involved with EAP planning. During a dam safety incident, WFOs provide situational awareness of the weather and its potential impacts on incident management. The WFO issues alerts and warnings, as requested by the incident managers. In coordination with WFOs, a model state program must assist a dam owner, as necessary, in the planning, development, and implementation of an EAP.

3. Emergency Action Plans

An EAP is the formal document used to categorize potential emergency conditions at a dam and specifies incident response actions to follow to minimize potential loss of life and property damage. The EAP describes the following.

- Essential dam information
- Event-level determination and expected actions to prevent incident escalation and dam failure
- Notifications of EAP holders
- Roles, responsibilities, and communication with members of the emergency response team throughout the incident
- Identification of locally available resources aligned with expected actions
- Evacuation information to aide first responders in getting populations at risk (PARs) out of harm's way
- Inundation mapping to show the anticipated limits of dam failure flooding
- Critical infrastructure within the dam failure flooding inundation zone
- Responsibilities for termination of an EAP activation

Model state programs must require EAPs for high and significant hazard potential dams. More specific details and guidance for EAPs are provided in FEMA 64 *Emergency Action Planning for Dams*. This Model Program will not repeat guidance found in that document.



FEMA [Emergency Action Planning for Dams](#)

State dam safety programs must review the various stakeholder roles in EAP development, exercises, and updates. Although the dam owner may be legally responsible for these activities, development of an EAP should be a partnership of the plan stakeholders who work together for the

emergency response team during incidents. State programs must review EAPs and help coordinate members of the emergency response team to determine whether they are meeting state requirements and using best practices. The state dam safety program must determine whether EAPs are updated and exercised periodically, as consistent with state requirements. The following sections provide additional information relative to the contents of an EAP.

3.1. Templates

The EAP must include the key elements described in FEMA 64. An EAP must be dam-specific to identify conditions particular to the dam and downstream from the dam. Some actions by the various responding agencies will be the same from dam to dam, based on the responsibilities and capabilities of those agencies. It is beneficial for state programs to develop “templates” to aide in EAP development and provide consistency in all EAPs. If a state chooses to use a state-specific template, it needs to be simple and complete and aid the dam safety program’s review of the EAP. The template must help ensure the owner’s development of an effective EAP, given owner or community limitations, and must assist emergency response agencies in completing orderly evacuations. The owner’s capabilities must also be considered in developing the EAP. This is especially important when owners are individuals or small communities with limited or no staff.

3.2. Inundation Maps

Inundation maps are needed to show locations that will likely be flooded in the event of dam failure; these maps aid in development of evacuation plans. Inundation maps may also be needed to portray hazardous “high flow” conditions created by necessary and intentional releases from outlet and spillway valves and gates. Inundation maps are used both by the emergency management officials, and in some cases a dam owner, to facilitate timely notification and evacuation of areas affected by a dam failure or flood conditions. Information on inundation mapping is found in FEMA P-946, *Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures*.



FEMA [Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures](#)

Inundation maps must be developed by an engineer with hydraulics and breach flow modeling experience. If the difference between sunny day failure and spillway design flood inundation is not great, using only one map is preferred because it is less confusing to emergency managers. If there are both sunny day and spillway design flood maps in an EAP, it is important that local officials know which map applies to which EAP activation level. For dams that can release large volumes during floods, especially dams with flood gates, inundation mapping of large non-failure releases may be needed. Inundation maps are not evacuation maps but, in some cases, may be the only tool for evacuation. The dam safety program will normally coordinate with emergency managers regarding the information provided on the inundation maps. Emergency managers must be advised to use inundation maps to develop evacuation maps and evacuation plans, especially for dams with a high

PAR within the inundation area. However, in some cases, inundation maps can include evacuation routes, eliminating the need for additional evacuation maps.

3.3. Event Detection

Historically, most potential incidents have been identified by direct observation (surveillance) of the dam and/or in advance by weather and flood forecasting. Risk analyses can be conducted to identify likely modes of failure or areas of heightened risk at given dams. This information can then be used in the EAP to describe the likely observations at nodes in the progression of those identified failure modes. Remote monitoring of a dam can also be particularly important for detecting incidents, especially instrumentation to sense reservoir levels, piezometers levels, and seepage weir flows. Monitoring of seepage and piezometers can sometimes be helpful in a slowly developing event or slow progression of an identified failure mode. The EAP must include specific guidance for determining emergency levels for a range of potential observations associated with overtopping or internal erosion failure modes. In some cases, an event-level determination will be based on measurements from monitoring equipment; in other cases, such a determination will be based on visual observations. It is important that the EAP include guidance on the rate of change of progressive failure modes, as that is critical information as incidents escalate.

3.4. Notifications and Communication

Notifications to and communication with all members of the emergency response team are critical for an effective and successful response to dam safety incidents. Modern methods of communication can enable effective and efficient notifications and facilitate coordination of multi-agency response during incidents. Effective communication allows stakeholders to share the best available information regarding the situation so the response team members can determine what resources and capabilities to employ. Dam owners without staff or other assistance may coordinate with others for assistance in making notifications, setting up conference calls, etc.—even something as simple as notification to the 911 system and the state dam safety program. Dam owners may need time to execute preventative actions instead of making multiple phone calls.

Some states have started using single notification lists or charts for all levels of events. This preference has been identified in coordination activities with state and local emergency managers. Some federal EAP templates still include multiple notification charts for different event levels. This Model Program recommends that state dam safety officials coordinate with local and state emergency managers in their jurisdictions to arrive at the most suitable templates. In any case, establishing rapid and repeatable communication protocols is the goal. This will allow response team members to discuss and assess the situation as it progresses, identify the needed capabilities, and apply the appropriate resources to control the incident.

At remotely located dams, landlines may be unavailable and cell phones unreliable. EAPs for remotely located dams with known communication issues must include descriptions of protocols for alternative means of effective notification and communication.

3.5. EAP Updating and Exercising

EAPs must be periodically updated and exercised to ensure that all stakeholders and emergency response team members are fully prepared. The dam safety program may set standards for the frequency and expected actions for both activities. Responsibility for these efforts typically falls on the dam owner, but dam safety programs must support improvement to EAPs as resources allow.

Dam owners have the responsibility to notify holders of EAPs with the updated EAPs (preferably as PDF files—see below). EAPs must be updated immediately if there is a change in dam ownership.

In many states, EAP libraries have gone digital, and EAPs are archived and accessible as PDF documents on network servers. As such, the current state of the practice with EAP updates is to produce and distribute full digital copies of updated documents. It is more efficient simply to replace an entire PDF file with a new PDF, instead of removing and replacing individual pages from paper or digital documents.

Emergency managers that may be involved in emergency warnings and evacuations must be invited to EAP exercises. In some cases, state and local emergency managers may want to organize and facilitate an EAP exercise, in combination with exercising emergency operations centers (EOCs). Dam owners and state dam safety officials should seek out such collaborative activities. State programs may consider the condition of the dam, PAR, and change in key staff when determining or recommending exercise and update frequency. State programs should also consider multiple-dam, county-wide, or regional emergency exercises.

4. Incident Response

Incident response relies on the efforts described above to ensure the preparedness of the emergency response team. It is the responsibility of all members of the emergency response team to know their roles and responsibilities to ensure an effective and efficient incident response.

Emergency managers use the National Incident Management System (NIMS) and the Incident Command System (ICS) for structured responses to all-hazards. NIMS is a comprehensive, national approach to incident management that is applicable at all jurisdictional levels and across functional disciplines. The Incident Command System (ICS) is a standardized approach to the command, control, and coordination of emergency response, providing a common hierarchy within which responders from multiple agencies can be effective. ICS is a component of NIMS which has evolved for use in all-hazards response situations.

Since dam safety incidents are managed under NIMS and ICS principles and practices by all states, senior dam safety engineers need to be trained and conversant in the language of NIMS and ICS. Online classes are available for NIMS and ICS so that state dam safety engineers can become familiar with these systems and enable a more effective role as part of a multi-agency response to dam safety incidents.

4.1. Actions During an Incident

During an incident, all members of an emergency response team must take appropriate and timely actions to reduce the potential for incident escalation. The decision to activate an EAP is the dam owner's responsibility. State dam safety programs must educate and empower their dam owners to make these critical determinations. State dam safety officials may also support a dam owner in making this determination if the dam is owned by an individual with limited supportive resources or if the owner is not in a position or does not have the capability to detect an incident. If time allows, owners must be required to confer with their state dam safety program to concur on the appropriate EAP activation level, as well as initiating notifications. Owners will need time to execute preventative actions to prevent dam failure.

While the dam owner(s) and engineer(s) are working to manage the incident at the dam, local and state emergency managers will be assessing the need for evacuation or other actions to reduce consequences. These activities occur concurrently with actions at the dam. Initial discussions following EAP activation must establish the technical capabilities to prevent failure and the strengths and weaknesses of the team in relation to the scale of the incident. If additional expertise is needed, it must be identified and procured.

If the model dam safety program engineers determine that an owner's actions are insufficient, the program must communicate this to the dam owner. State programs may need to take direct action, if authorized by law. State actions must be consistent with a program's authority. These actions may include taking over incident command, contacting emergency managers, working to release water from the dam, or instigating other necessary actions. Some states have developed an incident response team, and in such cases, the team's response must be consistent with its authority and resources.

5. Incident Information

Every dam safety program is subject to the possibility of a dam incident. If the dam safety program plans for incidents during routine times, the transition to a real incident will be much more effective, with accurate and timely information flow from the agency to the emergency response team, to the media, and to the general public. The plan will help manage critical information quickly and efficiently.

Incident Information Plans Must Include:

- Communications scenarios, including social media, radio, or cellular telephone coverage, security, and procedures, as well as the potential need for continuous (24-hour) communication with key personnel
- Designation of specific agency officials who can take questions and provide answers, sticking only to established facts without any guessing or speculation; for dam owners and dam safety officials with limited resources or experience, designation of an experienced local or state PIO to speak on their behalf

- Dam safety program facts and current capabilities (Chapter 2)

5.1. Major Incidents and Multi-Dam Emergencies

Major incidents and multi-dam emergencies can occur after a large earthquake or regional extreme rainfall/flooding event. Response to such emergencies can be hindered by road closures that may restrict ground access to potentially affected dams. Dam safety programs must have alternate transportation plans to access high-priority dams that may have restricted access during emergencies. Rapid, multi-dam safety inspections may be needed in such emergencies to assess the condition of dams within the affected areas, to aid the incident response, and to help facilitate an immediate recovery. A major concern following these events is the safety of response and recovery workers working within dam failure inundation zones. Inspections must ensure dams upstream of these work zones will not present a risk to workers or obstruct response/recovery efforts.

5.2. Emergency Inspections

Large regional incidents may require assistance from technical experts outside of the dam safety program. The state program must determine the priority dams for emergency inspections so they can perform triage on dams with the most safety risk. Conducting rapid emergency inspections of a large number of dams is a significant undertaking—especially during a major incident—so dam safety programs must prepare to support these efforts. Preparations include:

- Maintaining dam access information for priority dams
- Determining how best to indemnify engineers working on behalf of the state during an emergency (states may have existing statutes in place, so ask your attorney general’s office)
- Establishing experience-based or other credentialing criteria for engineers offering to conduct post-event inspections
- Providing a scope of work for the inspections so engineers perform the work consistently
- Establishing a priority system for actions based on interim inspection findings such as:
 - Needs immediate attention
 - Some minor damage but dam is safe
 - No damage; dam is safe
- Required schedule (durations) for inspections, interim inspection report findings, and final inspection report submission
- Plans for management of volunteer engineers and processing inspection reports

5.3. Emergency Management Assistance Compact

Agreements for inspections using resources from other states, federal agencies, and consultants may all be considered and explored, and arrangements made ahead of time. Such agreements can be made using established criteria within the Emergency Management Assistance Compact (EMAC)

process, which is available for state-to-state resource sharing during emergencies, as described below.

The EMAC is an all-hazards, all-disciplines interstate mutual aid agreement that enables states to share resources during times of disaster. The EMAC offers assistance during governor-declared states of emergency or disaster through a system that allows states to provide personnel, equipment, and other services to assist with response and recovery efforts in other states. Through an EMAC, states can also transfer services and conduct virtual missions (such as GIS mapping). The EMAC complements the federal disaster response system by providing timely and cost-effective relief to states requesting assistance from assisting member states. The most common articles referenced under the EMAC address the primary concerns for personnel and for states offering and receiving assistance. These include licenses and permits, liability, compensation, and reimbursement.

Model dam safety programs need to work closely with the state emergency management office to identify dams with high consequences and/or dams providing critical lifeline resources, such as water supply, energy, or transportation. The state program and state and local emergency managers may, with the coordination of owners of high consequence and critical dams, identify and plan for personnel, equipment, and other services that would be needed under the EMAC to support the response and recovery effort of these important dam assets.

EMAC activation starts with an emergency or disaster declaration by the governor of an affected state (also known as the Requesting State). Once the declaration is established, the Requesting State makes known its needs via a Request for Assistance form to one or more states through a “broadcast” within the EMAC Operations System. A state that can provide assistance (Assisting State) creates an offer that outlines available assistance and associated costs.

For example, an EMAC agreement was requested and executed between the states of Colorado and Wyoming during the September 2013 regional flood event on the front range of Colorado. Colorado Dam Safety identified over 200 dams that needed immediate inspection to check for signs of distress due to impacts from regional extreme rainfall. An EMAC offer/acceptance was formalized, and Wyoming Dam Safety sent engineers to inspect affected dams in Colorado near the Colorado–Wyoming border.

The basis for implementation of an EMAC agreement is a pre-established document, originally called a Mission Capability Set and more recently referred to as a Mission Ready Package (MRP). The MRP establishes the desired mission accomplishments and need, as well as the costs associated with personnel, travel, equipment, commodities, and other costs not specified. This document establishes the anticipated cost of the resource requested and anticipated result and deliverable.

6. Investigation of Incidents and Failures

Model state programs must conduct investigations of all failures of high and significant hazard potential dams and should consider inspection of low hazard dam failures. The state program should

strongly consider establishing independent dam failure investigations when major failures and incidents occur, i.e., those that result in loss of life, high population evacuations, or major damages.

The state program must arrange to have personnel at the dam during or shortly after failure to document physical changes at the dam prior to additional weather- or equipment-related impacts. An independent team may be requested for investigation of dam failures with severe consequences, such as fatalities, or events that had the potential to be deadly. Many agencies have developed guidelines for incident investigation. In 2021, the Association of State Dam Safety Officials published the *Dam Failure and Investigation Guide*, which is designed to assist state dam safety agencies and dam owners with making good decisions during the chaotic and high-stress period during and following a dam failure or major incident.

 ASDSO [Dam Failure and Investigation Guide](#)

7. Recovery Planning

Dams that provide critical resources to a community may need to develop a recovery plan, in coordination with local emergency management authorities. The loss of a dam that provides a key resource such as power or drinking water could significantly affect the recovery of a community or region. Recovery and continuity of operations of critical infrastructure for these types of dams are discussed in *Dams Sector Crisis Management Handbook: A Guide for Owners and Operators*.

 DHS [Dams Sector Crisis Management Handbook: A Guide for Owners and Operators](#)

Chapter 6 – Program Administration and Management

Key Takeaways

1. Dam safety programs need sufficient resources through statutory appropriations and authorization to implement all Model Program activities
2. Staffing levels and expertise must be sufficient to implement all Model Program actions, both programmatic and administrative
3. Technical staff must be provided with education and training on a regular basis to increase understanding of dam safety issues, changes in technology, and understanding of risk

Checklist

- Have written policies, procedures, and guidelines developed for all major dam safety functions
- Develop a complete budget and present to the agency as a whole
- Program manager working to obtain support for sufficient program funding
- Program performance reports developed each year
- Provide staff education including on-the-job training, continuing education, seminars, and short courses
- Provide specific training for inspectors that covers topics such as legal entry, records management, field measurement technique, visual inspection techniques, emergency inspection techniques, field safety, communication skills, and public relations
- Conduct dam owner workshops
- Provide technical assistance to private sector engineers and emergency management officials
- Make continuous improvements to the program

Definitions

Program policy – describes how the dam safety program will administer laws and regulations, including authorities that are broader than just dam safety

Programmatic functions – technical actions particular to the dam safety program that reduce the likelihood of dam failure and potential consequences

Administrative functions – organizational practices, typically governed at the agency level, that are important to the day-to-day operation of the program

1. Introduction

Effective management of a state dam safety program is key to improving the safety of dams and preventing dam failures. Chapters 3, 4, and 5 of this manual describe the necessary components of a state dam safety program. This chapter outlines the basic elements necessary for program administration and management. Dam safety programs need sufficient resources through statutory appropriations and authorization to implement all Model Program activities. The program and the larger agency must create the policies, procedures, and guidelines that form the framework of the program. Staffing levels and expertise must be sufficient to implement all Model Program actions, both programmatic and administrative. Dam safety program managers need to develop budget estimates for full implementation of Model Program actions consistent with regulatory authorities.

Internal and external communications and a robust information management system are essential for effective work and progress tracking. Performance reports are necessary to help the program, agency, lawmakers, and the public evaluate program effectiveness in addressing dam-related risks. Technical staff must be provided with education and training on a regular basis to increase understanding of dam safety issues, changes in technology, and understanding of risk. All programs must have processes for continuous improvement over time.

2. Policies, Procedures, and Guidelines

Every dam safety organization must develop and maintain a set of policies, procedures, and guidelines for internal operations, technical standards, and organizational management and decision making. These policies, procedures, and guidelines are essential if dam safety programs are to do their work in an efficient and transparent way. Policies and guidance should include processes for common technical and business practices and interpretations of statutory responsibilities. Policies and guidance must be in written form, available to staff, and periodically reviewed and updated.

Program policy is set at the agency or program level and describes how the dam safety program will administer laws and regulations, including authorities that are broader than just dam safety. Dam safety policy includes rules, regulations, procedures, and/or guidelines relating to dam safety and how the dam safety program will administer these consistent with its role in the parent agency. Development of effective dam safety policies is critical to the successful performance of the required dam safety program functions.

Dam safety program functions fall into two categories: programmatic functions and administrative functions.

Programmatic functions are technical actions particular to the dam safety program and encompass the following areas:

- Dam inventory
- Hazard potential classification

- Inspections
- Risk evaluation and management
- Public safety and security
- Compliance and enforcement
- Technical review and approval processes
- Incident response

These functions have been described in previous chapters of this manual.

Administrative functions are the organizational practices, typically governed at the agency level, that are important to the day-to-day operation of the program. The following administrative functions support the programmatic requirements described above:

- Staffing and budgeting
- Program funding
- Communications
- Information management
- Performance reporting
- Education and training
- Continuous improvement

For the dam safety program to run smoothly and efficiently, there must be standard procedures and guidelines for all programmatic and administrative functions. The program manager must ensure that dam safety staff follow these procedures and guidelines. Procedures and guidelines must provide consistent instruction and guidance on how to perform each dam safety program activity.

3. Staffing and Budgeting

3.1. Staffing

Staffing requirements for a dam safety program depend in part on the scope of the state's statutory authority and responsibilities. Typical factors affecting these needs include the following:

- Number, hazard potential classification, location, and condition of dams subject to state jurisdiction

- Type of inspection program: owner-responsible, state-responsible, or a hybrid
- Geography and topography of the state, which may make it necessary to have some non-centralized staff
- Skills and experience of existing staff
- Overall organization structure of the state agency housing the dam safety program
- PAR below state-regulated dams

This section provides information useful for determining staffing needs. Areas covered include expected staff responsibilities and typical job classifications. Each state dam safety program must assess its particular needs based on its own set of legislative, organizational, geographic, and political constraints. There are many work functions necessary in a dam safety program. The agency must determine which functions are in the dam safety program and which are provided elsewhere in the agency. Appendix E provides additional detail to help calculate staffing requirements for a state dam safety program.

3.1.1. DETERMINING STAFFING NEEDS

A dam safety program must have sufficient qualified and experienced engineers on staff. Technical managers, supervisors, and senior technical staff will be licensed professional engineers or engineering geologists. It is essential for each program to have a senior engineer to manage the dam safety program. This manager-engineer must be a registered professional engineer with specialized training in hydraulics, geomechanics, and regional hydrology and geology. This engineer also needs to be an experienced dam inspector with experience in evaluating and specifying necessary maintenance, repairs, operating procedures, and necessary actions during dam safety incidents. Depending upon program size, the chief dam safety engineer should have at least 5 years of dam safety experience (for smaller programs) and up to 15 or more years of experience (for larger, more complex programs).

An appropriate mix of experienced and junior engineers must staff a Model Program. The following specialties are critical in a dam safety program:

- Hydrology and hydraulics
- Geotechnical engineering
- Engineering geology
- Structural
- Construction
- Mechanical

Other support necessary in the dam safety program or elsewhere in the agency include:

- Engineering technician
- Administrative and clerical support
- Information technology
- Geographic information systems
- Remote sensing specialists
- Public information officer
- Accounting and budget management
- Attorney(s)
- Environmental or soil scientists
- Emergency management planners

To ensure a smooth transition of duties and responsibilities important to the dam safety program, it is important that program leaders include succession planning with other staffing considerations. The program manager must identify key positions, determine how readily these positions can be filled when they become vacant, and have procedures in place to develop staff so that they are able to step into these key positions. At a minimum, succession practices must be in place for the head of the program and other key dam safety personnel whose departure would prevent important program functions from being completed.

3.2. Budgeting

Budgeting requirements for dam safety programs vary greatly between the states. It may be useful for Dam Safety Programs with limited funds to develop budgets to determine what resources are required to fully comply with state dam safety statutes and meet Model Program objectives. This exercise could be used as a roadmap for development of a fully funded program. Until that time, dam safety programs with insufficient funding must use risk informed processes to prioritize regulatory responsibilities, recognizing that this will require the state to have a much higher degree of risk tolerance than if the program was fully funded and staffed.



Key Elements of a Dam Safety Program Budget

- Salaries and benefits of staff

- Consultant services for investigations, third-party opinions, or expertise not possessed by current staff
- Training costs for staff and owners
- Outreach for stakeholders
- Travel for inspections and training, including cost of vehicles and per diem when on travel status
- Overhead costs, such as utilities and rent
- Inspection equipment
- Computers, software, and cell phones
- Financing mechanisms for public and private dam repair and rehabilitation projects (optional)

3.2.1. BUDGET PREPARATION

Specific tasks and some guidance on budgeting follow. A budget must consider statutory, administrative, and inspection requirements, in addition to overlapping responsibilities with related agencies. Dam safety budget preparation is not simple; however, it is an essential function.

Program budgets are typically developed based on the average times to complete the following:

- Inspection and/or inspection review work, including construction inspections
- All aspects of design review for construction, modification, and removal
- Safety evaluations and emergency actions
- Enforcement actions when owners do not voluntarily take corrective actions, and legal proceedings when owners appeal state orders
- Various administrative activities typically associated with program operation

To aid in program budget preparation, the following paragraphs provide average times to complete the functions described above. Appendix E provides example Staffing Level Requirements for a typical dam safety program.

Inspections and Inspection Reviews

Inspections and inspection reviews typically employ one of three approaches to ensure state-regulated dams are inspected thoroughly. The first approach is a state-responsible program, in which the state dam safety agency performs the Periodic Inspections with its own staff. The second approach, which has a somewhat reduced staffing requirement, is an owner-responsible program in which periodic inspections are conducted by engineers hired and paid for by the dam owner. A third approach is a combination of both state-responsible and owner-responsible inspections. This

approach requires sufficient staff both to conduct inspections and to review reports of inspections conducted by the owner's engineers.

An adequate number of qualified engineers and technicians must be available for inspections and associated enforcement work. It will be necessary to determine the number of dams that need to be inspected annually. Often, this number is based on the state program's standard inspection frequency by hazard potential or other classifications. The time spent on periodic inspections of permitted/approved dams includes travel, onsite inspection, and report writing; the average time per inspection varies between about one and four person-days per dam, depending on the dam complexity, hazard potential classification, and detail required by each state. At least one engineer and one technician will comprise a full inspection team.

The locations of the dams and the required travel time to and from the inspection sites should be considered when preparing a budget. For states with larger geographic areas and/or with complex topographic conditions, regional or field offices may be desirable. However, rather than having staff work individually out in a regional office, it is sometimes advantageous to have all staff centrally located so they can interact and provide multiple levels of expertise in different engineering disciplines. Some states do both by placing high-level dam engineering expertise in a central location and dam inspection engineers in regional or field offices. Other states with a single office find it most efficient to have employees on travel status for several days at a time, to reduce back and forth travel.

Inspections should also be required to assure construction of new dams and repair or modifications to existing dams are performed in accordance with the approved application. The recommended number of construction assurance inspections is 15 for a new dam and up to 10 for modifications or repair to existing dams. A recommended inspection length is 2 person-days which includes preparation, travel, and the inspection report. As with routine, periodic inspections, the required travel time is the largest variable in construction inspections.

Comprehensive Review and Inspections

Comprehensive review inspections will take significantly more time than routine inspections. The former includes design reviews, evaluation of modes of failure, and engineering risk analyses. Because of the significant time and effort involved, a state program may choose to use a mix of state-conducted and owner-engineer-conducted comprehensive reviews and inspections and/or other in-depth engineering evaluations. A detailed analysis and comprehensive evaluation of a dam, with the production of a complete report, may take 20 person-days and, in some cases, may require 2 person-months or more.

Design Reviews

Design review depends on factors over which the dam safety program may have little control. The number of applications or submittals for new dams, modifications, and removals can vary significantly from year to year. Long-term average submittals may be a useful start, but in states in which little or no dam infrastructure work has been conducted for a long time, there could be a

sudden increase in applications at some point. However, the program does have control over its procedures for review, and these should provide a good idea of how long reviews take based on legal and procedural requirements and the size, complexity, and hazard potential of the dam. A minimum level of review is needed to determine whether the submittal is complete, with careful review of investigation and design assumptions and limited evaluation of design calculations. Review of a new dam may require 25 person-days, or far more for especially large or complex dams. Estimated effort for review of modifications to an existing dam may be 10 person-days, and 2 person-days for a dam removal project. On-call contracts with consulting engineers can supplement dam safety program staff to accomplish workload completion.

Hazard Classification Reviews

Periodic review of hazard classification for each dam in the state's inventory is necessary to identify the potential increase in risk to downstream populations that could change a dam's hazard classification. Reviews should be performed at regular intervals, involving hydraulic analysis and mapping of the inundation area, as well as some field verification. The effort required for these reviews can be 10 person-days per dam.

Emergency Action Plans and Incident Response

EAPs and incident response can include the following activities:

- Developing EAPs or reviewing and approving plans
- Reviewing breach analysis modeling and inundation mapping
- Participating in tabletop, functional, or other exercises
- Planning for incidents (i.e., developing response procedures and ensuring the right tools and personnel are available for response)
- Responding to incidents

In most states, dam owners are responsible for developing EAPs, but the amount of time needed to perform a thorough review of the modeling and plan should be considered as part of the program's staffing plan.

Compliance and Enforcement

The state shall follow-up on deficiencies identified during inspections to ensure that a plan and schedule for remediation of the deficiency is completed. Occasionally, enforcement will be required to gain owner compliance. In the case of unsafe dams, follow-up on deficiencies is essential. This work may include notices to dam owners, cooperative actions, administrative orders, administrative court cases, and criminal court cases. Time required will depend greatly on regulatory requirements in the state and on whether states are able to maintain cooperative relationships with most of their owners. Producing a Notice of Violation typically takes 3 person-days, and enforcement may take 15

person-days per action. It is difficult to estimate the total time required for enforcement, but it may require 50 person-days or more for each case.

Administrative Activities

Administrative activities include duties related or unrelated to the dam safety program that will have a direct bearing on staffing and budgeting requirements. Administrative activities unrelated to the dam safety program may include selected staff members being required to devote portions of their time to other duties, e.g., a dam safety program administrator who is responsible for overseeing other programs as well. An expanding staff will place an added burden on experienced supervisory personnel, particularly with respect to the hiring and training of new staff. The training of new staff without experience in dam safety can take up to two years or more, and having new staff participate in available dam safety training requires significant financial investment. It is recommended that a minimum of 5% of staff time be devoted to training.

Budgets should also consider the large amount of unanticipated work that falls upon all state programs. The program manager must note the time required for personnel and budget development, public records requests, strategic planning, and other matters pertaining to overall program operation.

4. Program Funding

Regulatory dam safety program funding may vary significantly based on statutory requirements. Principal funding sources for dam safety programs are direct legislative appropriations, various types of fees, and FEMA grant programs. It is important for the dam safety program to prepare detailed and well-written budget proposals based on the framework of this Model Program and the specific characteristics of that state. If a dam safety program has adequate funding for its operations, it may consider developing options for the repair or removal of unsafe dams.

Many state programs rely in part on fees. The appropriate fee structure will be particular to each state and must be justified to stakeholders, especially dam owners. Fees can include application, design review, annual operations, and permitting fees. Application or construction permit fees are intended to cover all or a portion of the costs of plan review and approval, inspections, and associated aspects of new dam construction, reconstruction, repair, or removal. These fees may be charged as a flat rate, as a graduated schedule based on the size of the dam and/or estimated construction cost, or by another scale, as determined by the state program.

Certificates of approval-to-impound, permit-to-operate, or registration fees can be charged annually for the continued operation of the dam. A fee may be in the form of \$X per dam dependent on hazard potential classification or \$Y per foot of height, acre-foot of storage, or another designated metric. Inspection fees are usually imposed to help offset the costs of the state's periodic inspection program. The fees may be similar to the ones noted for a certificate of approval to impound or may be for the actual cost of the inspection. They can be charged for each inspection or can be prorated

to an annual fee based on the inspection cycle. States may charge an annual fee to all owners of dams regulated by the state dam safety program.

The FEMA National Dam Safety Program provides financial assistance to state programs. The state assistance grants are part of the National Dam Safety Program and must be periodically reauthorized by Congress. These grants can be used to hire additional staff or consultants, hold workshops or training, or complete a special project. Other funding sources may include targeted federal grants, direct assistance, or fees/taxes levied upon another industry.

It is also important to develop and maintain a non-lapsing source of funds for emergency actions. Some states have a specially designated fund for such actions. Others make funds available through the state emergency management agency or other sources. States must identify the source of funds and have written procedures for use in a policy manual or internal EAP. There should also be a process for recovering the cost of an emergency action from the dam owner.

4.1. Strategies to Obtain Sufficient Program Funding

Many states have insufficient resources for tasks important to keeping dams safe. State employees may be limited in the types of actions they can pursue to directly request a funding increase. Preparation of an effective budget proposal for sustained or increased funding is essential. Programs should have an independent audit or peer review of the program's effectiveness and funding sufficiency. Additionally, a periodic report on dams with safety deficiencies in the state may help policy makers and the public better understand the risks. These reports may identify the owner, detail the owner's ability to correct deficiencies, and provide an estimate of the cost of correcting the deficiencies. The report can also provide an overview of how dams are managed and highlight program efforts to reduce the risks posed by dams. It is key that this information on funding requirements reach decision makers.

5. Communications

Effective internal and external communications are essential. Dam safety programs must have procedures to encourage and document information flow within the program and agency and with dam owners and other stakeholders, including the public. Regular staff meetings are good vehicles for internal information exchange, such as for setting program priorities; reporting, monitoring, and analyzing dam safety incidents. Staff meetings are also platforms for staff to share experiences and lessons learned and air any concerns within the program.

It is also imperative that the dam safety program regularly inform senior management within the program's agency about critical dam safety needs for staffing, budgeting, etc. through routine meetings, communications, and reporting. The amount and effectiveness of this communication often depends on where the program is situated within the agency. A properly located dam safety program enhances communication with agency leadership and provides the Chief dam safety engineer with increased support and ability to affect important dam safety decisions. Communication

with and support by agency senior management decrease in programs which are placed too deeply within the agency's organizational hierarchy.

Since dam owners are responsible for the safety of their dams, all programs must communicate effectively and clearly with them. Effective dam safety programs develop an understanding of different dam owners' (or their staffs') abilities, limitations, and personalities. This relationship must be based upon trust. A good working relationship will facilitate formal compliance reporting, as well as informal owner contact with the dam safety staff when they have questions or concerns about their dams or requirements of the dam safety program.

6. Information Management

Information management for a dam safety program regularly involves maintaining the dam inventory and all necessary scanning, electronic filing, and archiving of paper and electronic records. This information includes plans; specifications; design, construction, or inspection reports; engineering studies or evaluations; photographs; incident tracking; owner compliance and non-compliance history; training programs; and all related internal and external correspondence. Information management must also include all programming needed for maintenance of spatial information.

Documents should be securely stored, easily accessible, and readily available for use by employees and sometimes other stakeholders. The files should be organized such that information can easily be found chronologically by subject. Making backups of files should be a routine activity, as it is necessary for protecting critical data.

Many state dam safety programs are moving toward "paperless" processes. This requires development of a suitable content management software system to allow "day forward" electronic processes in which documents can be stored and retrieved from the system. The processes must also allow for scanning of historic documents (back file scanning) into the content management system. States have found that using such systems provides many advantages, including access to documents from anywhere with a network connection (offices transitioning to remote operations), transparency and ease of access for dam owners and engineers seeking information about dams in their states, and rapid access to information during responses to incidents and emergencies at dams. State dam safety program representatives should work with their respective information technology departments to ensure adequate cybersecurity measures are in place to protect and ensure the long-term sustainable access to the data.

7. Performance Reporting

Dam safety organizations need tools to help plan, control, implement, monitor, and document work and program accomplishments. The reports listed below can be used to help evaluate program performance and to advocate for program support.

- **Strategic Plan** – Aligned with the organization’s dam safety policy, this high-level document sets the mission, vision, goals, and actions for the dam safety program, typically for a short to medium term of three to five years.
- **Annual Work Plan** – A work plan would stem annually from the strategic plan and set specific, detailed goals, objectives, and action plans to be carried out during the year.
- **Annual Report** – This year-end summary report measures the progress of the work accomplished for the year.

ASDSO provides standard reports that can be used to compare different state dam safety programs. Internal reports must compare accomplishments documented in the annual report against the original program goals and objectives listed in the annual work plan. The difference between what the program needed to accomplish and what the program was able to accomplish represents a gap in performance and potentially identifies a program need.

8. Education and Training

Dam safety programs must provide opportunities and funding for staff to enhance their engineering and other skills through ongoing educational efforts. Professional and technical staff must possess the necessary skills to investigate and assess the safety of dams and to manage a dam safety program. Dam safety programs must encourage and support staff to improve their skills through pursuit of continuing educational opportunities; attendance at seminars, short courses, workshops, and conferences; and participation in professional societies and associations.

On-the-job training may offer the most relevant instruction that program staff can receive. Technical development plans may also include on-the-job requirements such as completing certain in-house training sessions, taking temporary job assignments with different groups to gain exposure to various parts of the program, or being assigned a mentor to learn from that person’s experiences, especially when working in the field.

Dam safety programs must have staff recently trained on a number of analysis topics including the following:

- | | | |
|---------------------------|----------------------------|---|
| ▪ Hydrology | ▪ Seismic | ▪ Emergency action planning and incident response |
| ▪ Probable maximum floods | ▪ Internal erosion | ▪ Dam security |
| ▪ Spillways | ▪ Subsurface investigation | ▪ Public safety at dams |
| ▪ Penetrating conduits | ▪ Concrete and structural | ▪ Instrumentation and monitoring at dams |

- Hydrology
- Seepage
- Slope stability
- Seismic
- Valve and gate control
- Local engineering geology
- Emergency action planning and incident response
- Potential failure modes
- Risk analysis

The typical career path for an engineer includes the eventual advancement from design and technical work to management of that work. However, many engineers are not interested in management, so dam safety programs are advised to set up an alternate career path for those engineers who wish to advance their careers while remaining on a purely technical track to become true subject matter experts. Lack of this second track has resulted in the loss of some technically excellent engineers.

Other Topics to Cover During Staff Training:

- Legal entry onto private property
- Use of database and courthouse records to obtain information about state-regulated dams
- Field measurement techniques for determining whether the state has jurisdiction over a dam
- Use of remote sensing tools, including imagery and light detection and ranging (LIDAR)
- Routine dam inspection protocols
- Emergency inspection techniques, including determining the freeboard, rate of reservoir rise or fall, amount of overtopping, and seriousness of embankment seepage or piping, as well as criteria for recommending EAP incident levels
- Travel and field safety, including trenching and excavating, confined space, height, and water hazards, as well as plant, animal, and weather hazards
- Communication skills and public relations
- Use of new and changing technologies

Dam owners and operators need to learn their state's dam safety laws and regulations, the associated responsibilities and liabilities, and the proper operation, maintenance, and inspection of their dams. Typically, the best education and training for the dam owner is provided through contacts with the state's dam safety office. State programs need to sponsor workshops, seminars, and training sessions designed to instruct owners about dams, necessary monitoring, operation, maintenance and inspection procedures, liability, EAPs, and financing for rehabilitation. Dam safety staff must help organize and provide instruction for these dam owner education and training events. Such participation also works as training for dam safety staff. ASDSO and FEMA provide assistance to states in conducting workshops and seminars for dam owners about care of their dams and

general liabilities and responsibilities. Additionally, states should offer printed or online materials, such as fact sheets or manuals, that cover these requirements.

9. Continuous Improvement

The state of practice in dam safety is constantly changing. Dam safety managers and staff must continually share results, knowledge, and lessons learned from:

- Changes in the state of practice in dam safety
- Dam safety inspections and operating history
- Training
- Case histories of incidents and failures
- Findings from audits or reviews of dam safety programs

Information learned from these sources will facilitate continuous improvement of the program.

Dam safety programs can also improve through review of program implementation. As mentioned above in the section “Performance Reporting,” a basic method of measuring program performance is to evaluate the degree of accomplishment of program goals, objectives, and activities documented in the year-end annual report. State programs must compare their programs to the Model Program. They must encourage feedback from staff to help determine the reasons any goals, objectives, or activities may have fallen short for the year. This type of internal review must take place annually.

Periodic external review of program implementation by a qualified and independent team of dam safety experts is an excellent means of identifying areas for program improvement. An independent peer review team will evaluate the effectiveness of the state program and may offer conclusions and recommendations for improvement based on the team’s observations and findings. ASDSO has been performing independent peer reviews of state dam safety programs since 1990, and these reviews have been well received by states that have been peer reviewed. The ASDSO Peer Review Team typically comprises a current or former dam safety regulator, current or former dam owner, and current or former dam engineering consultant. This team mix ensures a comprehensive peer review with experience and knowledge from three different perspectives. Large multidisciplinary dam safety engineering consultants may be able to provide a similar service to the states. This type of external review should take place every 10 years.

Appendix A. Acronym List

ASDSO	Association of State Dam Safety Officials
C2M2	Dams Sector Cybersecurity Capability Maturity Model
CISA	Cybersecurity and Infrastructure Security Agency
CRI	Comprehensive Review and Inspection
DHS	Department of Homeland Security
DSTET	Dam Sector Tabletop Exercise Toolbox
EAP	Emergency Action Plan
EMAC	Emergency Management Assistance Compact
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FOUO	For Official Use Only
GCC	Government Coordinating Council
GIS	Geographic Information Systems
HMA	Hazard Mitigation Assistance
HMP	Hazard Mitigation Plan
HSEEP	Homeland Security Exercise and Evaluation Program
HSIN-CI	Homeland Security Information Network—Critical Infrastructure
ICS	Incident Command System
LIDAR	Light Detection and Ranging
MAC	Multi-Agency Coordination
MRP	Mission Ready Package

NID	National Identification
NID	National Inventory of Dams
NIMS	National Incident Management System
NTAS	National Terrorism Advisory System
NOV	Notice of Violation
PAR	Population at Risk
PD	Person-Day
PFMA	Potential Failure Mode Analysis
PIO	Public Information Officer
RIDM	Risk-Informed Decision Making
SBA	Standards-Based Approach
SCC	Sector Coordinating Council
SHMO	State Hazard Mitigation Officer
SME	Subject Matter Expert
SRMA	Sector Risk Management Agency
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
WFO	Weather Forecasting Offices

Appendix B. Model Law

Model Law for State Administration of a Dam Safety Program

1. Definitions

“**Agency**” means the [name of actual state agency] which is designated by this law as solely responsible for implementation and administration of dam safety statutes.

“**Construct**” means building a new dam, or replacement of the existing dam with a dam of similar dimensions.

“**Dam**” means any artificial barrier, including appurtenant works, with the ability to impound water, wastewater, or liquid-borne materials including mine tailings, above the natural ground surface

“**Emergency**” means any condition at a dam that, if left unattended, could lead to a dam failure or any other sudden dangerous release of water from a dam and its appurtenant structures that would result in consequences including life loss, property, infrastructure and/or environmental damages.

“**Emergency Action Plan**” means a plan developed by the dam owner that identifies the area that would likely be inundated by the failure of a dam and the actions that must be taken in the event of a failure, potential failure, or unusual condition at the dam.

“**Hazard potential**” means the possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or mis-operation of the dam or appurtenances.

“**High hazard potential**” means failure or mis-operation will likely cause loss of human life.

“**Modify**” means any change to the design condition of a dam that might affect the safety of the dam, or any major repair as further described in rules.

“**Removal/deregulation**” means removal of all parts of the dam that could store water or restrict flood flow and may include complete elimination of the dam embankment. For dams that are not on a stream channel, this means complete long-term stabilization of the structure so that it will not fail in an extreme event.

“**Reservoir**” means any area which contains or will contain impounded water, wastewater, or liquid-borne materials by virtue of its having been impounded by a dam.

“Significant hazard potential” means failure or mis-operation results in no likely loss of human life, but economic losses, environment damage or disruption of lifeline facilities are likely.

“State Dam Safety Office” means that Division or Program of the Agency designated by statute to be responsible for implementation of these statutes.

2. Jurisdiction

It is the intent of the legislature by this Act to provide for the regulation of dams and reservoirs exclusively by the State [actual agency of state government filled in] for the protection of public safety, property, and infrastructure.

The law shall apply to any dam meeting at least one of the following jurisdictional criteria:

- It has a high or significant hazard potential classification
- It is equal or exceeds 25 feet in height and exceeds 15 acre-feet in storage
- It is equal to or exceeds 50 acre-feet storage and exceeds 6 feet in height

This law shall not apply to:

- Any dam not meeting jurisdictional criteria
- Any obstruction in a canal used to raise or lower water
- A fill or structure for highway, railroad use or any other purpose that does not permanently impound water or is otherwise use for flood control.

3. Approval of Plans for Dam Construction and Modification

No dam shall be constructed or modified before the plans and specifications for that dam have been filed with the Agency and approved by them in accordance with regulations established by the agency governing such structures.

A new dam or dam requiring draining prior to modification may not be used to impound water until final documentation for the site, plans and specifications, features, and other supporting information of the dam have been submitted to and accepted by the Agency after completion of construction. The owner of the dam shall pay a fee as established by the Agency for design review and construction inspections prior to approval of design documents.

Prior to filling the reservoir, the dam owner must receive written approval from the Agency stating the project completion report has been reviewed and accepted.

The Agency will develop rules for design, construction, modification, and project completion reports for dams.

4. Removal

Before commencing the removal/deregulation of a dam, the owner shall secure the written approval of that removal plan and necessary supporting documents from the Agency.

All necessary removal plans must be developed by a qualified engineer.

The Agency will develop rules for dam removal and deregulation, including a requirement for Agency review and approval of the completed removal.

5. Safety Inspections

The Agency shall, by rule, establish a periodic schedule for dam safety inspections based on the hazard rating of the dam and other factors, as deemed necessary by the Agency.

The Agency shall determine the responsibility for inspections; either the owner, the state, another government Agency, or any combination of these.

The agency shall develop standards for inspections and inspection forms and procedures. Inspections shall be conducted by a qualified professional engineer who will prepare and submit a report on the condition of the dam, any deficiencies and actions needed, and the timeframes for completion of necessary actions. Inspection reports must be provided to the Agency and to the dam owner.

If potential safety concerns are found during the inspections, the Agency may require the owner to conduct specialized inspections, investigations, and analyses sufficient for the Agency to determine the safety of the dam.

The Agency shall investigate complaints of unsafe conditions, and if an inspection is warranted, shall provide the complainants with a copy of the inspection report.

The Agency or its representatives may enter private property of the dam owner as necessary to inspect a dam. The Agency may make inspections at any time to evaluate the operation, maintenance, and structural integrity of dams and reservoirs.

6. Incidents and Emergency Action Plans

Owners of high and significant hazard potential dams shall develop, periodically exercise, and update an emergency action plan (EAP) for the dam.

The Agency shall maintain specific criteria or templates for owners to use in developing an EAP consistent with national standards and appropriate for local conditions.

The Agency will require the dam owner to consult the Agency and state and local emergency managers on EAP contents, exercises, and updates.

The Agency shall review and, and when sufficient, approve the emergency action plan.

Owners of dams and reservoirs are responsible for determining when an unusual condition or dam develops, and in such cases shall immediately implement the emergency action plan. Upon such conditions, owners shall take all actions necessary to reduce the potential for the dam to fail.

If an emergency may exist at a dam, Agency personnel may enter upon any property that affords access to the dam to investigate the situation.

If the Agency determines that an emergency exists and the owner is not taking all necessary actions, the Agency may in an emergency do any or all of the following:

- Take full charge and control of any dam or reservoir
- Lower the water level by releasing water from the reservoir
- Completely drain the reservoir
- Perform any necessary remedial or protective work at the site
- Take such other steps as may be essential to safeguard life and property

Such action by the Agency shall not relieve the owner of a dam of legal liabilities.

Any necessary and reasonable costs and expenses incurred by the Agency fulfilling the duties mandated by the above sections in connection with a remedial or emergency action shall be recoverable by the Agency from the owner of any such dangerous or threatened dam.

7. Dam Owner Responsibilities and Liability

The dam owner shall review and evaluate the conditions at the dam as necessary to: (a) Keep the dam in good repair and properly maintained; and (b) address any conditions that may pose a risk of dam failure or unsafe releases of water from the dam.

Dam owners or their agents shall conduct regular dam surveillance to identify unusual conditions or potential failure conditions

Dam owners shall conduct engineering safety analysis for safety issues as directed by the Agency or based on suspected deficiencies in the dam.

The dam owner shall do all of the following:

- Provide the Agency with contact information for the dam owner, the operator of the dam if other than the owner, and the individual in immediate charge of the dam
- Notify the Agency of any changes in the contact information
- Provide the Agency with notice after completing a transfer of title for the dam

The dam owner will maintain all records including design drawings and reports, inspections, analyses, operations and maintenance plans, emergency action plans, readings from instrumentation, and notices of non-compliance.

Compliance with this Act shall not relieve an owner or operator of a dam or reservoir of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam or reservoir.

Agency actions and services under this Act do not relieve the owner or operator of a dam or an individual in immediate charge of a dam from any duty, obligation or liability regarding the ownership, maintenance, or operation of the dam.

8. Agency Authorities, Duties and Liability

The Agency may enter property as needed for administration of these statutes.

The dam safety office shall be administered and directed by an engineer, licensed by this state, and clearly qualified by training and experienced in the safety, construction, modification, and removal of dams.

The Agency shall adopt hazard potential classifications and assign a classification to all jurisdictional dams, and to new dams prior to construction of the dam. The Agency shall use national standards as appropriate and may use additional classifications.

The Agency shall use hazard potential classification in its development of any rules and standards as deemed necessary for the protection of people, property, infrastructure, and other resources.

At its discretion, the Agency may develop a permit system and permit requirements or any part of this Act that requires an Agency approval.

The Agency may develop rules, including additional definitions, as necessary to implement any part of this of this act.

The Agency will set maximum timeframes of validity for construction, modification, or removal plans. The Agency may extend these timeframes if the approved documents are consistent with current dam safety practices at the time of the extension.

The Agency will provide an annual report on dam safety program accomplishments to this legislature.

No action shall be brought against the state, the Agency, or its agents or employees for the recovery of damages caused by the partial or total failure of any dam or reservoir as a result of the Agency's inspection, emergency action, or any regulatory enforcements of such dam or reservoir.

The Agency may require additional independent specialists or consulting boards for technical considerations pertaining to an application, approval for plans and specifications, or certificate of approval to impound water. Appointment of these specialists/consulting boards must be approved by the Agency. The expenses of these specialists/consulting boards shall be paid for entirely by the owner.

9. Fees and Funds

9.1 Dam Construction, Modification and Removal Fee

The Agency shall charge a fee for review of dam construction, modification, or removal. The Agency will develop rules for this fee, which may be based on a portion of the estimated cost of the project and or the actual review time required for review, approval, and all construction inspections.

All fees and other charges collected under the provisions of this Act shall be paid into a special fund in the state treasury, to be available to the Agency for expenditure for any purposes authorized by this Act.

9.2 Annual Dam Owner Assessment Fee

Owners of existing dams shall be assessed an annual registration fee as established by rule.

9.3 Emergency Dam Repair Fund

An emergency dam repair fund shall be funded through monies appropriated by the legislature and monies collected by the Agency. The Agency may spend monies from this fund to respond to dam emergencies, including but not limited to, obtaining supplies necessary for emergency actions and implementation of those actions to reduce the water level, control internal erosion, or construct an emergency spillway. The emergency dam repair fund shall be continuously appropriated.

9.4 Dam Rehabilitation Funding

The Agency shall create a Dam Rehabilitation Loan Program and may partner with other public or private agencies or organizations as practicable. The program shall initially be funded [state to determine funding] through monies appropriated by this legislature.

The Dam Rehabilitation Loan Program is a revolving fund to be used exclusively for the purposes of this law and to reduce dam safety risks statewide.

The Agency may grant loans from the dam rehabilitation fund to dam owners to improve the safety of deficient dams and reduce risk to people, property or infrastructure downstream of the dam, or to remove those dams. The Agency shall adopt rules for administration of this program, including risk-informed determinations of dam eligibility.

The Agency will provide information on the uses of this fund in its annual report to this legislature.

10. Compliance and Enforcement

If the Agency conducts an action that is necessary to address a violation of statute or rule, or any condition rendering the dam unsafe, the Agency shall notify the dam owner regarding the following:

- A specific citation of law, rule, or order, of which the person is in violation
- Why the inspection or conditions caused the Agency to conclude that the dam is unsafe or in violation
- The actions necessary to address the violation or unsafe condition
- The opportunity for the dam owner or their engineer to meet with the Agency.

The Agency must provide this notice in writing to the dam owner by registered or certified mail with return receipt, or personal service.

The Agency and a dam owner may at any time use informal or alternative means, including but not limited to stipulation, agreed settlement, or consent orders to resolve a matter for which the department has notified the dam owner.

If enforcement is necessary, the Agency shall develop an order or other formal notice that includes:

- The specific actions required
- Timeframe to complete specific actions
- The right to a hearing
- Penalties for non-compliance

The Agency shall develop rules for notice and opportunity for hearings consistent with the Administrative Procedures Act of the state. Any action or proceeding under this article shall be initiated either administratively or by appropriate legal filing in a court of appropriate jurisdiction.

Whenever the Agency finds that any owner or any person has violated any provision of the Act or any rule, regulation or order issued pursuant thereto, the Agency may do any of the following actions:

- Issue an administrative order requiring any such person to comply

- Bring a civil action or place a lien on the dam owner's property
- Issue a punitive reservoir level restriction
- Levy a civil administrative penalty
- Bring an action for a civil penalty
- Petition the Attorney General to bring a criminal action

Nothing in this Act shall be construed to deprive any owner of such administrative or judicial recourse to the courts as they may be entitled to under the laws of this state.

Recourse to any of the remedies available under this section shall not preclude recourse to any of the other remedies prescribed in this section or by any other applicable law.

In addition to any other available remedies, if the Agency has information that a person is violating or intends to violate an order issued under this Act, or concludes that a dam poses an imminent risk to life, property, or public infrastructure, the Agency may apply to the court for a temporary or permanent injunction requiring the person to do one of the following:

- Refrain from violation of the order
- Take any actions necessary to remedy an imminent risk to life, property, or infrastructure

11. Penalties

The Agency is authorized to assess civil administrative penalties for each violation of any provision of this Act, or any rule, regulation, or order issued pursuant thereto, and each day during which each violation continues shall constitute an additional, separate, and distinct offense.

The Agency shall develop rules that include a schedule of civil penalties. Any amount assessed under this subsection shall fall within a range established by regulation by the Agency for violations of similar type, seriousness, and duration. In adopting rules establishing the amount of any penalty to be assessed, the Agency may take into account the economic benefits from the violation gained by the violator.

A person who purposely, knowingly, or recklessly violates any provision of this Act is subject to criminal prosecution under a Class __ Misdemeanor, or if the action results in serious damage or personal injury, a Class __ Felony.

In addition to the penalties prescribed in this section, a notice of violation of any provision of this Act, or any rule, or order issued pursuant thereto, shall be recorded on the deed of the property wherein the violation occurred, by the clerk of the county wherein the affected property is located and shall

remain attached thereto until such time as the violation has been remedied and the Agency orders the notice of violation removed.

All monetary penalties collected shall be deposited in the Dam Rehabilitation Fund.

Appendix C. Dam Inventory Database Fields

Table C1: Dam Inventory Database Fields (Required by NID)

Field Name	Field Type, Size	Definition
NID ID	Alphanumeric, 7 characters	<p>The official National ID (NID) identification number for the dam. This is a required field and must have a unique entry for each dam included in the NID.</p> <p>The first two characters of the identity are the state two-letter abbreviation, based on the location of the dam.</p> <p>Typically, the last five characters of the identity are a unique number (AB#####), although states are allowed to use alphanumeric combinations in these last five characters.</p> <p>For saddle dams or dikes, the NID ID is the same as the main dam. See saddle dam definition in Number of Separate Structures field (listed below).</p>
State ID	Alphanumeric	The state identification number assigned to the dam.
Dam Name	Alphanumeric	The official name of the dam. No abbreviations unless the abbreviation is a part of the official name. For dams that do not have an official name, the popular name is used.
Other Dam Names	Alphanumeric	Names other than the official name (i.e., lake or reservoir name) of the dam in common use. Names are separated using a semi-colon. Blank if not applicable.
Dam Former Name	Alphanumeric	Previous reservoir or dam name(s), if changed. Names are separated using a semi-colon.
Hazard Classification	Alphanumeric	<p>Code to indicate the potential hazard to the downstream area resulting from failure or mis-operation of the dam or facilities:</p> <ul style="list-style-type: none"> ▪ H for High ▪ S for Significant ▪ L for Low ▪ U for Undetermined ▪ N for Not Available

Field Name	Field Type, Size	Definition
PAR (Population at Risk)	Number	The population downstream of a dam that would be subject to risk from flooding in the instance of a potential dam failure; usually documented in numbers of persons at risk. Not all PAR will be subject to loss of life as a result of dam failure. Analyses of potential for loss of life will also take into account the travel time of flood wave and warning time available for evacuation. (Source: USACE ER 1110-2-1156)
Longitude	Number	Longitude at dam centerline as a single value in decimal degrees, NAD83.
Latitude	Number	Latitude at dam centerline as a single value in decimal degrees, NAD83.
Section	Alphanumeric	This is an optional field if your state uses Section, Township, and Range Location. Enter the information in any form that is understandable and that clearly designates the individual values, e.g., S21, 73N, R69W. If the prime meridian location is needed to locate the dam within the state, include it in the field, e.g., S21, T3N, R68W of 6PM (Sixth Prime Meridian).
County	Alphanumeric	The county in which the dam is located. If dam is located in more than one county (e.g., across a river that forms the boundary between the counties), the state shall designate only one county for this field.
River	Alphanumeric	Name of the River or Stream on which the dam is located. Standard Entry: The official name of the river or stream on which the dam is built. If the stream is unnamed, identify it as a tributary to a named river, e.g., Snake-TR. If the dam is located offstream, enter the name of the river or stream plus "-OS", e.g., Snake-OS. Alternative Entry (1995 NID format): The official name of the river or stream on which the dam is built. If the stream is unnamed, identify it as a tributary to a named river, e.g., TR-Snake. If the dam is located offstream, enter the name of the river or stream plus the word, "OFFSTREAM," e.g., Snake OFFSTREAM.
Nearest Downstream City	Alphanumeric	Name of the nearest downstream city, town, or village that will be affected by floods resulting from the failure of the dam.
Distance	Number	Distance (in miles) to Nearest Downstream City/Town.
Owner Name	Alphanumeric	Name(s) of the dam owner. If multiple owners, different owner names are separated by a semi-colon.

Field Name	Field Type, Size	Definition
Owner Type	Alphanumeric	<p>Code to indicate the type of owner:</p> <ul style="list-style-type: none"> ▪ F for Federal ▪ S for State ▪ L for Local Government (defined as have taxing authority or being supported by taxes) ▪ U for Public Utility ▪ P for Private ▪ X for Not Listed <p>Codes are concatenated if the dam is owned by more than one type. For example, if the dam is owned by a lake association and a public utility, the owner type would be listed as PU. For multiple owners under the same type, one code is used. For example, if multiple individuals own one dam, it will list P for private dam ownership. Local Government should have taxing authority or be supported by taxes. A Lake District is supported by taxes and considered Local Government. A Lake Association is supported by association dues and would not be a Local Government owner type but rather Private owner type.</p>
Dam Designer	Alphanumeric	<p>Name of the principal firm(s) or agency accomplishing design of dam and major appurtenant operating features and major modifications. Original designer is listed first, then modification designers (if applicable). The names are separated using a semi-colon. If an architect-engineer firm designed the dam under a state or federal government contract, the state or federal agency name is listed first, followed by the company name, separated by a semi-colon.</p>
Private Dam	Y/N	<p>Non-federal dam on federal property. Enter the code indicating whether this dam is a non-federal dam located on federal property:</p> <ul style="list-style-type: none"> ▪ Y for Yes ▪ N for No

Field Name	Field Type, Size	Definition
Dam Type	Alphanumeric	<p>Codes, in order of importance, to indicate the type of dam:</p> <ul style="list-style-type: none"> ▪ RE for Earth ▪ ER for Rockfill ▪ PG for Gravity ▪ CB for Buttress ▪ VA for Arch ▪ MV for Multi-Arch ▪ RC for Roller-Compacted Concrete ▪ CN for Concrete ▪ MS for Masonry ▪ ST for Stone ▪ TC for Timber Crib ▪ OT for Other <p>Codes are concatenated if the dam is a combination of several types. For example, the entry CNCB would indicate a concrete buttress dam type.</p>
Core	Alphanumeric	<p>Code to indicate the position, type of watertight member, and certainty.</p> <p>Position:</p> <ul style="list-style-type: none"> ▪ F for upstream-facing ▪ H for homogeneous dam ▪ I for core ▪ X for unlisted/unknown <p>Type:</p> <ul style="list-style-type: none"> ▪ A for bituminous concrete ▪ C for concrete ▪ E for earth ▪ M for metal ▪ P for plastic ▪ X for unlisted/unknown <p>Certainty:</p> <ul style="list-style-type: none"> ▪ K for known ▪ Z for estimated

Field Name	Field Type, Size	Definition
Foundation	Alphanumeric	<p>Code for the material upon which dam is founded, and certainty.</p> <p>Foundation material:</p> <ul style="list-style-type: none"> ▪ R for rock ▪ RS for rock and soil ▪ S for soil ▪ U for unlisted/unknown <p>Certainty:</p> <ul style="list-style-type: none"> ▪ K for known ▪ Z for estimated
Purposes	Alphanumeric	<p>Enter one or more of the following codes to indicate the current purpose(s) for which the reservoir is used:</p> <ul style="list-style-type: none"> ▪ I for Irrigation ▪ H for Hydroelectric ▪ C for Flood Control and Storm Water Management ▪ N for Navigation ▪ S for Water Supply ▪ R for Recreation ▪ P for Fire Protection, Stock, Or Small Farm Pond ▪ F for Fish and Wildlife Pond ▪ D for Debris Control ▪ T for Tailings ▪ G for Grade Stabilization ▪ O for Other <p>The order should indicate the relative decreasing importance of the purpose. Codes are concatenated if the dam has multiple purposes. For example, SCR would indicate that the primary purpose is Water Supply, followed by Flood Control and Storm Water Management, and then Recreation.</p>
Year Completed	Integer, 4 digits	Year when the original main dam structure was completed. If unknown, and a reasonable estimate is unavailable, "0000" is used.
Year Certainty	Alphanumeric	<p>Year Certainty:</p> <ul style="list-style-type: none"> ▪ K for known ▪ E (or Z) for estimated

Field Name	Field Type, Size	Definition
Year Modified	Alphanumeric, 50 characters	<p>Year (four digits) when major modifications or rehabilitation of dam or major control structures were completed. Major modifications are defined as a structural, foundation, or mechanical construction activity that significantly restores the project to original condition; changes the project's operation, capacity, or structural characteristics (e.g., spillway or seismic modification); or increases the longevity, stability, or safety of the dam and appurtenant structures. Entries should be followed by one or more of the following codes indicating type of modification:</p> <ul style="list-style-type: none"> ▪ S for structural ▪ F for foundation ▪ M for mechanical ▪ E for seismic ▪ H for hydraulic ▪ O for other <p>Up to ten modifications can be entered, separated by semicolons. Example: 1965S;1995E;2020M</p>
Dam Length	Number	Length of the dam, in feet, which is defined as the length along the top of the dam. This also includes the spillway, powerplant, navigation lock, fish passage, etc., where these form part of the length of the dam. If detached from the dam, these structures should not be included.
Dam Height	Number	Height of the dam, in feet to the nearest foot, which is defined as the vertical distance between the lowest point on the crest of the dam and the lowest point in the original streambed (generally the downstream toe).
Structural Height	Number	Structural height of the dam, in feet to the nearest foot, which is defined as the vertical distance from the lowest point of the excavated foundation to the top of the dam. Top of dam refers to the parapet wall and not the crest.
Hydraulic Height	Number	Hydraulic height of the dam, in feet to the nearest foot, which is defined as the vertical difference between the maximum design water level and the lowest point in the original streambed.
Maximum Discharge	Number	Number of cubic feet per second (cu ft/sec) that the spillway is capable of discharging when the reservoir is at its maximum designed water surface elevation.

Field Name	Field Type, Size	Definition
Maximum Storage	Number	Maximum storage, in acre-feet, which is defined as the total storage space in a reservoir below the top of the dam (or below the maximum attainable water surface elevation), including any surcharge storage.
Normal Storage	Number	Normal storage, in acre-feet, which is defined as the total storage space in a reservoir below the normal retention level, including dead and inactive storage and excluding any flood control or surcharge storage. For normally dry flood control dams, the normal storage will be a zero value. If unknown, the value will be blank and not zero.
Surface Area	Number	Surface area, in acres, of the impoundment at its normal retention level.
Drainage Area	Number	Drainage area of the dam, in square miles, which is defined as the area that drains to a particular point (in this case, the dam) on a river or stream.
Emergency Action Plan	Alphanumeric	Enter the code (Y, N, or NR), indicating whether this dam has an emergency action plan (EAP). An EAP is defined as a plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood. <ul style="list-style-type: none"> ▪ Y for Yes ▪ N for No ▪ NR for Not Required
Date Emergency Action Plan was Last Revised	Date Mm/dd/yyyy	The date (month, day, and year) of the most recent revision of the EAP. The format is mm/dd/yyyy (for example, 04/20/2012).
Spillway Type	Alphanumeric	Code that describes the type of spillway: <ul style="list-style-type: none"> ▪ C for Controlled ▪ U for Uncontrolled ▪ N for None
Spillway Width	Number	The width of the spillway, to the nearest foot, available for discharge when the reservoir is at its maximum designed water surface elevation. For an open channel spillway, this is typically the bottom width.

Field Name	Field Type, Size	Definition
Outlet Gates	Alphanumeric	<p>Code(s) that describe the type of (1) spillway and (2) controlled outlet gates, if any:</p> <ul style="list-style-type: none"> ▪ X for None ▪ U for Uncontrolled ▪ T for Tainter (radial) ▪ L for Vertical Lift ▪ R for Roller ▪ B for Bascule ▪ D for Drum ▪ N for Needle ▪ F for Flap ▪ S for Slide (sluice) Gate ▪ V for Valve ▪ O for Other Controlled <p>Allowed up to five types in decreasing size order, separated by semicolons, followed by number of gates.</p>
Volume	Numeric	Total number of cubic yards occupied by the materials used in the dam structure. Portions of powerhouse, locks, and spillways are included only if they are an integral part of the dam and required for structural stability.
Number of Locks	Numeric	The number of existing navigation locks for the project.
Length of Locks	Numeric	Length of the primary navigation lock to the nearest foot.
Width of Locks	Numeric	Width of the primary navigation lock to the nearest foot.
Federal Agency Involvement in Funding	Alphanumeric	Code* identifying which federal agency was involved in funding of the dam. Codes are separated by semi-colon if several agencies were involved.
Federal Agency Involvement in Design	Alphanumeric	Code* identifying which federal agency was involved in the design of the dam. Codes are separated by semi-colon if several agencies were involved.
Federal Agency Involvement in Construction	Alphanumeric	Code* identifying which federal agency was involved in the construction of the dam. Codes are separated by semi-colon if several agencies were involved.
Federal Agency Involvement in Inspection	Alphanumeric	Code* identifying which federal agency is involved in the inspection of the dam. Codes are separated by semi-colon if several agencies are involved.

Field Name	Field Type, Size	Definition
Federal Agency Involvement in Operation	Alphanumeric	Code* identifying which federal agency is involved in the operation of the dam. Codes are separated by semi-colon if several agencies are involved.
Federal Agency Owner	Alphanumeric	Code* identifying which federal agency partly or wholly owns the dam. Codes are separated by semi-colon if several owners are involved.
Federal Agency Other	Alphanumeric	Code* identifying which federal agency partly or wholly owns the dam. Codes are separated by semi-colon if several owners are involved.
Other Structure ID	Alphanumeric	The identification number (S001, S002, etc.) for the saddle dam or dike associated with the larger dam project. This field applies only to saddle dams or dikes. This field is blank for all other dams.
Number of Separate Structures	Number	Number of separate structures associated with this dam project. Include saddle dams (or dikes) as defined in FEMA 148: Federal Guidelines for Dam Safety, Glossary of Terms: a subsidiary dam of any type constructed across a saddle or low point on the perimeter of a reservoir. Not included in the number of appurtenant works which include, but are not limited to, such structures as spillways, either in the dam or separate therefrom; the reservoir and its rim; low-level outlet works; and water conduits such as tunnels, pipelines or penstocks, either through the dam or its abutments (FEMA Model State Dam Safety Program Glossary of Terms).
State Regulated Dam		This is a computed field for the NID.
State Regulatory Agency	Alphanumeric	Name of the primary state agency with regulatory or approval authority over the dam.
Inspection Authority	Yes/No	Yes if the state regulatory organization has the authority to require or perform the inspection, at least once every five years, of all dams and reservoirs that would pose a significant threat to human life and property in case of failure to determine the continued safety of the dams and reservoirs (from the Dam Safety Act of 2006).
Enforcement Authority	Yes/No	Yes if the state regulatory organization has the authority to issue notices, when applicable, to require owners of dams to perform necessary maintenance or remedial work, revise operating procedures, or take other actions, including breaching dams when necessary (from the Dam Safety Act of 2006).

Field Name	Field Type, Size	Definition
State Jurisdictional Dam	Yes/No	Yes if this dam meets the state regulatory organization’s definition of a jurisdictional dam. For example, in New Mexico, a jurisdictional dam is defined as a dam that exceeds 10 feet in height, regardless of storage, or a dam that stores more than 10 acre-feet, regardless of height. Therefore, in New Mexico, all dams that meet that state criterion will have Yes listed in this field.
Inspection Frequency	Number	The scheduled frequency interval for periodic inspections, in years.
Inspection Date	Date	Date of the most recent inspection of the dam. The format is mm/dd/yyyy (e.g., 04/20/2012).
Condition Assessment Date	Date	Date of the most recent condition assessment of the dam. The format is mm/dd/yyyy (e.g., 04/20/2012).
Condition Assessment	Alphanumeric	<p>Assessment that best describes the condition of the dam based on available information:</p> <p>Satisfactory; Fair; Poor; Unsatisfactory; Not Rated.</p> <p>Definitions, as recommended by the National Dam Safety Review Board:</p> <ol style="list-style-type: none"> 1. SATISFACTORY No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines. 2. FAIR No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action. 3. POOR A dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary. POOR may also be used when uncertainties exist as to critical analysis parameters that identify a potential dam safety deficiency. Further investigations and studies are necessary. 4. UNSATISFACTORY A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. 5. NOT RATED The dam has not been inspected, is not under state jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Field Name	Field Type, Size	Definition
Condition Assessment Details (Removed from NID 2020)	Alphanumeric	<p>The specific detail that best describes the reason for the condition assessment. This field applies only to dams that were assigned the condition Satisfactory, Poor, or Not Rated. If a dam was rated Unsatisfactory or Fair, this field will be left blank.</p> <ol style="list-style-type: none"> 1. SATISFACTORY Meets applicable hydrologic and seismic regulatory criteria; meets applicable tolerable risk criteria 2. POOR Deficiency recognized; more analysis needed 3. NOT RATED Dam has not been inspected; not under state jurisdiction 4. Other
Operational Status	Alphanumeric	<p>Select the one category that best describes the situation:</p> <ul style="list-style-type: none"> ▪ Normal Operations ▪ Under Investigation, Planning, Permitting, or Design for Remediation ▪ Under Remediation ▪ Enforcement Pending/Ongoing ▪ Not Applicable
URL Address	Alphanumeric	<p>Website for more information on particular dam. This information is not collected at this time and represents a placeholder for future data collection.</p>

Appendix D. Dam Security Program

Guidelines for State Dam Safety Office: Implementation of a Dam Security Program

1. Introduction

The National Inventory of Dams (NID) currently lists over 91,000 dams, most of which are regulated by state dam safety agencies. A number of these state-regulated dams are high-consequence structures that could potentially cause sudden downstream flooding with very severe casualties and catastrophic economic impacts if failure were to occur. The consequences of a deliberate attack on a dam could be wide-ranging and depend heavily on a number of variables, including the type of dam, its function, what lies downstream, the nature of the failure, and the state of reservoirs above and below the dam. Even if a given attack is not immediately successful in inducing catastrophic dam failure, the resulting partial damage could limit the use of the project, causing significant regional consequences. In addition to avoiding downstream flooding resulting from a dam failure, it is important to protect dams because they constitute a vital component of the nation's infrastructure, continuously providing a wide range of economic, environmental, and social benefits.

Dam security is the degree of protection for a dam against damage or loss caused by intentional acts, such as criminal or terrorist acts. Achieving such protection requires owners and operators to understand the risks facing the organization—including threats, vulnerabilities, and consequences—and make decisions to manage those risks to an acceptable level.

Owners, operators, and government agencies all have an important role to play in ensuring the safe and secure operation of Dams Sector assets and the reliable continuity of their benefits. However, while a national dam safety program implements and regulates dam safety requirements, and federally owned dams and certain facilities regulated by the Federal Energy Regulatory Commission must follow dam security protocols, dam security is otherwise a voluntary effort within the sector. Owners and operators can find value in integrating security into their dam safety program for the following reasons:

- Understanding and managing the risk to the facility, regardless of the cause of the incident, can protect communities upstream and downstream.
- Securing and protecting facility assets and operations can ensure the reliable and dependable delivery of project benefits and protect the organization's image and reputation.
- Understanding and planning for cascading impacts from decisions during incidents can prevent a life safety incident from also becoming a security incident, or vice versa.

Investments can include conducting security assessments to identify gaps and mitigation measures; installing perimeter and access control equipment and technologies to prevent access to, theft of, or damage to equipment; and writing and exercising plans inclusive of security procedures.

This document was developed by the Association of State Dam Safety Officials (ASDSO). For additional information, please contact ASDSO at info@damsafety.org.

2. Purpose

This document presents baseline activities and actions for state dam safety officials to implement a dam security program and additional resources to assist owners in improving the security of their dams. While many states have neither the clear authority in their statutes nor the resources to regulate dam security, many state dam safety agencies have added security-focused activities to their office responsibilities to support the security of this critical infrastructure sector. With differing responsibilities and inventories of dams, each state will vary in the level of support it can provide to owners and operators in protecting their critical infrastructure from security threats.

State dam safety officials can utilize the following baseline activities and actions to implement a dam security program, depending on their authority, inventory of dams, overall responsibilities, priorities, and resources:

Dam Security Activities	Dam Security Actions
1. Develop Awareness of Dam Security and Responsibilities	1.1 Stay Informed and Develop a Basic Understanding of Dam Security
	1.2 Conduct Information Sharing and Outreach
2. Collaborate with State, Federal, and National Organizations with Dam Security Responsibilities	2.1 Coordinate and Collaborate with State and Local Stakeholders
	2.2 Coordinate and Collaborate with Federal and National Stakeholders
3. Identify, Prioritize, and Evaluate Security Risks on State-Regulated Dams	3.1 Identify High-Priority State-Regulated Dams
	3.2 Conduct Risk Assessments for High-Priority State-Regulated Dams
	3.3 Support and Coordinate Development of Security Plans
	3.4 Monitor Status and Progress
4. Conduct Security Exercises and Participate in Related Activities	4.1 Conduct Security Exercises for High-Priority State-Regulated Dams
	4.2 Participate in Related Exercise Activities Relevant to Dam Security

3. Develop Awareness of Dam Security Issues and Responsibilities

3.1 Stay Informed and Develop a Basic Understanding of Dam Security

Conduct Periodic Security Briefings and Provide Security Training to Dam Safety Personnel: Focus on current and emerging threats (e.g., local crime trends, cyber threats against control systems, worldwide attacks against dam infrastructure), Dams Sector activities and collaborative efforts, input from dam owners, and other potential tools or resources. Access dam security reference material and training opportunities via the Cybersecurity and Infrastructure Security Agency (CISA), Federal Emergency Management Agency, Association of State Dam Safety Officials (ASDSO), and other federal and state agencies.

Access the ASDSO Website: From the main webpage, navigate to the Resource Center, click the “Select Resources, Technical Manuals and Guidelines” option, and select the “Cybersecurity and Infrastructure Security Agency Dams Sector Products” page. This listing provides owners/operators, state dam safety officials, and other sector stakeholders with a variety of helpful information, resources, and reference material regarding security, protection, and crisis management issues focused on improving stakeholder understanding of dam-related security and protection concepts. A link to the website is provided in the References and Resources listed in Appendix A [note: an appendix to this appendix].

Access and Monitor the Homeland Security Information Network—Critical Infrastructure (HSIN-CI) Dams Portal: The HSIN-CI Dams Portal provides members with access to a variety of helpful references and guides regarding dam security, protection, and crisis management; receipt of special notifications regarding dam safety and security incidents; upcoming events; and training opportunities. Owners/operators, state dam safety officials, and other sector stakeholders greatly benefit from access to this resource. To become a member of the HSIN-CI Dams Portal, contact the Dams Sector Management Team at DamsSector@cisa.dhs.gov. State dam safety officials must provide information to CISA personnel for the purpose of processing requests for access to the HSIN-CI Dams Portal.

Develop a Consolidated Reference Library of Dam Security Documents: Maintaining a library of reference materials and documents related to the security of dams in the state will ensure state dam safety officials have access to the most recent best practices, lessons learned, and situational awareness needed to support security-related decision-making. Examples of helpful documents include the following:

- Inventory of dams requiring elevated security scrutiny with contact names, telephone numbers, and e-mail addresses
- Security-related correspondence to select dam owners

- Inundation maps
- Meeting notes for various state and federal coordination meetings and events
- Strategic documents and templates produced by CISA and/or other agencies related to dam security
- Logs for site visits (e.g., security inspections, vulnerability and risk assessments) and security incidents
- Physical security- and cybersecurity-related tools, brochures, fact sheets, general references, guides, and handbooks

3.2 Encourage Information Sharing and Outreach

Enhance Dam Owner/Operator and First Responder Awareness of Dam Security: Owners, operators, and employees can be trained to observe, assess, and report potential asset vulnerabilities and suspicious incidents. Emergency response and law enforcement agencies will also benefit from increased awareness of Dams Sector assets in their jurisdictions. Provide basic verbal advice to dam owners, directing them to useful reference materials or available tools including security-related guidance documents posted on the websites of the state dam safety program, ASDSO, CISA, or other federal and state agencies. A list of helpful resources and websites is provided in Appendix A.

Encourage Reporting of Suspicious Activities: Suspicious activity reporting is the official documentation of observed behavior reasonably indicative of pre-operational planning related to terrorism or other criminal activity. Timely reporting helps local authorities act quickly to identify potential threats and can provide an indicator of national-level activities against similar facilities or operations. The reporting of suspicious activity at and around dams is everyone's responsibility. Employees should be encouraged to report suspicious activity by taking the following steps:

- Maintain awareness of the environment. This includes in or near entry or exit points, parking areas, restricted areas, and in the immediate vicinity.
- Identify behaviors that are out of the ordinary.
- Report the activity to the security shift leader, a supervisor, and/or local law enforcement with as much detail as possible.

More information on suspicious activity can be found in the *Surveillance and Suspicious Activities Indicator Guide for Dams and Levees* referenced in Appendix A [note: an appendix to this appendix].

4. Collaborate with State, Federal, and National Organizations with Dam Security Responsibilities

4.1 Coordinate and Collaborate with State and Local Stakeholders

Coordinate and Collaborate with State and Local Agencies: Meet with personnel from state and local emergency management agencies and the state office of homeland security on an annual or more frequent basis to stay apprised of dam security-related activities, formulate interagency strategies, and coordinate important follow-up activities. Establish a working relationship with the relevant state and major urban fusion centers, which serve as focal points within the state and local environments for the receipt, analysis, gathering, and sharing of threat-related information.

Coordinate and Collaborate with Dam Owners: Establish coordination and collaboration mechanisms to discuss current concerns, challenges, and needs. An example of such a mechanism is a state-level dam security working group consisting of state dam safety office representatives and owners of high-priority dams deemed critical.

Coordinate and Collaborate with State Agency Dam Owners: Security at state-owned dams, such as state parks and fish and game agencies, offers a different set of challenges (e.g., remote facilities, public access). Meet with these agencies to discuss their unique challenges and needs and to develop and maintain a state-owned dam security plan.

4.2 Coordinate and Collaborate with Federal and National Stakeholders

Participate in National Dam Security Meetings and Committees: The nation's infrastructure is divided into 16 critical infrastructure sectors, which constitute the basic building blocks for national security and protection coordination efforts. The fundamental responsibility of coordinating and facilitating prioritization and protection efforts for each critical infrastructure sector has been assigned to a corresponding Sector Risk Management Agency (SRMA) within the federal government. CISA, within the U.S. Department of Homeland Security (DHS), has been designated as the SRMA for the Dams Sector. At the national level, coordination of dam security and resilience is conducted through a Government Coordinating Council (GCC) comprising representatives from across various levels of government, including federal owners and operators, and state and federal regulators of sector assets. The GCC coordinates with its private sector counterpart, the Sector Coordinating Council (SCC), which is an organized, self-run, and self-governed organization that consists of members from the private sector, trade associations, and non-federal public owners/operators. The Dams GCC and SCC provide a forum in which government and private sector partners can engage in a broad spectrum of activities to support and coordinate critical infrastructure security and resilience programs and activities.

Participate in meetings such as those hosted by the Dams GCC and ASDSO. These venues provide a means for maintaining and fostering beneficial working relationships with individuals involved in dam security matters, effectively working with other members on GCC working group assignments and staying apprised of the government's overall approach toward dam security.

Support Federal Requests for Information Regarding Dam Security: Compile and submit data pertaining to select dams and the downstream areas at risk from their potential failure. This

information may be used to support the identification of those critical facilities within the Dams Sector whose failure or disruption could potentially cause the most significant impact among sector assets and individual portfolios.

Meet and Collaborate with CISA Protective Security Advisors and Cybersecurity Advisors: Coordinate with the state office of homeland security to participate in site visits conducted by CISA’s field staff. Protective security advisors and cybersecurity advisors are deployed in 50 states and Puerto Rico, with the following capabilities:

- **Protective security advisors** are resilience subject matter experts who coordinate vulnerability assessments and training; support incident management; and provide a vital communication channel between state and local officials, private sector owners and operators, and CISA. They also assist law enforcement and state homeland security advisors with ongoing state and local critical infrastructure security efforts such as local exercises and planning initiatives.
- **Cybersecurity advisors** are trained cybersecurity subject matter experts who help owners and operators and state, local, territorial, and tribal governments to prepare for and protect from cybersecurity threats. Cybersecurity advisors engage stakeholders through partnership and direct assistance activities to promote cybersecurity preparedness, risk mitigation activities, and incident response capabilities. These experts offer a range of services, including providing briefings on specific cybersecurity topics and available resources, coordinating information requests during times of increased threat, and conducting assessments.

5. Identify, Prioritize, and Evaluate Security Risks on State-Regulated Dams

5.1 Identify High-Priority State-Regulated Dams

Conduct Consequence-Based Prioritization of State-Regulated Dams: The potential downstream impacts from a failure of a dam, and the function/purpose of a facility, must be evaluated to determine which dams should be considered critical. Review available dam breach inundation mapping to estimate the population at risk (PAR) and critical facilities located downstream of the impacted area. The critical services provided by the facility—including but not limited to functions such as water supply and power generation—should also be considered.

5.2 Conduct Risk Assessments for High-Priority State-Regulated Dams

Complete Security Inspections: A security inspection involves the evaluation of the current state and appropriateness of the onsite security system/procedures and what needs to be completed at a project or facility to address concerns regarding security. A complete security system must address deterrence, detection, delay, assessment, and response. This evaluation identifies whether any security enhancements are needed and what those enhancements comprise. A security inspection must also address the state of maintenance and readiness of the existing security systems/

procedures. In addition to physical security, cybersecurity must also be assessed by dam safety personnel, including evaluating physical security for cyber assets, reviewing how network connections are monitored, assessing risk of wireless networking, and regularly reviewing cyber asset criticality and cybersecurity procedures. A sample security inspection checklist to help evaluate overall security is included in Appendix B [note: an appendix to this appendix].

Complete Vulnerability Assessments: A vulnerability assessment is the product or process of identifying physical features or operational attributes that render an entity, asset, system, network, or geographic area susceptible or exposed to hazards. This type of an assessment ultimately leads to recommended changes to the physical security or operational procedures that will serve to decrease overall risk. State dam safety agencies should consider having procedures in place to complete vulnerability assessments or require completion of the assessments by the dam owners through the regulatory process.

Complete Risk Assessments: Risk is the potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood and the associated consequences. A risk assessment is the process or product of collecting information and assigning values to risks for the purpose of informing priorities, developing or comparing courses of action, and informing decision making. Risk within the context of security is therefore broader than what dam owners and operators regularly practice during safety-related, risk-informed decision making. State dam safety agencies should consider having procedures in place to complete risk assessments or require completion of the assessments by the dam owners through the regulatory process.

5.3 Support and Coordinate Development of Security Plans

Develop a State Dam Security Implementation Plan: Coordinate with the state office of homeland security to develop a work plan that outlines the processes, procedures, and interagency coordination mechanisms related to dam security. This will include high-priority dam identification, priorities, and responses to security threats.

Oversee the Development of Plans for Individual Dams: Plans could include emergency action plans, security plans, recovery plans, and/or continuity plans. Planning is an essential component of the preparedness cycle because it provides a methodical way to think through the entire lifecycle of a potential crisis, facilitates the rapid exchange of information, and may shorten the time required to gain control of an incident. Using a team or group approach to the planning process helps organizations define their perceptions of the roles they will play during an operation. Security plans should include procedures that reflect increasing protective measures (also known as security measures) and procedures during periods of heightened terrorist threat, as determined by the DHS National Terrorism Advisory System (NTAS). The following resources may help with plan development:

- The *Dams Sector Protective Measures Handbook* (FOUO) highlights the different NTAS levels and suggested protective measures.

- The Federal Energy Regulatory Commission (FERC) Security Plan Template may be used as a guide by dam owners to develop their respective plans.
- The Dams Sector Crisis Management Suite, housed on the HSIN-CI Dams Portal, includes templates for developing emergency action plans, hazard-specific response plans, crisis communication plans, recovery plans, and continuity plans. The *Dams Sector Crisis Management Handbook* describes the importance and elements of the plans.

5.4 Monitor Status and Progress

Oversee Implementation of Protective Measures on Dams: State dam safety personnel should perform periodic site visits with the owners/operators of high-priority dams to confirm that the enhancements recommended in their security, vulnerability, and/or risk assessments and plans are implemented. State personnel may also communicate with owners/operators during changes in the NTAS levels to confirm appropriate increases in protective measures, such as increased security patrols, vehicle and bag inspections, and restriction of visitors and/or contractors.

Monitor Effectiveness of Protective Measures on Dams: After the measures are in place, state dam safety personnel should monitor the effectiveness and condition of the measures and recommend modifications and technology advances to the measures.

Track General Status/Progress of Dam Security for State-Regulated Dams: Conduct periodic security inspections of high-priority dams to evaluate completed security enhancements and procedural changes. Develop and maintain a reference library for security-related documents, as outlined in Section 1.1 of this document [appendix]. Submit consolidated data regarding security as part of the National Inventory of Dams data call, conducted annually by the U.S. Army Corps of Engineers.

6. Conduct Security Exercises and Participate in Related Activities

6.1 Conduct Security Exercises for High-Priority State-Regulated Dams

Encourage a Periodic Security Exercise Program for High-Priority State-Regulated Dams: Exercises are an essential element of the preparedness cycle because they help to raise the general awareness of potential crisis situations and ensure that key staff members are familiar with the plans and understand their roles and expected actions. Exercises are available in two basic formats, discussion- and operations-based, that include several types (e.g., seminars, workshops, tabletops, games, drills, functional, and full-scale). Discussion-based exercises familiarize participants with current plans, policies, agreements, and procedures. They may also be used to develop new plans, policies, agreements, and procedures. Operations-based exercises validate plans, policies, agreements, and procedures; clarify roles and responsibilities; and identify resource gaps in an operational environment. These exercise types will typically include real-time responses, such as initiating communications or mobilizing resources.

Take Advantage of Existing Exercise-Planning Tools: CISA developed a sector-specific resource, the Dam Sector Tabletop Exercise Toolbox (DSTET), to assist in the development and implementation of security exercises. The DSTET provides dam owners and operators with basic planning resources to conduct a series of facilitated discussions aimed at addressing sector-specific threats, issues, and concerns related to the protection of dams. The intent of the toolbox is to enhance effective information sharing and coordination between owners and operators, first responders, and relevant stakeholders during various threat and incident phases, as detailed in the corresponding scenarios. The toolbox is consistent with the Homeland Security Exercise and Evaluation Program (HSEEP), which is a capabilities- and performance-based exercise program that provides a standardized methodology and terminology. To gain access to the DSTET, contact the Dams Sector Management Team at DamsSector@cisa.dhs.gov.

6.2 Participate in Related Exercise Activities Relevant to Dam Security

Participate in Federal, Cross-Sector, or Regional Exercises and Assessments: Whenever possible, participate in exercises or assessments conducted by federal dam owners. In addition, other critical infrastructure sectors (e.g., water, energy, and maritime transportation) exhibit important dependencies and/or interdependencies with dams. Participation in their exercises may prove mutually beneficial. Finally, participate in regional critical infrastructure assessments, such as those conducted through the Regional Resiliency Assessment Program led by CISA, to identify critical infrastructure dependencies, interdependencies, cascading effects, overall resilience characteristics, regional capabilities, and security gaps.

Appendix D1: References and Resources

Unless otherwise noted, Dams Sector publications are available on CISA's Dams Sector Publications webpage at cisa.gov/dams-sector-publications. Information about the HSIN-CI Dams Portal is available at cisa.gov/hsin-dams-portal.

Handbooks

Dams Sector Crisis Management Handbook: Introduces crisis management concepts, explains how crisis management measures are an important component of an overall risk management framework, and highlights guidelines to apply these concepts to dams and related infrastructure. Describes various planning documents (emergency action plan, hazard-specific response, crisis communications, recovery, and continuity). The associated Crisis Management Suite, housed on the HSIN-CI Dams Portal, features templates for these types of plans.

Dams Sector Protective Measures Handbook (FOUO): Provides an introduction to protective measures for dam owners; assists in selecting protective measures addressing the physical, cyber, and human elements; and includes recommendations for developing site security plans. Available on the HSIN-CI Dams Portal.

Dams Sector Security Awareness Handbook (FOUO): Introduces sector-specific security concepts to assist in identifying security concerns and coordinating proper response. Throughout the handbook, listed resources provide owners and operators additional information to continue to learn about and apply security risk management principles. Available on the HSIN-CI Dams Portal.

Fact Sheets and Guides

Dams Sector Resources Fact Sheet: Provides an overview of sector-specific resources available to Dams Sector stakeholders, including publications, training and exercise support, workshops and webinars, and information-sharing resources. The fact sheet and dates of upcoming workshops and webinars are available on the HSIN-CI Dams Portal.

Dams Sector Cybersecurity Documents Fact Sheet: Highlights sector-specific cybersecurity documents to aid owners and operators in efforts to improve cybersecurity preparedness and create a robust cybersecurity posture. Available on the HSIN-CI Dams Portal.

Information Sharing in the Dams Sector Fact Sheet: Highlights the practices, products, tools, and resources utilized for Dams Sector information sharing. Includes an overview of the HSIN-CI Dams Portal, and provides links to various content providers for incident-related information. Available on the HSIN-CI Dams Portal.

Physical Security Measures for Levees Fact Sheet: Highlights information on physical security measures that a levee owner could employ and the factors affecting the selection of those measures. Available on the HSIN-CI Dams Portal.

Security Awareness for Levee Owners Fact Sheet: Highlights information specific to levees about surveillance indicators (particularly during periods of potential flooding or heightened national threat advisories) and how to report suspicious activities and incidents. Available on the HSIN-CI Dams Portal.

Roadmap to Secure Control Systems in the Dams Sector: Describes a plan and strategic vision for voluntarily improving the cybersecurity posture of control systems within the Dams Sector. Available on the HSIN-CI Dams Portal.

Dams Sector Cybersecurity Framework Implementation Guidance: Supports efforts by owners and operators to apply the principles and effective practices of cyber risk management to improve the security and resilience of critical infrastructure.

Dams Sector Cybersecurity Program Guidance: Outlines various strategies and methods to develop or improve a basic cybersecurity program, enabling owners and operators to select cybersecurity activities and measures appropriate to their cybersecurity assets and risk profiles, including industrial control systems. Available on the HSIN-CI Dams Portal.

Dams Sector Cybersecurity Capability Maturity Model (C2M2): Aims to advance the practice of cybersecurity risk management across the Dams Sector by providing all Dams Sector organizations,

regardless of size or type, with a flexible tool to help them evaluate, prioritize, and improve their cybersecurity capabilities.

Dams Sector Cybersecurity Capability Maturity Model (C2M2) Implementation Guide: Addresses implementation and management of cybersecurity practices associated with information technology and operations technology assets and the environments in which they operate. Provides options for implementing the C2M2 in a systematic manner.

Dams Sector Security Guidelines: Consolidates industry security practices into a framework to help owners and operators select and implement security activities and measures that reduce risk; improve the protection of personnel, public health, and public safety; and reinforce public confidence. Available on the HSIN-CI Dams Portal.

Dams Sector Active and Passive Vehicle Barriers Guide: Assists dam owners and operators in understanding the need for vehicle barriers as part of an overall security plan and familiarizes security personnel with the various types of active and passive vehicle barriers.

Dams Sector Consequence-Based Top Screen Methodology Guide: Provides a methodology used to identify critical facilities within the Dams Sector (i.e., those high-consequence facilities whose failure or disruption could be potentially associated with the highest possible impact among Dams Sector assets). Provides information pertaining to the overall implementation process, description of the parameters used within the methodology, and the prioritization scheme. Available on the HSIN-CI Dams Portal.

Dams Sector Personnel Screening Guide for Owners and Operators: Provides information that assists in developing and implementing personnel screening protocols.

Surveillance and Suspicious Activities Indicators Guide for Dams and Levees: Provides dam and levee owners and operators with information on issues related to surveillance and suspicious activity, including objectives, indicators, reporting methods, and other actions to take to counter surveillance and suspicious activity. Available on the HSIN-CI Dams Portal.

Dams Sector Waterside Barriers Guide: Developed to assist dam owners and operators in understanding the possible need for waterside barriers as part of an overall security plan. Provides information on waterside barriers, including their use and maintenance.

Estimating Economic Consequences for Dam Failure Scenarios: Describes the economic consequence estimation approaches most used in the United States and discusses their advantages and limitations. Available on the HSIN-CI Dams Portal.

Estimating Loss of Life for Dam Failure Scenarios: Describes the loss of life estimation approaches most used in the United States and Canada and discusses their advantages and limitations. Available on the HSIN-CI Dams Portal.

Emergency Preparedness Guidelines for Levees: Aims to assist owners or operators in managing levees, floodwalls, pumping stations, and any other components of flood risk management systems. Provides guidance in preparing for, and responding to, potential natural and human-caused incidents at levees. Available on the HSIN-CI Dams Portal.

Web-Based Training

[IS-870a Dams Sector Crisis Management](#): Addresses crisis management activities as an important component of an overall risk management program and provides dam and levee stakeholders with recommendations to assist in the development of various plans focused on enhancing preparedness, protection, recovery, and resilience capabilities. The training course describes the purpose and basic elements of emergency action plans, recovery plans, and continuity plans and addresses the basic elements of an effective exercise program.

[IS-871a Dams Sector Security Awareness \(FOUO\)](#): Provides information to enhance the ability to identify security concerns, coordinate proper response, and establish effective partnerships with local law enforcement and first responder communities. The training course describes common security vulnerabilities, potential indicators of threats, surveillance detection, and reporting of incidents and suspicious activities.

[IS-872a Dams Sector Protective Measures \(FOUO\)](#): Addresses protective measures related to physical, cyber, and human elements and describes the importance of these measures as components of an overall risk management program. The training course describes the basic elements of the risk management model and discusses the steps required to develop and implement an effective protective program.

To access any of the Dams Sector resources listed above, contact the Dams Sector Management Team at DamsSector@cisa.dhs.gov.

Websites

Association of State Dam Safety Officials

www.damsafety.org

- Cybersecurity and Infrastructure Security Agency Dams Sector Products: damsafety.org/resourcecenter/CISA-Dams-Sector

Cybersecurity and Infrastructure Security Agency (CISA)

- Critical Infrastructure Information: www.cisa.gov/infrastructure-security
- Dams Sector Resources: www.cisa.gov/dams-sector
- Active Shooter Preparedness: www.cisa.gov/active-shooter-preparedness

- Unmanned Aircraft Systems Resources: www.cisa.gov/uas-critical-infrastructure
- Cybersecurity Resources: us-cert.cisa.gov/resources/business
- Protective Security Advisors: www.cisa.gov/protective-security-advisors
- Cybersecurity Advisors: www.cisa.gov/csa

Federal Energy Regulatory Commission

www.ferc.gov/industries/hydropower/safety/guidelines/security.asp

Homeland Security Exercise and Evaluation Program

training.fema.gov/programs/hseep/

U.S. Department of Homeland Security – State and Major Urban Fusion Centers

www.dhs.gov/fusion-centers

Appendix D2: Sample Security Inspection Checklist

Note: Checklist begins on the next page.

Long Term:

49. Has security been considered and incorporated into dam safety modifications and rehabilitation work?

50. Does Management have a funding program to address and improve security shortfalls?

K. Current State of Security:

51. Have different response levels been identified and implemented based on the potential threat conditions?

52. Are the measures on the day of inspection consistent with the current threat level?

53. Protective/Security Measures appear to be reasonable:
If “No”, determine what follow up actions/improvements will be required.

YES	NO	N/A

Appendix E. Staffing-Level Requirements

Example State Dam Safety Program

This appendix is intended to assist states in determining the proper staffing for their dam safety programs. The categories presented here coincide with those discussed in the budget preparation section of Chapter 6.

For any state dam safety program to be effective and accountable, personnel levels must be sufficient to satisfy the statutory mandates. Each state should assess its particular needs based on its legislative, organizational, geographic, topographic, and political factors. Considering these factors, guidelines have been developed to assist in the estimation of staffing levels required for a state dam safety program.

This appendix will list and describe the most time-consuming responsibilities of a dam safety program and provide typical durations for completing these responsibilities. An example staffing budget will be presented at the end of this appendix. Although the example provides guidance on how to calculate staffing requirements for a “typical” dam safety program, adjustments must be made as necessary for each state, based on the state program’s actual task durations, situation, and needs.

Inspections and Inspection Reviews

Routine periodic inspections: Recommended inspection schedules are as follows:

- High hazard potential dams – annual inspections
- Significant hazard potential dams – biennial inspections
- Low hazard potential dams – inspections every 5 years

Chapter 3 acknowledged that states typically employ one of three methods to inspect their dams:

- State-responsible program
- Owner-responsible program
- Hybrid approach

Most state programs have state-employed engineers conduct safety inspections. For budget preparation, the recommended time to perform a detailed visual inspection of one existing high hazard potential dam is 4 person-days; this estimated timeline includes file review, preparation, travel time, on-site inspection time,

engineering analysis, and report writing. For significant and low hazard potential dams, the recommended time for inspections is 3 and 2 person-days, respectively. It is recommended that each inspection team comprise at least one engineer and one technician. There are many reasons to send a team of at least two people, including training, personal safety, and special needs at the dam. Special needs (e.g., surveying and a particular dam's complexities) may require staff members with different areas of expertise.

In states that utilize an owner-responsible program, the owner hires a qualified engineer to conduct the inspections. When this approach is taken, a staff of one engineer per 250–400 inspections would be required to review the owners' inspection reports and to attend 20% of the inspections for quality control purposes.

Some states utilize a hybrid approach whereby the owner conducts inspections for some dams and the state conducts inspections of other dams. This approach may require the most staffing since staff must both conduct inspections and review reports of inspections conducted by the owner.

Follow-up on deficiencies: Inspections of operational dams frequently reveal deficiencies that require correction. The inspection report shall identify deficiencies and include an appropriate schedule to complete corrective actions. A program to follow up and ensure that these actions are taken should be part of all state programs. The amount of time required to conduct a follow-up inspection can vary, however; for operating dams, it can take an average of 3 person-days per deficiency. For budget preparation purposes, it may be anticipated that deficiencies will occur at 20% of the dams inspected, although percentages may be lower in states with historically proactive programs and higher in states with historically reactive programs.

Unsafe dams: An essential part of follow-up activities is contacting owners of unsafe dams to bring about the remediation of unsafe conditions. The actual amount of time required can vary greatly. It is recommended that 15 person-days per unsafe dam be used in budget preparation. This is only the time needed to relay the determination to the owner and negotiate for the desired action: the submission of a plan for rehabilitation. The 15 person-days recommended does not include any protracted legal enforcement effort or application review time for repair, reconstruction, breach, or removal of the dam.

Construction Inspections: In most states, it is the owner's responsibility (through the owner's engineer) to ensure that any construction is completed according to the approved application and that all unforeseen conditions are properly handled. Nonetheless, the state's review of construction activity is recommended. Inspection and approval of all foundation preparation are essential and are part of most programs. Inspection of the outlet, the main structure, and the spillway should also be conducted. In addition, many projects include prefinal and final inspections. A recommended inspection length is 2 person-days, including preparation, travel, and report completion. The recommended time could double in states where travel distances are significant. The following are recommended numbers of construction assurance inspections:

- For new large dams: 15 construction assurance inspections
- For new small dams: 5 construction assurance inspections
- For repair or modification of existing dams: 2 to 10 construction assurance inspections

- For a dam removal project: 2 to 5 construction assurance inspections

The above inspection frequencies include review of quality assurance records of the owner's engineer. Changes to the approved application during construction require additional review not included in this section. The time required for such additional review is included in the Design Reviews section, below.

Comprehensive Reviews and Inspections

For comprehensive reviews and inspections (CRIs) or other in-depth engineering evaluations, owner-conducted reviews are preferred because of the significant time and effort involved. This approach has the least effect on the dam safety program's staffing requirements, although the state's involvement in completing a review of an owner-conducted CRI can take 10 to 20 person-days or more.

If the state were to conduct these in-depth studies, the state's involvement can take 20 to 40 person-days or more. Risk management may be necessary to prioritize state-conducted CRIs, which can easily overwhelm any dam safety budget.

A third approach is for the state to hire a consultant to conduct these in-depth studies, followed by state review of the CRIs performed by the consultant. The estimated time to review these studies is between 10 and 20 person-days, depending upon the quality of the report.

Chapter 3 of this manual recommends that comprehensive reviews and inspections be performed at a 10-year frequency for high hazard potential dams and a 15-year frequency for significant hazard potential dams.

Design Reviews

It is very difficult to predict the number of applications that will be submitted to the dam safety program in any given year. It is possible, although still challenging, to estimate the time to review and approve or deny an application. The complexity of the application under review, the completeness of the data provided, and the experience of the staff assigned to the review are just a few of the many factors that determine the length of a particular review. Although the length of the permitting process can vary greatly, a recommended engineering review time for a complete application for a new dam is 25 to 50 person-days. Estimated average times for reviews of modifications to an existing dam is 5 to 20 person-days and for dam removals is 2 to 5 person-days. The engineering review should include a site inspection and a review of major aspects of the engineering design for the proposed work, including hydrologic, hydraulic, geotechnical, structural, seismic, and stability considerations.

Hazard Classification Reviews

Periodic review of hazard classification for each dam in the state's inventory is necessary to identify the potential increase in risk to downstream populations that could change a dam's hazard classification. Hazard

classification reviews should be performed at regular intervals. As an example, each dam would undergo review every 20 years, or more frequently in areas showing active downstream development. Hazard classification reviews involve hydraulic analysis and mapping of the inundation area, as well as some field verification. The effort required for these reviews can be 10 person-days per dam.

Emergency Action Plans and Incident Response

Emergency action planning includes reviewing and approving new emergency action plans (EAPs) and plan updates submitted by the owner. New EAPs require reviews of breach analyses modeling and inundation mapping. An estimated time to review a new plan including mapping and modeling is 3 to 5 person-days. The effort required for review of annual EAP updates (no breach analysis or inundation map review) is 0.25 to 0.5 person-days per update. The number of EAP reviews to be performed each year can be estimated based on the number of dams that have or require EAPs and the interval required by the regulator for submitting plan updates.

Emergency action planning also includes participating in EAP exercises. It is recommended that each dam with an EAP perform, at a minimum, a tabletop exercise once every 5 years. The dam owner is responsible for developing and implementing the exercise. State staff time required to participate in an EAP exercise would be minimal. For estimation purposes, states can assume 1 person-day per exercise, with 20% of dams with EAPs performing EAP exercises in any given year.

It is prudent to allocate time each year to incident planning for agencies and dam safety programs. Activities could include updating agency emergency procedures and ensuring the correct tools and personnel are available to respond to dam emergencies. Also, time will likely be necessary to communicate with and educate local or county emergency management agency officials on the importance of EAPs for regulated dams. An estimate of 20 person-days annually for emergency planning is reasonable.

The time required to respond to dam incidents or dam emergencies could be extensive and could easily overwhelm a state's dam safety program staff and budget. A state may go several years without having to respond to a significant dam incident or emergency. However, stalled storms, a line of training heavy storms, a tropical event, or remains of a tropical event may result in several dam incidents or emergencies statewide in a very short time. Incident or emergency response time will include personnel at the dam site dealing with the actual dam incident and time communicating with stakeholders, including the media, both during and after the event. The size of the dam and the consequences of failure are controlling factors regarding the effort required to implement an EAP. The time required can be estimated to be 10 to 20 or more person-days per year. One way to address emergency response budgetary needs is to secure a non-lapsing source of funds within or outside the dam safety program specifically for use in dam safety emergencies.

Compliance and Enforcement

Occasionally, deficiencies at a dam will be identified, but timely progress toward correction of those deficiencies will not be satisfactory. In such a case, enforcement actions must be pursued. Enforcement

actions can be very time-consuming, lasting upwards of 50 person-days per enforcement action. For budget purposes, producing a notice of violation (NOV) can be estimated to take 3 person-days and completing the enforcement actions can be estimated to take 15 person-days each. The above estimate assumes that actions taken by the dam safety staff have been properly documented to support the enforcement actions.

Administrative Activities

Administrative activities in this context include management of the dam safety program and also general administration and clerical support within the program. The dam safety chief administers the program; this work can require significant time. The recommended dam safety program administrative staffing time can be up to 30% of the technical staff time described above. This recommendation does not attempt to address higher-level administrative time above or outside the dam safety program.

Staff education and training is another important part of an effective program. It is recommended that a minimum of 5% of staff time be devoted to specific technical training in the subject areas listed in Chapter 6.

Example Program Staffing-Level Requirements

This example calculates staffing requirements in the following seven major categories of dam safety activities:

1. Inspections and Inspection Reviews
2. Comprehensive Reviews and Inspections
3. Design Reviews
4. Hazard Classification Reviews
5. Emergency Action Plans and Incident Response
6. Compliance and Enforcement
7. Administrative Activities

Note: All staffing effort calculations are stated in person-days (PDs) and shown in blue text.

General Program Assumptions

- The example program regulates 300 dams:
 - 100 high hazard potential
 - 40 significant hazard potential
 - 160 low hazard potential
- Periodic inspection intervals will utilize model program recommendations.
- The program will utilize a state-responsible inspection approach (e.g., the state will conduct all routine periodic inspections).

- 20% of dams will have a deficiency requiring follow-up.
- Comprehensive reviews and inspections will be performed by the state every 10 years for high hazard dams and every 15 years for significant hazard dams.
- Hazard classification reviews will be performed on the entire portfolio every 20 years.
- EAPs will require annual updates.
- EAPs exercises will be conducted every 5 years.
- 10% of dams will require a NOV.
- 33% of dams receiving an NOV will require enforcement actions.
- Program administration will be 20% of the technical staffing requirement.
- Technical staff training will require 5% of staff time.
- The following will take place during the example year:
 - 1 unsafe dam
 - 1 new dam construction
 - 10 dam modifications (10% of high hazard dams)
 - 4 dam modifications (10% of significant hazard dams)
 - 16 dam modifications (10% of low hazard dams)
 - 2 dam removals
 - 1 actual dam emergency

1. Inspections and Inspection Reviews

Routine Periodic Inspections

- Inspection frequency
 - High hazard potential, annual (1.0 multiplier)
 - Significant hazard potential, every 2 years (0.5 multiplier)
 - Low hazard potential, every 5 years (0.2 multiplier)
- State-responsible inspection program
 - Dam safety program staff perform all routine periodic inspections at the frequency defined above
- Estimate of required effort to complete routine periodic inspections is:
 - 4 PD for a high hazard dam
 - 3 PD for a significant hazard dam
 - 2 PD for a low hazard dam

100 HH dams inspected annually (x 1.0) x 4 PD per inspection =

400 PDs

40 SH dams inspected every other year (x 0.5) x 3 PD per inspection =	60 PDs
<u>160 LH dams inspected every five years (x 0.2) x 2 PD per inspection =</u>	<u>64 PDs</u>
Subtotal	524 PDs

Follow-up on Deficiencies

- Number of inspections are performed each year:
 - 100 high hazard dams inspected annually
 - 40 significant hazard dams inspected biennially
 - 160 low hazard dams inspected every 5 years
$$(100 \text{ dams annually} \times 1.0) + (40 \text{ dams biennially} \times .5) + (160 \text{ dams every 5 yrs.} \times 0.2) = 152 \text{ inspections per year}$$
- 20% of inspections each year will have a deficiency (0.2 multiplier)
 - 152 inspections x 0.2 = 30 dams with deficiencies
 - Each deficiency requires 3 PDs to address
$$30 \text{ dams with deficiencies} \times 3 \text{ PD/deficiency} = 90 \text{ PDs}$$

Unsafe Dams

Each state dam safety program should have a pretty good idea of whether there are any unsafe dams in its inventory. The program be proactive in seeking that those dams are repaired, breached, or removed as quickly as possible.

For purposes of this example, it is assumed there is one unsafe dam that needs to be addressed. The work will require 15 PDs.

$$1 \text{ unsafe dam} \times 15 \text{ PDs/unsafe dam} = 15 \text{ PDs}$$

Construction Inspections

The number of dam inspections recommended for new dam construction is 15, for dam modifications is 10, and for dam removals is 5. Suggested effort is 2 PDs for a new dam or for modifications to an existing dam and 1 PD for a dam removal. It is assumed there will be one new dam and that 10% of the state's inventory of 300 regulated dams will have modifications performed.

1 new dam x 2 PDs/inspection x 15 inspections =	30 PDs
30 dam modifications x 2 PDs/inspection x 10 inspections =	600 PDs
<u>2 dam removals x 1 PDs/inspection x 5 inspections =</u>	<u>10 PDs</u>
Subtotal	640 PDs

2. Comprehensive Review and Inspections

- Frequency of Comprehensive Review and Inspections (CRI)
 - Every 10-years for HH dams, (0.1 multiplier)
 - Every 15-years for SH dams, (0.067 multiplier)
 - Each Review requires 20 PD

<u>100 HH Dams (x 0.1) = 10 CRIs/year x 20 PD/CR =</u>	<u>200 PDs</u>
<u>40 SH Dams x (x 0.067) = 3 CRIs/year x 20 PD/CR =</u>	<u>60 PDs</u>
Subtotal	260 PDs

3. Design Reviews

This example estimates 25 PDs would be required to review a new dam, 10 PDs for modifications to an existing dam, and 3 PDs to review a dam removal project.

1 new dam x 25 PDs/review =	25 PDs
30 modifications x 10 PDs/review =	300 PDs
<u>2 Dam Removals x 3 PDs/review =</u>	<u>6 PDs</u>
Subtotal	331 PDs

4. Hazard Classification Reviews

300 dams reviewed every 20 years averages 15 dams/year

15 dams reviewed/year x 10 PDs/dam reviewed = **150 PDs**

5. Emergency Action Plans and Incident Response

Review of New EAP

1 new dam x 4 PDs/new dam = **4 PDs**

Review of EAP Updates

- 100 high hazard and 40 significant hazard dams require EAP updates annually (1.0 multiplier)
- Each requires 0.25 PD to review

140 dams (x 1.0) = 140 EAP updates/year

$$140 \text{ EAP revisions / year} \times 0.25 \text{ PD/review} = 35 \text{ PDs}$$

Participation in EAP Exercises

- 140 high hazard and significant hazard dams will exercise their EAPs every 5 years (0.2 multiplier)
 - 140 dams (x 0.2) = 28 dam exercises/year
- $$28 \text{ dams} \times 1 \text{ PD per exercise} = 28 \text{ PDs}$$

Planning for Incidents or Emergencies

- Developing or updating response procedures
 - Ensuring tools and personnel are available for response
 - Communicating with county and local emergency management agency officials
- $$\text{Estimate } 20 \text{ PD required each year} = 20 \text{ PDs}$$

Responding to Dam Emergencies

The time required to respond to an actual dam emergency could be extensive. For estimating purposes, assume there will be one dam emergency each year requiring 15 PDs to respond.

$$1 \text{ dam emergency} \times 15 \text{ PDs per dam emergency} = 15 \text{ PDs}$$

6. Compliance and Enforcement

- Assume owners of 10% of dams are non-compliant (0.1 multiplier)
 - 300 dams (x 0.1 non-compliance) = 30 dams requiring NOVs
- $$30 \text{ NOVs} \times 3 \text{ PDs/NOV} = 90 \text{ PDs}$$
- Assume 1/3 of dams that received NOVs will require enforcement (0.33 multiplier)
 - Each enforcement action will require 15 PDs
- $$\underline{30 \text{ dams} \times 0.33 = 10 \text{ dams} \times 15 \text{ PD per dam per enforcement} = 150 \text{ PDs}}$$
- $$\text{SUBTOTAL OF REQUIRED TECHNICAL STAFFING} = 2352 \text{ PDs}$$

7. Administrative Activities

For mature programs that already have a good grasp of the time it takes to complete the various administrative tasks required of a dam safety program, and which tasks are performed within and outside of the program, it should be relatively easy to determine the staffing levels required for administrative activities inside the program.

This example uses 20% of the required technical staffing as a general estimate of administrative time needed to support the dam safety program. An additional 5% should be allocated specifically to the training of technical staff.

Administrative functions: $0.20 \times 2352 \text{ PD} =$	470 PDs
<u>Training of technical staff: $0.05 \times 2352 \text{ PD} =$</u>	<u>118 PDs</u>
SUBTOTAL OF ADMIN/TRAINING REQUIREMENT	588 PDs

TOTAL REQUIRED STAFFING CALCULATION

TOTAL PERSON-DAYS REQUIRED = $2352 + 588 =$ 2940 PDs

Workdays Available per Person per Year

- Assume 3 weeks (15 days) for vacation and personal time and 12 holidays

Total days per year	365 Days
Weekend days (52×2)	-104 Days
Holidays	-12 Days
<u>Vacation and personal</u>	<u>-15 Days</u>
Total workdays available per year	234 Days

TOTAL STAFF REQUIRED FOR THIS EXAMPLE PROGRAM

$2940 \text{ PDs} / 234 \text{ PDs/Person} =$ 12.6 Persons

13 PERSONS REQUIRED

Note: This example staffing requirement is for a program that performs virtually all its dam safety work using in-house staff. This staffing requirement could be reduced if the program chooses owner-responsible inspections and employs consultants to help complete many of the most time-consuming dam safety activities.