

# **SAFETY OF DAMS PROGRAM HANDBOOK**

## **DAM SAFETY, SECURITY, AND EMERGENCY MANAGEMENT**

**55 IAM - H**



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# 1 OVERVIEW AND SCOPE

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## 1.1 Overview

This Safety of Dams (SOD) Program Handbook conveys standard operating procedures and guidelines intended to achieve the mission of the Program, as discussed in Section 1.4. It is not intended as a standard of technology for dams; rather, it is intended to guide the overall program activities for the safety of the Bureau of Indian Affairs' (BIA) high- and significant-hazard potential dams. The information contained in this Handbook will help provide consistency throughout the Program, including the Branch of Dam Safety, Security, and Emergency Management (DSSEM), and will be periodically reviewed and updated.

All Program personnel should familiarize themselves with this Handbook and must abide by its procedures. Users of this Handbook include, but are not limited to:

- Program personnel in the Central Office and Regional Offices.
- Tribal dam safety personnel.
- BIA operation and maintenance personnel.
- State and Federal agencies participating in DSSEM activities.
- Consultants and water user associations under contract with the BIA or tribes.

## 1.2 Scope

This Handbook applies to all new and existing high- and significant-hazard potential dams. Unless otherwise stated, this Handbook does not address actions for low-hazard potential dams, as defined by the Indian Dams Safety Act (IDSA) and the Federal Guidelines for Dam Safety (FGDS) Hazard Potential Classification System (FEMA 333). This Handbook details critical aspects and directives of the following activities:

- Overall process of decision making and prioritization that is risk-informed and conforms with the Bureau of Reclamation (USBR) "Dam Safety Public Protection Guidelines."
- Assessment of risks associated with dam failure and the consequences of dam failure.
- Expedited actions and interim actions to reduce short-term risk of dam failure.
- Safety inspection of dams and appurtenances.
- Field and laboratory data collection for safety evaluations, risk-reduction design and construction, and environmental compliance.
- Engineering analyses and evaluations to identify potential dam failure modes and to reduce risk of dam failure.
- Assignment of hazard potential classifications for BIA dams.
- Preparation of dam failure downstream inundation limits.

- Conceptual design and evaluation of alternatives to reduce long-term risk of dam failure.
- Final design to prepare construction documents for modifying dams to reduce long-term risk of dam failure.
- Procurement and administration of construction for modifying program dams to reduce the risk of dam failure.
- Independent technical review and value engineering (VE) processes.
- Environmental permitting to comply with the National Environmental Policy Act (NEPA).
- Monitoring dam performance and dam instrumentation.
- Operation and maintenance of dams and appurtenances.
- Emergency management and preparation of Emergency Action Plans (EAPs).
- Early Warning Systems (EWS) to provide early warnings for adverse dam behavior and dam failures.
- Security of dams and public safety implications.
- Training of dam safety personnel and dam operators/dam tenders.

### **1.3 Handbook Availability and Revisions**

This Handbook is available on the BIA website, at: <http://www.bia.gov/WhatWeDo/Knowledge/Directives/Handbooks/index.htm>. This Handbook will be updated as needed to reflect changes in laws, policies, guidelines, and directives.

### **1.4 BIA Safety of Dams Program Overview**

The Program was established under the IDSA of 1994, Public Law (P.L.) No. 103-302, 25 U.S.C. § 3801 et seq. Its mission is to reduce the potential loss of human life and property damage caused by dam failure by making BIA dams as safe as practically possible. It is responsible for 135<sup>1</sup> high- and significant-hazard potential, dams in eight (8) regions and on 41 Indian reservations. These dams form a significant part of the water resources infrastructure and trust assets for the various Indian reservations.

For Program purposes, the term *dam* includes any artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water that meets at least one of the following criteria: (1) is 25 feet or more in height from the natural bed of the stream channel or watercourse measured at the downstream toe of the barrier or, if the barrier is not across a stream channel or watercourse, from the lowest elevation of the outside limit of the barrier to the maximum storage elevation; (2) has an impounding capacity for maximum storage elevation of 50 acre-feet or more; or (3) is likely to pose a significant threat to human life or property if the barrier fails even if it does not meet these height or impounding capacity criteria.<sup>2</sup> This Handbook does not normally apply to any dam 6 feet or less in height,

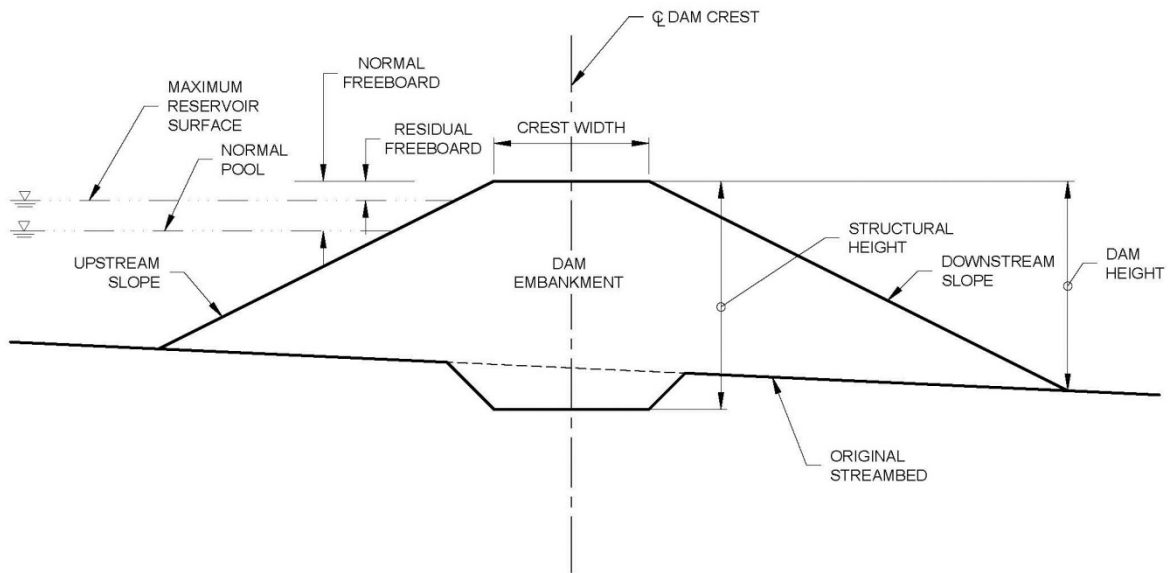
<sup>1</sup> The number of Program dams as of January 2013.

<sup>2</sup> See IDSA, 25 U.S.C. § 3802(2); National Dam Safety Program Act, 33 U.S.C. § 467(2).

regardless of storage capacity, or dams having a storage capacity at maximum water storage surface of 15 acre-feet or less. However, judgment should be used in the application of these guidelines to site-specific circumstances involving dams smaller than these minimum sizes, where there is life loss potential. Figure 1.1 shows the definitions of dam height and other terms commonly used in an embankment dam.

BIA classifies dams as high-hazard potential if dam failure or mis-operation will probably cause loss of human life and cause extensive property damage.<sup>3</sup> BIA classifies dams as significant-hazard potential if dam failure or mis-operation can cause significant property damage but no probable loss of human life.

**Figure 1.1**  
**Cross Section of a Typical Dam**



The Program manages its portfolio of dams using a risk-informed approach. The primary emphasis is to protect downstream residents from undue risks, utilizing a risk-informed decision process to prioritize risk-reduction actions. Continuous and periodic dam inspections and evaluations are critical to an effective dam safety program. The robust risk-informed approach is a best practice adopted to develop balanced and informed assessments of the safety of BIA dams and to evaluate, prioritize, and justify dam safety decisions.

<sup>3</sup> Office of the Inspector General (OIG), Report No. WR-EV-MOA-0002-2013 (September 2013), Recommendation No. 1 states, “Update BIA policies to align with the [FEMA 333] dam hazard classification.” In accordance with OIG’s recommendation, BIA revised its hazard potential classifications. Consistent with FEMA 333, BIA dams are now classified as high-hazard potential if dam failure or mis-operation will probably cause loss of human life and cause extensive property damage. In addition, all Program dams which were previously classified as significant-hazard potential are now classified as high-hazard potential.

Key Dam Safety, Security, and Emergency Management (DSSEM) branch activities include, but are not limited to:

Risk Management and Risk Reduction: To effectively utilize Program resources, a risk-informed approach is used to prioritize dam safety assessments, to aid in decision making, to protect downstream populations from the consequences of dam failure, to support justification for risk-reduction actions where needed, and to prioritize funding for SOD projects. Risk-reduction actions include repair and rehabilitation to address static, seismic, and/or hydrologic potential failure modes (PFMs).

Emergency Management and EWS: Emergency management helps reduce the likelihood of life loss and damage to property from a dam failure. EWS and EAPs are developed, implemented, and maintained. The BIA conducts tabletop and functional exercises of all EAPs on a regular basis.

The Program is responsible for installing and maintaining EWS on BIA dams. With the assistance of tribes, the BIA has installed EWS on 116 dams.<sup>4</sup> The EWS are currently connected to the BIA's National Monitoring Center (NMC) operated by the Confederated Salish and Kootenai Tribes on the Flathead Indian Reservation, Ronan, Montana.

Inspections and Evaluations: These activities provide key information necessary to determine the overall condition of Program dams. The BIA schedules annual inspections, Periodic Reviews (PRs), and Comprehensive Reviews (CRs) at various frequencies and cycles. Risk assessments for dam safety decision making integrate the analytical methods of risk analysis along with the sound professional judgment of engineers, architect and engineer (A/E) consultants, and review boards in determining reasonable actions to minimize risk at BIA facilities.

Maintenance and Repairs: Recurring maintenance and repairs are performed to keep dams from deteriorating into an unsafe condition. Annual maintenance is performed on EWS and repairs are made on dams with critical repair needs.

Security: Security assessments are performed to ensure adequate security for key dam facilities and structures against credible threats and appropriate protective measures are implemented.

In addition to these activities, the BIA SOD Officer has national oversight of the BIA dams within the National Inventory of Dams (NID), and is responsible for ensuring that the list of BIA dams in the NID database is updated each year.

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<sup>4</sup> The number of dams with EWS as of July 2014. Of the 116 dams, 114 provide data to the NMC.



## **2 CONTRACTING AND COMPACTING WITH INDIAN TRIBES**

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### **2.1 Overview**

This chapter describes the processes and procedures required in contracting with tribes under P.L. No. 93-638 and compacting for services, functions, and construction activities in the Program.

Contracting or compacting under P.L. No. 93-638, 25 U.S.C. 450 et seq., as enacted, allows tribes to contract or compact certain functions, services, or activities. Both maintenance and construction can be performed under a P.L. No. 93-638 contract and/or a self-governance funding agreement.

The Secretary [of the Interior] is directed, upon the request of any Indian tribe by tribal resolution, to enter into a self-determination contract or contracts with a tribal organization to plan, conduct, and administer programs or portions thereof, including construction programs . . . (25 U.S.C. 450f(a)(1)).

The Secretary shall negotiate and enter into an annual written funding agreement with the governing body of each participating tribal government [that] . . . shall . . . authorize the tribe to plan, conduct, consolidate, and administer programs, functions, services, and activities, or portions thereof, administered by the Department of the Interior through the Bureau of Indian Affairs . . . (25 U.S.C. 458cc(a), (b)(1)).

Although certain Program functions, services, and activities (or portions thereof) may be contracted or incorporated into a self-governance funding agreement by tribes under P.L. No. 93-638, the Program includes inherently Federal functions that are neither contractible nor compactable. The Program requires that the Regional SOD Officer be designated by the Regional Awarding Official (AO) as the Awarding Official's Technical Representative (AOTR) and participate in the contracting or compacting process, especially in developing the scope of work and providing technical assistance.

The Regional Director and the AO are responsible for ensuring that contracts or self-governance funding agreements require tribes to adhere to: the IDSA of 1994 (P.L. No. 103-302); "Indian Affairs Manual" (IAM), Part 55, SOD; BIA "Indian Self-Determination, Delegation of Signature Authority Handbook"; other pertinent regulations and any other requirements identified by the AOTR that are necessary to produce a completed quality product. One such requirement to be negotiated is that tribes establish Tribal SOD Coordination Offices and utilize the services of a registered Professional Engineer (P.E.) knowledgeable in the dam safety, security, and emergency management fields. Under P.L. No. 93-638, tribes need only comply with statutes and regulations that have not been waived and other negotiated requirements.

## **2.2 SOD Program Components Covered**

Tribes can contract or incorporate into self-governance funding agreements certain Program functions, services, or activities. This section only focuses on operations and maintenance (O&M) and construction.

Under Title 25 of the *Code of Federal Regulations (CFR)* Part 900 Subpart J – Construction and 25 *CFR* Part 1000 Subpart K – Construction, tribes may contract or compact to assume preplanning, planning, design, and construction activities. Under these regulatory provisions, they may also assume Conceptual Design and Final Design, which are both major Program components.

Besides construction, O&M can also be contracted to tribes through a P.L. No. 93-638 contract or self-governance funding agreement.

## **2.3 Tribal Work**

Tribes can perform preplanning, planning, design, and construction work if they have professional staff or if they subcontract for the services of registered P.E.s. Most tribes hire engineering consultants for all or part of construction activities.

Tribes may perform contract administration with the assistance of consultant(s). The tribe and its consultant act as the construction project manager, handling the day-to-day activities of the construction project and coordinating between the designer and contractor. Tribes normally handle a portion of the maintenance contracting as well.

## **2.4 Subcontract Firms**

### **Engineering Firms**

The Program recommends that the Regional SOD Officer, who acts as the AOTR, offer assistance to the tribes in subcontracting with professional consultant(s). The preferred method is to select a professional consultant using the Quality Based Selection Criteria (refer to Appendix A for the ranking sheet). Under this process, a board, consisting of the Regional SOD Officer and other tribal and BIA personnel, ranks each consultant based on the consultants' work experience and professional qualifications. A few firms (usually four) are short-listed and best and final offers are requested from them and reviewed by the board. The firms are then interviewed. The board then ranks the firms based on their qualifications. The ranking is then given to the selection official (Tribal Contracting Officer, Tribal Council, etc.), and cost estimates are opened. The selection official then selects a firm based on the recommendation from the board.

Prior to the selected engineering firm beginning the work, the AO and AOTR should schedule meetings on contractual responsibilities with the tribe and BIA representatives to discuss the contract and reporting requirements from 25 *CFR* Part 900. This will help to ensure that tribal

and BIA representatives who are involved with the project understand their contractual responsibilities.

## **Construction Firms**

BIA recommends that the construction contract be awarded to the lowest qualified bidder.

## **Force Account/Tribal Construction Firms**

Tribes may choose to perform all or part of the work.

## **2.5 Payment Schedule**

Payment processes must be identified in the contract. Payments to tribes are based on a negotiated payment schedule, but are typically made on a monthly, quarterly, annual, or lump sum basis. For tribes with a good performance history, a lump sum advance payment methodology is often used. For other tribes, advance payments may be made on a semi-annual, quarterly or monthly basis, or payment may be made on a cost-reimbursement basis. All interest earned from the account belongs to the tribe. If the contract is a cost reimbursement type of contract, there is a clause that requires the tribe to notify the BIA in the event that additional funding is required. If the cost is less than the negotiated estimate, the Secretary (or designee) has the authority to keep the cost difference.

## **2.6 Using the IAM and BIA SOD Program Handbook in the Contract**

The Program recommends that IAM Part 55, SOD, and this Handbook, be included as references in construction and non-construction contracts and self-governance funding agreements. If negotiated into the contract or self-governance funding agreement, they become a binding requirement.

## **2.7 Property**

Tribes may purchase property and equipment and acquire excess surplus Federal Government equipment for use under P.L. No. 93-638 contracts and self-governance funding agreements. At the end of the contract or self-governance funding agreement, the BIA has the option to acquire title to equipment or property exceeding \$5,000 in value (25 U.S.C. 450j(f)(2)). The ownership of property and equipment acquired for use under P.L. No. 93-638 contracts or self-governance funding agreements should be discussed during contract or funding agreement negotiations. The disposition of equipment and property at the end of the contract should also be negotiated with the tribe during the contract or funding agreement negotiations.

## **2.8 Assist in Negotiations**

The following types of documents should be prepared before starting negotiations:

- Conceptual Design Scope of Work

- Final Design Scope of Work
- Construction Statement of Work
- Quality Based Selection Criteria (refer to Appendix A for a sample)

## **2.9 Process**

Refer to Title 25 of the *CFR*, Part 900, Subpart J – Construction and Title 25 of the *CFR*, Part 1000, Subpart K – Construction for the entire construction process.

## **2.10 Administration**

To be eligible for a P.L. No. 93-638 contract, a tribe must meet the definition of Indian tribe as defined in section 4(e) of P.L. No. 93-638 (25 U.S.C. 450B(e)) and have finance, property, and procurement systems in place which meet the minimum requirements in Subpart F of 25 *CFR* Part 900. To contract for DSSEM functions, services, or activities (or portions thereof), the tribe must have technical engineering staff abilities or provide a commitment to obtain technical engineering staff abilities.

When Program funds are allocated to the Regional Office, the Regional SOD Officer is required to set up the appropriate Project Cost Accounting System (PCAS) codes. The tribe(s) must be formally notified of the availability of preplanning, planning, design, and construction funds. A certified letter must be sent to the tribe within 30 days after the Secretary's allocation of funds. The tribe is given 30 days under this notice to respond if it is interested in contracting the project. If after 30 days, the tribe has not responded, then a follow-up letter is sent giving the tribe an additional 10-day notice. If no response is received after this, the BIA will proceed with taking on the project. The tribal president, governor, or council chairperson is usually the individual with the authority to sign contractual agreements, and therefore function as the Contracting Officer for the tribe.

The Program requires that the Regional SOD Officer be appointed as the AOTR and must participate in the tribal contract and funding agreement negotiations. A series of meetings usually takes place between the tribal staff, AO, and AOTR.

At this time, SOD modification project budgets do not include indirect funding. SOD modification project budget negotiations should include indirect costs. Indirect funding for construction contracts must be negotiated in accordance with P.L. No. 93-638, section 106(h) (25 U.S.C. 450j-1(h)).

In accordance with Title III, section 310 of P.L. 105-83, beginning in fiscal year 1998 and thereafter, where actual costs of construction projects under cost-reimbursable self-determination contracts, self-governance funding agreements, or grants, pursuant to P.L. No. 93-638, 103-413, or 100-97, are less than the estimated costs thereof, use of the resulting excess funds shall be determined by the Secretary (or a designee appointed by the Secretary) after consultation with the tribes. Excess funds may be pulled back to the region or kept by the tribe for other SOD program activities. These excess funds are not considered to be savings. The Secretary (or designee) may elect to withdraw any excess funds for use elsewhere.

P.L. No. 93-638 contracts can have multiple year terms. They can cover design and construction and they can address separate phases of a project. Contracts can also include more than one dam project; however, this approach can be difficult for accounting and reporting purposes. In general, the BIA and the tribe must have all the funding for a SOD phase before a contract is awarded. If the contract can be divided into separate phases, each phase can be awarded funding separately, but with an added requirement that funding to fully cover each phase must first be in place.

The negotiated budget for a construction contract should include salary, benefits, training, travel, utilities, indirect cost, contract administration, construction management, and the actual construction (25 CFR, 900.127).

For non-construction projects, the budget should have separate items for salary, benefits, training, travel, utilities, and indirect cost.

VE studies are not required under the P.L. No. 93-638 regulations; however, these studies add value, especially for large projects. VE studies should be considered for inclusion in the scope of work as part of the negotiations. The contract or funding agreement should require the tribe to have a third party technical review performed.

## **2.11 Declination**

A P.L. No. 93-638 contract can be declined for any of the following reasons:

- The services performed will be unsatisfactory.
- Protection of trust resources is not assured.
- Project cannot be properly completed.
- Lack of funding and/or appropriations.
- Not authorized—beyond scope.

The AO and AOTR should work with the Solicitor's Office to identify any declination issues and to offer technical assistance to the tribe to overcome any reasons for declination.

## **2.12 Performance**

P.L. No. 93-638 contracts need to include all required data and reporting obligations from tribes that support completing Construction-In-Progress (CIP) reports and any other required government reporting.

The following reports or information should be required in P.L. No. 93-638 contracts:

- Construction reports (daily, weekly, monthly, and quarterly depending on the length of the project)
- SF-425 quarterly and/or annual Federal financial reports
- Other required reports (negotiated, as required)

To ensure that reports are submitted on a timely basis, clear requirements should be identified in the contract or funding agreement. It is important to identify the position title of the individual from the tribe who will be responsible for the reporting.

The BIA is required to make at least one annual site visit for non-construction work. The number of site visits during construction is negotiated into the P.L. No. 93-638 construction contract.

The scope of work accomplishment should be tracked according to the schedule established in the contract or funding agreement. The tribe's record of performance on past P.L. No. 93-638 contracts contributes to the decision whether or not the tribe can expand its P.L. No. 93-638 contracting.

The required single-agency audit may include P.L. No. 93-638 construction contracts. The audit firm reviews a sampling of the tribe's major financial activities and chooses major programs to review. If a Regional SOD Officer identifies a need for a more thorough audit, Regional management and the AO should be consulted.

Spending must be done in accordance with the contract. Equipment can be purchased under the contract. The tribe's proposal should include its methods for accomplishing the work, including leasing or purchase of equipment. If substantial equipment is proposed to be purchased, factors such as initial cost, storage, maintenance, qualification of operators, and pooling of equipment with other programs should be considered. For all P.L. No. 93-638 contracts, ownership of equipment following construction must be explicitly stated in the contract.

Earned interest can be spent as the tribe determines. It may be advantageous for the Program to negotiate into the contract that the interest earned be spent on SOD program activities.

Emergency reassumption (non-construction) or termination for cause (construction) is allowed in circumstances where there is imminent threat to life or irreparable harm to trust resources. If a non-construction contract is reassumed or if a construction contract is terminated by the BIA, then the BIA can issue an emergency contract to a third party to ensure that the project is completed as required.

## **2.13 Contract Closeout**

When a 25 *CFR* Part 900 Subpart J – Construction contract or a 25 *CFR* Part 1000 Subpart K – Construction self-governance funding agreement is completed, a final SF-425 Federal Financial Report form should be obtained from the tribe. A resolution from the tribe stating that the contract work is complete and that there are no outstanding liens or claims should also be obtained. The tribe should acquire a release of claims or liens from its subcontractors and vendors. The AO documents that the contract is complete and sends a request to the finance office to close out the contract. On a cost-reimbursement contract, the excess funds should be returned to the Federal Government or given to the tribe to use for other program activities (depending on the terms of the negotiated contract). A statement is also required from the AOTR that all work orders are complete.

During the closeout process, it is recommended that a meeting between the tribe and BIA be held to discuss the contract work that was performed. The discussions should include describing what went well and what could be improved. In addition, the BIA should write up its experiences and share its experiences with the tribe.

## 3 RISK-INFORMED DECISION MAKING

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### 3.1 Overall Process

The Program uses risk-informed decision making to manage the BIA’s overall inventory of dams. It is similar to processes used by other Department of the Interior (DOI) agencies; however, it is tailored to address the Program’s unique needs.

Whereas traditional approaches typically relied solely on engineering analysis, with risk-informed decision making, decisions are made based on the outcomes of risk assessments in addition to traditional engineering analyses. Emphasis is placed on *making the case* for dam safety decisions based on a review of the PFMs and estimated risks in relation to the BIA tolerable risk (life-safety) guidelines.

Risk considerations inform all aspects of Program activities and provide a vehicle integrating all of the activities discussed in the remaining chapters of this Handbook. These activities are introduced in this chapter and their essential roles are summarized. They are mutually dependent and should never be considered in isolation from the overall risk-informed decision-making process. They help the DSSEM branch to achieve, demonstrate, and maintain an adequate level of safety for each Program dam. To avoid gaps or missed connections between information held in different parts of the Program, it is essential that all Program activities are fully integrated on a dam-by-dam basis.

The Program risk-informed decision-making process is shown schematically in Figure 3.1. The outer loop represents recurring activities and the inner loop represents non-recurring activities. Recurring activities facilitate the identification of potential dam safety issues. When potential issues are identified, they are immediately assessed as indicated by the diamond-shaped decision symbol labeled “Dam Safety Issue?” in the lower right corner of Figure 3.1. Next, confirmed or suspected dam safety issues are evaluated using investigations, engineering analysis, and risk assessment and addressed through various risk-reduction activities, as appropriate, in the non-recurring elements that are shown in the inner loop in Figure 3.1.

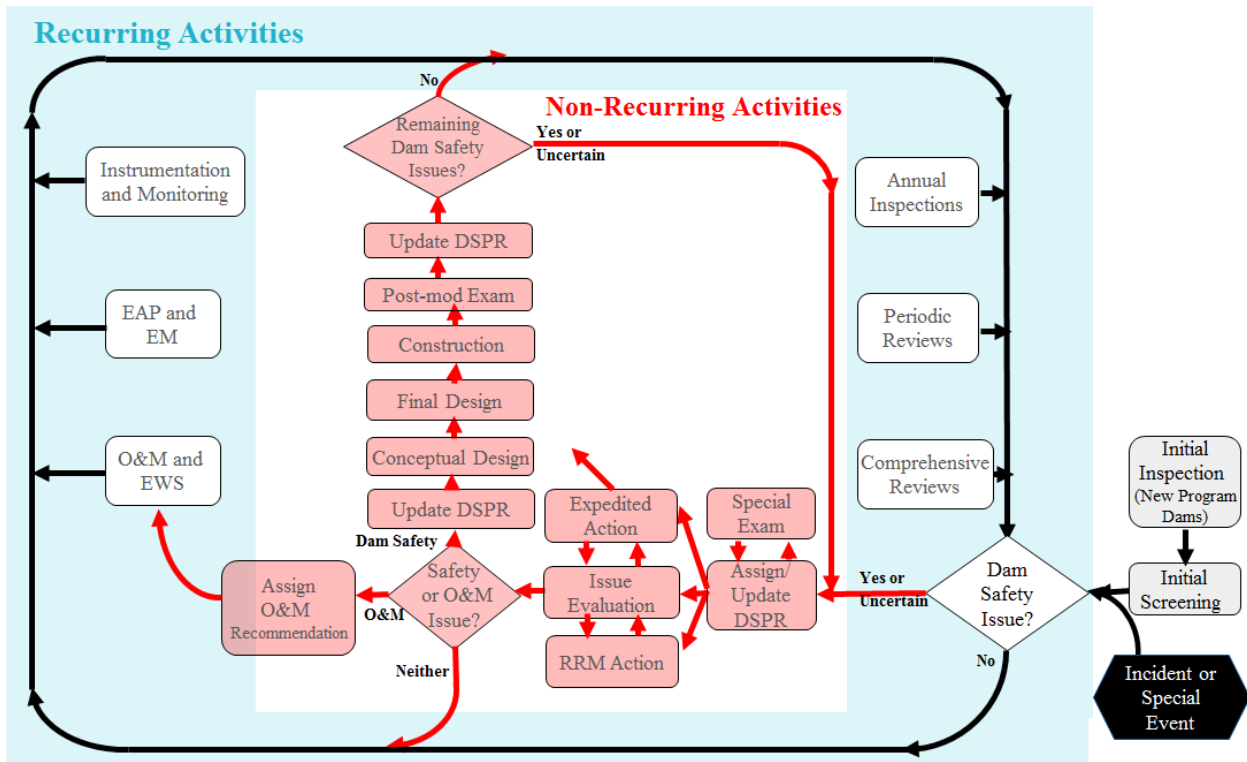
The USBR has completed screening level risk assessments on all high- and significant-hazard potential, BIA dams (as defined under the IDSA of 1994). These screening level assessments have identified PFMs and estimates of baseline risk. These risk assessments provide a basis for initiating the risk-informed decision-making process as indicated by “Initial Screening” in the lower right corner of Figure 3.1.

#### Recurring Program Elements

The outer loop in Figure 3.1 includes primarily on-site activities of O&M and EWS, EAPs and Emergency Management (EM), instrumentation and monitoring, annual inspections, PRs, and CRs.



**Figure 3.1<sup>5</sup>**  
**Program Risk-Informed Decision-Making Process**



### Non-Recurring Program Elements

Dam safety issues may be identified during recurring activities or as the result of an incident or unusual event, such as a flood or earthquake. When a potential dam safety issue is first identified, the Dam Safety Priority Rating (DSPR) assigned to the dam should be promptly reevaluated and changed as appropriate. These ratings range from 1 – Immediate Priority to 5 – Low Priority.

Following an assignment or update of the DSPR category, the next step in the non-recurring loop may be one or more of the following activities: (1) a special examination; (2) implementation of interim risk-reduction measures; (3) performance of an Issue Evaluation (IE); and (4) Expedited Actions (EAs).

For most issues, the next step is an IE to better determine the nature and severity of the safety issue, and recommended actions. The timing of an IE will depend on the urgency indicated by the DSPR category. Phasing investigations is a useful strategy to more cost effectively approach

<sup>5</sup> This figure is an adaptation of the approach agreed to by the US Army Corps of Engineers (USACE), the Bureau of Reclamation (USBR), the Federal Energy Regulatory Commission (FERC) and the Tennessee Valley Authority (TVA) in the “Federal Guidelines for Dam Safety Risk Management” (ICODS, 2013).

IEs, especially when detailed investigations and analyses are needed to achieve an adequate level of confidence in the results and recommendations.

Risk-reduction alternatives should include a no action alternative, structural and non-structural risk-reduction measures, consideration of making interim risk-reduction measures permanent, and decommissioning or replacing the structure. Phasing of risk-reduction measures at a particular dam and prioritizing of incremental measures across the entire portfolio can be an efficient and cost-effective approach to reducing portfolio dam safety risks.

After completion of construction, a Post-Modification Examination is performed to assess the level of risk reduction achieved against design criteria and tolerable risk guidelines and to revise the DSPR category as appropriate. Also, any interim risk-reduction measures should be reviewed and modified as appropriate.

### 3.2 Dam Failure Risk

Risk is generally defined as the probability that some undesirable event occurs. In the context of dam safety, the undesirable event is dam failure. The FGDS define catastrophic dam failure as “the sudden, rapid, and uncontrolled release of impounded water.”<sup>6</sup> (FEMA, 2004). Dam failures can lead to large-scale life loss, economic damage, environmental damage or damage to cultural heritage sites. The consequences of a dam failure are an important measure of the severity of a dam failure. Therefore, dam safety risk is measured not only by the *probability* of dam failure, but also by the *probability distribution* of the consequences of dam failure. Of the different types of consequences that can result from dam failure, life loss is given the greatest emphasis in managing dam safety risk and in formulating dam safety risk-reduction plans. It follows that the probability distribution of life loss is an important factor in evaluating dam safety risks, and also, the risks associated with activities such as the siting of chemical plants and nuclear power stations.

Therefore, dam safety risk management must seek to understand not only the *causes* of dam failure, but also the *factors* that determine the magnitude of life loss and other types of consequences in the event that a dam failure occurs. Some consequences of dam failure, such as damage to cultural heritage sites, are not readily quantifiable, but they are nevertheless very important and should not be overlooked in dam safety decision making.

It is recognized that there are lesser degrees of failure than a dam breach including any malfunction or abnormality outside the design assumptions and parameters that could adversely affect the performance of a dam, but dam safety risk assessments typically focus on the rapid and uncontrolled release of water impounded by a dam. All dams have multiple potential modes of

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<sup>6</sup> “It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters which adversely affect a dam’s primary function of impounding water is properly considered a failure. Such lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action.” (FEMA, 2004). Large releases through spillways can also lead to very undesirable consequences that are similar in nature to dam failure consequences. A dam safety risk assessment can also be used to evaluate these non-breach risks and to verify that they are not inappropriately increased as a result of dam safety risk-reduction measures.

failure. In addition to considering alternatives for reducing the likelihood of dam failure occurring, opportunities for reducing the magnitude of life loss in the event of dam failure should also be considered.

### 3.3 Guiding Principles

The following guiding principles have been established for the Program's risk-informed decision-making process:

1. Life safety is paramount: A key mission of the Program is to reduce the potential loss of human life due to dam failure by making BIA dams as safe as practically possible.
2. Cultural sensitivity: Address dam safety issues in a way that respects the values of tribes and Indians.
3. Adequately safe dams: Because absolute safety cannot be achieved, a BIA dam is considered adequately safe if it meets all essential BIA engineering guidelines, has no confirmed dam safety issues, and has a residual risk that is demonstrated to be tolerable, such that the risk is reduced to be *as low as reasonably practicable*.
4. Do no harm: The principle of *do no harm* should guide all actions intended to reduce dam safety risk. For instance, a modification intended to address a particular PFM should not increase the potential for other PFMs to occur. This ensures that interim risk reduction measures (IRRM), emergency or permanent construction, and temporary or permanent changes in operating rules will not result in the dam safety being compromised at any point in time including during the implementation of risk-reduction measures.
5. Risk-informed program-wide approach: The Program is managed from a risk-informed perspective applied to all features of all dams on a continuing basis.
6. Making the case: Each dam safety decision must be supported by well-reasoned arguments, informed by technical evidence and risk estimates, and with consideration given to the attendant uncertainties and the relevant non-technical factors. Decisions are risk-informed, not risk-based. Therefore, decision making is not automatically determined by numerical risk estimates.
7. Urgency of dam safety actions: The urgency of actions, including funding, to reduce risks on an expedited basis in the short-term (i.e., IRRMs) or in the long-term (i.e., dam safety modifications) is commensurate with the level of risk based on current knowledge and uncertainties. This may involve first addressing only those potential failure modes that contribute significantly to the overall risk.
8. Risk communications: Program communications provide stakeholders with information related to: dam benefits and risks, uncertainties that affect the current understanding of the risks, and the actions being taken to manage and reduce the risks and the associated uncertainties.
9. Studies and investigations: Studies and investigations are scoped with the goal of confirming dam safety issues and reducing uncertainties. The scope of the studies and investigations may be adjusted in response to the identification of new dam safety issues, and as the understanding of the dam safety issues improves.

10. Formulation and prioritization of risk management measures: Where feasible, risk-reduction measures are formulated as separable measures that can be phased and prioritized to achieve tolerable risk as quickly as practicable and in a robust, transparent, and cost effective manner across the portfolio of BIA dams.
11. Level of detail of risk assessments: The level of detail and scope of risk assessments are *scaled* using a *decision-driven*<sup>7</sup> approach to provide an appropriate level of confidence considering the level of risk and the risk management decision(s) that the assessment is intended to support. All credible and significant failure modes should be considered in addition to significant factors that affect life loss and other consequences that will influence the decision(s).
12. Recurring elements: Inspections, instrumentation, monitoring, periodic reviews, comprehensive reviews, operation and maintenance, emergency action planning, and other recurring activities are an essential part of effective risk management for all BIA dams and the reduction of portfolio dam safety risk.
13. Risk documentation: The basis for risk-informed decisions is documented, including the current level of risk, which is documented and updated, as needed.

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<sup>7</sup> See Section 3.4 for further discussion on the term “decision-driven.”

### 3.4 Role of Risk Assessments

Maintaining up-to-date risk assessments provides current information for managing and reporting on the risks posed by each dam.

There are eight instances when a risk assessment is typically performed or reviewed and updated, as appropriate. Each instance is represented by numbered symbols in Figure 3.2, with the numbers matching those in the list below. The colors of the symbols distinguish risk assessments performed or reviewed and updated as part of an Initial Screening (black), Recurring Activities (blue), or Non-Recurring Activities (red).

1. Initial Screening: Initial screening-level risk assessments were completed by USBR during the 2009–2010 period using a risk matrix approach. New Program dams will undergo an initial risk assessment during the initial inspection. Initial screening-level risk assessments are performed only once for each dam.
2. Annual Inspections: The most recent risk assessment is reviewed to inform the annual inspection process and to identify the need for updating.
3. PRs: The most recent risk assessment is reviewed, and the need for updating the risk assessment is evaluated. PRs are performed at a minimum of every 10 years (staggered with comprehensive reviews).
4. CRs: The most recent risk assessment is reviewed and updated, using an event tree approach including a potential failure modes analysis (PFMA). CRs are performed at a minimum of once every 10 years (staggered with PRs).
5. Interim Risk-Reduction Plans and Implementation: The most recent risk assessment may be adapted, using an event tree approach including a PFMA, for use in informing IRRMs, as appropriate.
6. IE Studies: The most recent risk assessment is updated, as needed, using an event tree approach, including a PFMA, for use in the IE.
7. Risk Reduction Program: The most recent risk assessment is updated using an event tree approach to evaluate the level of risk reduction expected to be achieved by various modification alternatives.
8. Post-Modification Examination: The risk assessment is updated using an event tree approach in conjunction with the post-modification examination.

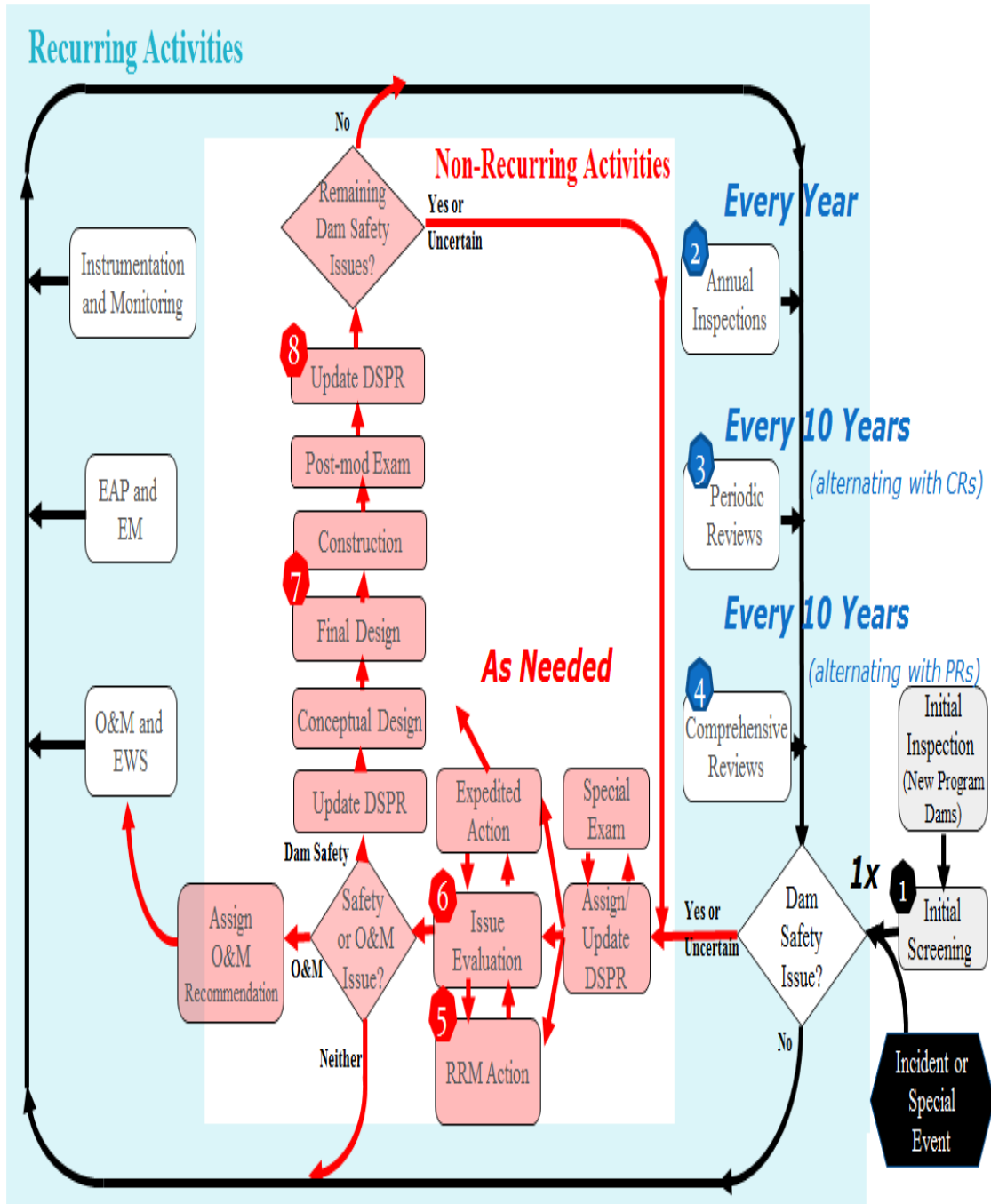
There are up to four instances of risk assessments associated with the inner loop of non-recurring activities in Figure 3.2. If available, an event tree model from the most recent CR is reviewed and updated as appropriate during the IE and subsequent risk-reduction activities. If only the Initial Screening risk matrix is available, an event tree risk assessment should be developed to adequately support the IE and subsequent risk-reduction activities.

Since the purpose of each risk assessment varies, the scope and level of detail in the risk analysis will vary. The required level of detail for all risk assessments should be *decision-driven*, that is,

it should be determined by the scope and level of confidence needed to support the dam safety decision being made.

**Figure 3.2**  
**Program Risk-Informed Decision-Making Process Showing Applications of Risk Assessment**

 Risk assessment (Black–initial screening, Blue–recurring, Red–non-recurring/as needed)



### 3.5 Risk Evaluation and Making the Case

#### Risk Evaluation and Tolerable Risk

Risk evaluation provides an important way of utilizing the estimates of risk from a risk assessment in decision making. The Program has adopted tolerable risk<sup>8</sup> guidelines and applied these guidelines to the dams in our program.

Four conditions are necessary for the residual risk at a dam to be considered tolerable:

- The dam provides benefits.
- The residual risk is not so small as to be considered negligible.
- The residual risk is routinely evaluated.
- The residual risk is reduced to as low as reasonably practicable (ALARP).

Refer to the Definitions section for the definition of residual risk.

The Program uses a two-part risk evaluation process described below.

#### *a) Part 1 – Limit Guidelines*

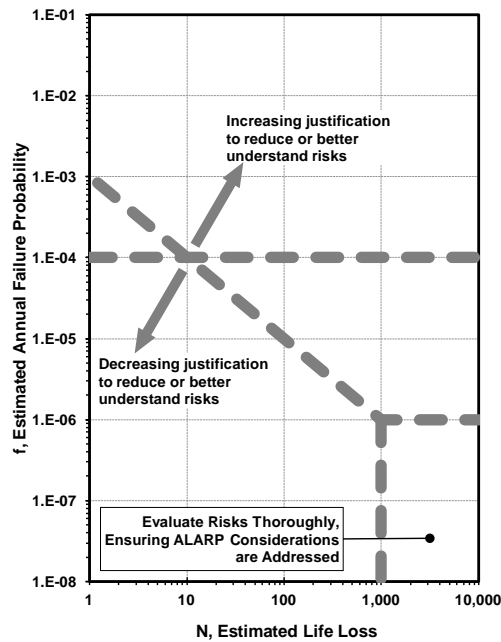
Part One of the risk evaluation process compares the total estimated risk for all PFMs against the following tolerable risk guidelines, as illustrated in Figure 3.3 below:

- An Annualized Failure Probability (AFP) of 1 in 10,000 ( $1 \times 10^{-4}$ )/year or less; and
- An Annualized Life Loss (ALL) of 0.001 ( $1 \times 10^{-3}$ ) lives/year or less.

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<sup>8</sup> Tolerable risk, as it is used here, is defined as the risk that society is aware of and is willing to live with in order to enjoy certain benefits because it is confident that the benefits are worth the risk and the risk is being properly monitored and controlled.

**Figure 3.3**  
**f-N Chart Showing AFP and ALL BIA SOD**  
**Program Tolerable Risk Guidelines**



***b) Part 2 – As Low As Reasonably Practicable (ALARP)***

Part Two of the risk evaluation process is a determination of whether risks have been reduced to be ALARP. This evaluation is both qualitative and quantitative and should take the following into account: (1) the level of risk in relation to the tolerable risk limits; (2) the disproportion between the cost (money, time, trouble, and effort) in implementing the risk-reduction measures and the subsequent risk-reduction achieved; (3) the cost-effectiveness of the risk-reduction below the tolerable risk guidelines; compliance with essential Program guidelines (described or referenced in this Handbook); and (4) tribal and societal concerns as revealed by consultation with the tribes and other stakeholders.

Making the Case

A key element in the risk-informed decision process is to recommend and provide justification for a decision. *Making the case* should be a primary focus throughout the risk assessment process. It is important that the case should be clearly made and documented in support of each dam safety decision recommendation as a logical set of arguments covering the following:

- Recommending and justifying additional safety-related action, or no additional safety-related action.
- Documenting the following
  - the dam's existing condition and projected capability to withstand future loadings;
  - the numerical risk estimates; and



- the recommended actions.
- Evaluating the sensitivity (uncertainty) to key parameters affecting the risk analyses and their effects on recommended actions.

### 3.6 Prioritization

The DSPR system comprises the following five categories of ratings:

- 1 – Immediate Priority: Total annualized life loss or total failure probability is extremely high with high consequences.
- 2 – Urgent Priority: Total annualized life loss or total failure probability is very high with high confidence or suspected of being very high to extremely high with low to moderate confidence.
- 3 – Moderate to High Priority: Moderate to high total annualized life loss or total failure probability with at least moderate confidence.
- 4 – Low to Moderate Priority: Low to moderate total annualized life loss and total failure probability with low confidence and the realistic potential to move the estimate into *high*; or moderate to high total annualized life loss and total failure probability with low confidence and the realistic potential to move the estimate into *low*.
- 5 – Low Priority: Low total annualized life loss and total failure probability with moderate to high confidence.

For more information on DSPR, refer to the USBR “Dam Safety Public Protection Guidelines.”

The DSPR system provides guidance for determining the priority of taking various non-recurring actions to address the dam safety issues or deficiencies at BIA dams. DSPR ratings should be assigned based on the current understanding of the level of risk. However, the system is dynamic, with changes being made as better information becomes available, as project features are modified, or when potential dam safety issues are identified.

### 3.7 Risk Communications

Risk communication is the two-way exchange of information and opinion about hazards and risks that leads to a better understanding of the risks and better risk management decisions. Risk communication ensures that the decision makers, tribes, and other stakeholders understand the risk assessment process and in so doing can contribute effectively to decision making. It is an activity that occurs throughout the decision-making process, not just after decisions have been made.

For each risk management activity, risk communication should answer the following questions:

- Why are we communicating?
- Who is our audience?
- What do we want to learn from our audience?
- What does our audience want to know?

- What do we want to get across?
- How will we communicate?
- How will we listen?
- How will we respond?

Effective risk communication has both internal and external communication components. Internal risk communication requires early and continuing communication, coordination, and collaboration among risk assessors and agency officials. External risk communication should reach all affected stakeholders, including tribes and emergency management officials on the Indian reservation in question. In some cases, external stakeholders will include owners of upstream and downstream dams and emergency management officials off the Indian reservation.

Some important aspects of risk communication for the Program are listed below:

- Stakeholder engagement: Stakeholder involvement ensures that tribal and other affected public values are considered in the decision-making process, with the goal of a shared acceptance of the risk management decisions.
- Communicating about the nature of risk: Stakeholders need an awareness and understanding of the magnitude and severity of the risk in different locations, the urgency of the situation, how the risk is evaluated, and whether the risk is increasing.
- Communicating uncertainties in risk assessment: The extent and significance of uncertainty, or conversely the level of confidence in the technical aspects of the risk, should be clearly conveyed. These can include inaccuracies in available data and technical analyses, the assumptions on which risk estimates are based, or other factors. Management needs to weigh the importance of these uncertainties in the decision process. An awareness of these uncertainties is also important for stakeholders to appreciate the need for precautionary actions while risks are being evaluated, or in the long-term if uncertainties cannot be reduced by investigations.
- Communicating risk management decisions: The actions taken to better understand the risk, and to control or manage it in the short- and long-term, must be carefully communicated to stakeholders. The justification for the chosen specific risk management plan must be made explicit and transparent. The residual risks that remain after a risk management plan is implemented and the actions that individuals should take to reduce personal risk must be clearly communicated to all stakeholders and decision makers.

## 4 RISK ASSESSMENTS

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### 4.1 Overview

This Handbook already identified eight specific instances when risk assessments are initially performed, reviewed or updated. The outcomes of these risk assessments are applied throughout the risk-informed decision making process.

Between 2009 and 2010, USBR conducted initial screening risk assessments for all Program dams using a risk matrix approach that incorporated the consequences rating system. The BIA has since replaced the risk matrix approach with a more robust event tree approach that builds on the outcomes of a PFMA.<sup>9</sup>

Risk assessments associated with the non-recurring activities will be implemented only if a potential dam safety issue is identified and the process enters the inner loop of non-recurring activities as shown previously in Figure 3.2. In these cases, an event tree risk model from the most recent CR would be the starting point for risk assessments.

While all dam safety risk assessments should include the same basic steps, the details will vary depending on the specific dam and the purpose for which it is being applied. A *decision-driven* approach should be followed to determine the necessary level of detail for each risk assessment.

The BIA views the capability to perform dam safety risk assessments and to manage the performance of these assessments as an important part of its trust responsibilities with the tribes. Therefore, the Program maintains the capability to conduct dam safety risk assessments in-house, although it may also contract with others to conduct them. The Regional SOD Officers should be well-versed in risk assessment methodology. Risk assessment knowledge and skills can be obtained through training, participating as a risk assessment team member, and participating in decision making for dams in their region.

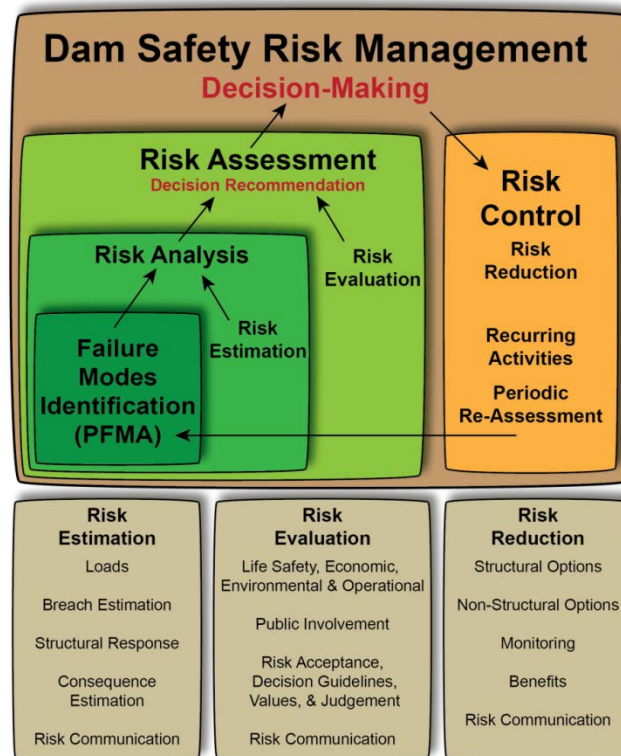
### Components of the Dam Safety Risk Assessment Process

The relationship between the various processes that comprise dam safety risk assessment and their relationship to risk management are represented schematically in Figure 4.1 below. At the highest level, risk management combines risk assessment, risk control, and decision making on all aspects of dam safety. Risk assessment comprises risk analysis, risk evaluation, and the formulation of decision recommendations. Risk analysis involves both risk identification and risk estimation.

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<sup>9</sup> These new risk assessments will generally be conducted as part of the recurring activities of a Comprehensive Review (CR), unless the dam is undergoing non-recurring activities before an event tree risk assessment has been developed, in which case one will be developed as an integral part of an Issue Evaluation (IE) or subsequent risk-reduction activities.

**Figure 4.1**  
**Interrelationships between the Components of Dam Safety Risk Management (ICODS, 2013)<sup>10</sup>**



The various components of the dam safety risk management process are defined as follows, based on definitions in *ICOLD Bulletin 130* (2005):

- Risk identification is the process of determining what can go wrong, why, and how.
- Risk estimation is the process of quantifying probabilities and consequences for all credible and significant failure modes.
- Risk evaluation is the process of examining and judging the significance of the estimated risk.
- Risk analysis is the use of available information to estimate the risk to individuals or populations, property or the environment, or from hazards.
- Risk assessment is the process of making a decision recommendation on whether existing risks are tolerable, including consideration of important and related cultural, economic, social, environmental, cost and other factors, and whether the present risk control measures are adequate, and if not, whether alternative risk control measures are justified or should be implemented.

<sup>10</sup> Adapted from Bowles (1999) in USSD (2003).

- Risk control (mitigation/reduction) is a selective application of appropriate techniques and management principles to reduce either the likelihood of an occurrence or its adverse consequences, or both.
- Risk management is the systematic application of management policies, procedures, and practices to the tasks of identifying, analyzing, assessing, mitigating, and monitoring risk.

## **Risk Assessment Steps**

The major steps to be completed in a dam safety risk assessment are as follows:

### Risk Identification

1. Define the purpose (What decisions need to be made?).
2. Conduct a site visit (desirable but may be waived if key team members are familiar with the dam), an engineering assessment, and a PFMA.

### Risk Analysis

3. Develop the risk model.

### Risk Estimation

4. Estimate loading (external hazard) probabilities.
5. Estimate system response probabilities for external and internal hazards.
6. Estimate consequences.
7. Calculate the risk including consideration of uncertainties.

### Risk Evaluation

8. Evaluate the risk (What risk is tolerable?).
9. Recommend and *make the case* for a decision.

Additional details regarding these steps are provided later in this section.

## **Team Composition**

Ideally, the risk analysis team should consist of the following members:

1. Facilitator: Leads the team activities.
2. Core estimating team: Participate in all team working sessions and are involved with estimating the risks for each of the PFMs considered in the risk analysis. Core team members often include dam engineers and the dam operator/dam tender.
3. Supporting team: Provide specialized inputs, and only participate in parts of the team working session as needed (e.g., hydrologist, seismologist, consequences expert, etc.).
4. Technical reviewers: Participate in reviewing the risk assessment at key points in the team process and/or at the end of the process prior to the wrap-up presentation to the “asset owner” and decision makers.
5. Asset owner and decision makers (BIA SOD Central Office, Regional SOD Officer, and/or tribal representatives): Responsible for making dam safety decisions or decision

recommendations and supporting budget requests. They primarily participate in endorsing or agreeing on the risk assessment purpose and in a wrap-up presentation of risk assessment results, findings, and decision recommendations.

6. **Observers:** Other individuals who may be present at the team working session because they have an interest in the particular dam, such as tribal officials and leaders and other stakeholders.

## **4.2 Risk Identification**

### **Scoping**

Scoping and selecting the extent and level of detail or complexity for a risk assessment should build on the statement of purpose and on a PFM identification process. Although many BIA risk assessments will likely be similar, a scoping process should be conducted before initiating a risk assessment to identify any unique considerations that need to be included in the risk assessment. The scoping process may include the following items for a particular dam:

- Decisions that will be informed by risk assessment outcomes, including, but not limited to investigations, surveillance, monitoring and measurement improvements, operation and maintenance, interim risk-reduction actions, long-term risk-reduction options, and non-structural risk-reduction measures.
- Decision context including any unique aspects such as special cultural, tribal, environmental, critical infrastructure, or other stakeholder concerns, and any coordination with the operations of other dams upstream or downstream.
- Decision guidelines including BIA engineering guidelines, tolerable risk guidelines, and any additional decision bases such as cultural or economic considerations or stakeholder considerations.
- PFMs that will be considered as part of the risk analysis. For instance, some risk analyses may focus on only seepage/internal erosion PFMs in response to observed seepage at a dam. Other risk analyses may focus on all of the PFMs (static, seismic, and hydrologic) that may occur. Prior to the risk analysis meeting(s), it is important for the team to have a clear understanding of the types of PFMs that will be considered.
- Level of confidence desired for decision making.
- Team composition and roles including stakeholder participation.
- Risk model requirements.

### **Potential Failure Modes Analysis (PFMA)**

In the PFMA process, all PFMs for the subject dam are enumerated and described, including the relationship between each PFM and the consequences of failure that are relevant to satisfying the statement of purpose. A structured and systematic process should be followed to complete thorough PFM identification. The list of PFMs is narrowed to a list of those that are considered to be credible; that is, they are physically plausible PFMs.

During the risk analysis meeting(s), the list of credible PFMs is further reduced to those PFMs that are actually considered to be significant. Only significant PFMs are estimated by the team, while PFMs that are credible yet considered to be so remote that they are non-significant are not estimated by the team.

For each significant PFM estimated by the team, the following steps should be followed:

1. Prepare a detailed, written description of the significant PFM under consideration from initiation all the way through to dam breach. This description can include a preliminary event tree diagram. Visual aids, such as dam cross sections showing the path and progression of the PFM can also be useful in helping the team to visualize the PFM. It is critical that all team members have a thorough understanding of the mechanism and progression of the PFM being considered.
2. For each node of the event tree, develop a list of the key more likely (adverse) and less likely (positive) factors. Based on these factors, the team will develop a consensus estimate (or range of estimates) for each node of the event tree.
3. Multiply the estimate (or range of estimates) for each node of the event tree together to develop an overall AFP estimate (or range of estimates) for the PFM being evaluated. Spreadsheet tools or other risk estimating software can be useful in performing this task.

Although not part of the PFMA, it may be useful and efficient to take additional steps when the team conducts the PFMA. Additional steps may lead to improvements in recurring activities and the identification of appropriate risk-reduction measures.

### **4.3 Risk Analysis – Development of Risk Model**

A risk model is used to calculate the risk of dam failure. Typically, an event tree model structure is used. The form of this model builds on the risk scoping, including the identified significant PFMs and other scoping considerations. The event tree model typically includes the following:

1. Probability distribution(s) of hazards: Typically, floods and earthquakes are considered using their annual exceedance probability distributions. In the case of earthquake hazards, the probability of coincident reservoir pool levels is also considered. The characterization of the loads must match the key attributes of these loads that drive the significant PFMs. For static PFMs, this factor is represented by a *reservoir rises* node, which takes into account the reservoir level (or levels) above which the PFM under consideration might occur. For all PFMs, whether static, seismic, or hydrologic, this factor is the first node of the event tree.
2. Conditional (system response) probabilities distributions: These represent the responses of all the key components of the dam-reservoir system for all significant PFMs over the entire range of loads, and comprise the remaining nodes of the event tree. For example, for internal erosion event trees, these nodes typically include erosion initiates, unfiltered exit exists, roof forms, upstream zone fails to fill a crack, upstream zone fails to limit the flows, intervention fails, and dam breaches. All of the nodes of the event tree, including all of these nodes as well as the initial reservoir rises/loading probability node, must take place in order for a dam failure to occur.

For the initial reservoir rises/loading probability node of the event tree, several loading ranges should be considered. For example, if liquefaction is to be represented, then different intervals of earthquake magnitude should be represented since the liquefaction response is sensitive to earthquake magnitude.

Dams in a series on the same river may be considered in risk assessments as follows:

- By assigning the consequences associated with failure of downstream dams that are initiated by a failure of an upstream dam, to the upstream dam.
- Making no change to the probability of failure of the downstream dam because of the potential for its failure to be initiated by the failure of an upstream dam.

## 4.5 Estimation of Consequences

### Inundation

Breach models have been developed and applied for many BIA dams to prepare inundation maps for EAPs or to support potential downstream hazard classifications. These models can be used to estimate consequences for use in risk assessment. At some BIA dams, the most severe case results from heavy releases through the dam (such as high spillway flows) rather than releases through a dam breach following dam failure. Inundation studies should also consider these scenarios for non-dam-failure flood releases.

### Life Loss

#### a) *Factors Affecting Life Loss*

Site-specific factors should be used to calculate reasonable estimates of probable life loss in the event of dam failure. There are numerous factors that affect the potential for life loss in the event of a dam failure or flooding associated with normal spillway operation.

Some of the factors that may increase the potential life loss resulting from dam failure on Indian reservations include the following:

- Population density differences such as occupancy rates in residences and at group gatherings, including after-school activities.
- Transportation options for evacuation.
- Reluctance to evacuate.
- Timeliness of warning communications.
- Reliability of electricity supply.
- Emergency response times.
- Proximity of emergency responders.



**b) *Life Loss Estimation Approaches***

There are various approaches that may be used to estimate life loss associated with floods and dam failure, and the appropriate approach for estimating life loss may vary between the dams included in the Program. The BIA SOD Officer will choose the best approach for each dam safety risk assessment.

**Economic Loss**

Recognizing the paramount importance of protecting human life from dam failure, economic consequences will generally not be estimated for BIA dam safety risk assessments. However, if significant economic damages such as the destruction of key structures and/or infrastructure are likely following a dam failure, a qualitative consideration of economic loss may be useful in aiding decision making.

**Cultural Resource Loss**

The failure of a dam could lead to the loss of cultural resources. Such consequences cannot be quantified; however, if the loss of cultural resources is likely following a dam failure, this may be considered as part of the risk-informed decision-making process.

**Other Consequences**

The degree to which other consequences should be considered in dam safety risk assessments should be assessed during the scoping phase on a case-by-case basis.

**4.6 Risk Analysis Calculations**

**Basic Risk Calculations**

**a) *Annualized Failure Probability (AFP)***

The AFP for an individual PFM is obtained by multiplying the individual probabilities for each of node of the event tree together. The AFP may be a discrete value if best estimate values are used throughout the various nodes of the event tree; however, in most cases it will be a range of values based on the range of values estimated for the various nodes. An example calculation is shown in Table 4.1 below.

**Table 4.1**  
**Example Estimate of AFP**

Event Tree Node	Best Estimate
Reservoir Rises	1.0
Erosion Initiates	0.0005
Unfiltered Exit	0.95
Crack not Filled	0.90
Flows not Limited	0.30
Intervention Fails	0.50
Dam Breaches	0.99
<b>AFP</b>	<b>6.3E-05</b>

**b) Annualized Life Loss (ALL)**

The ALL for an individual PFM is calculated by multiplying the AFP by the estimated life loss, as shown below:

$$ALL = AFP \times N$$

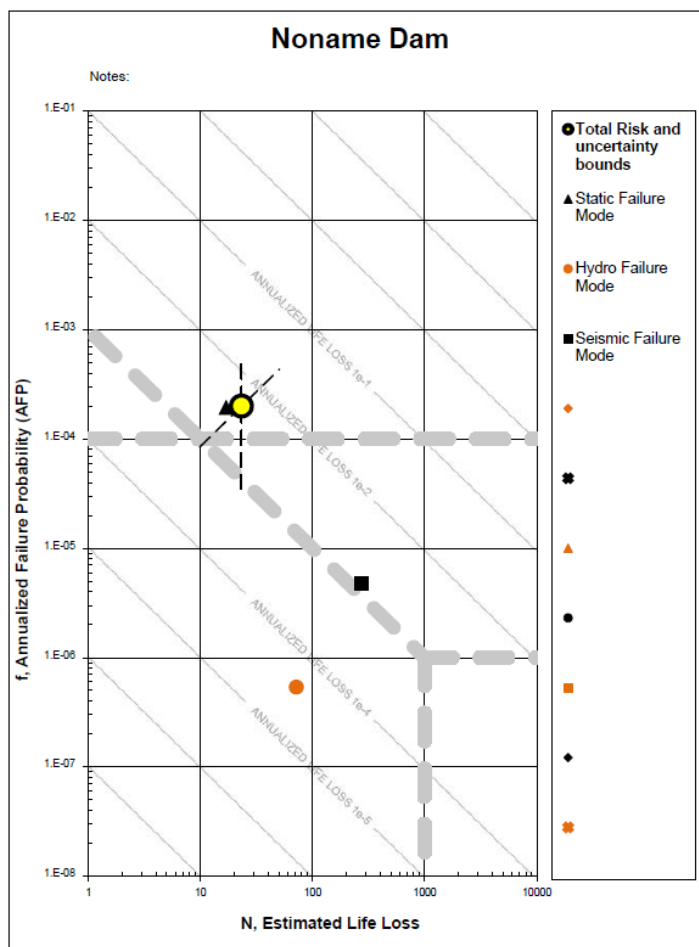
$$(\text{Annualized Life Loss}) = (\text{Annualized Failure Probability}) \times (\text{Estimated Life Loss})$$

The ALL may be a discrete value if *best estimate* values are used for both the AFP and the estimated life loss; however, in most cases the ALL will be a range of values based on the range of values determined for the AFP and/or the estimated life loss.

**c) *f-N Chart***

The best estimate AFP and estimated life loss (*N*) for each individual PFM is plotted on an *f-N* chart, an example of which is shown in Figure 4.2 below. On the *f-N* chart, AFP is the vertical axis, estimated life loss (*N*) is the horizontal axis, and ALL is shown diagonally. In addition, the overall AFP, ALL, and estimated life loss for all of the significant PFMs combined are represented on the *f-N* chart by a large circle. The uncertainty associated with the AFP and ALL is plotted on the chart as vertical and diagonal dashed lines, respectively, which are attached to the large circle.

**Figure 4.2**  
**Sample  $f\bar{N}$  Chart**



## Uncertainty

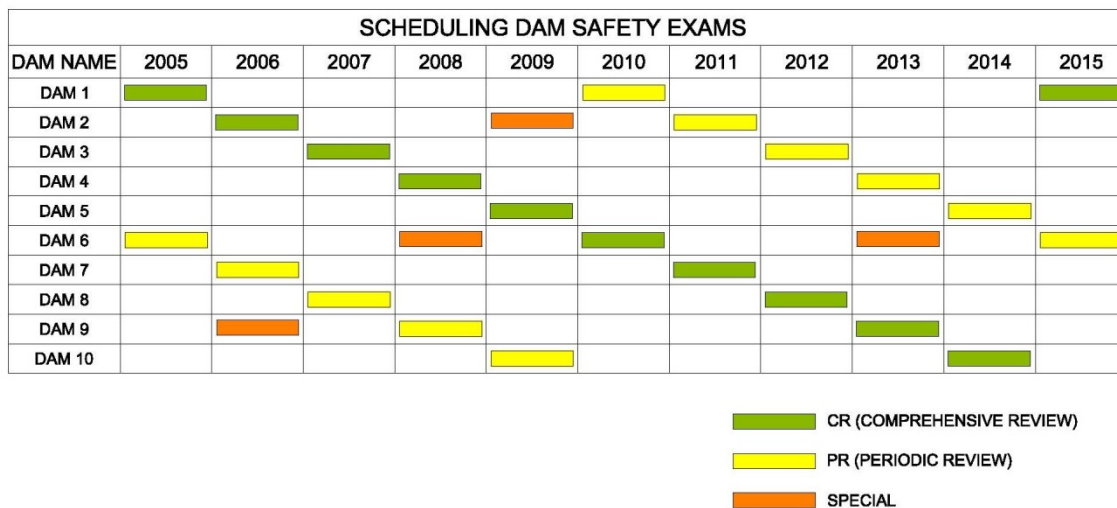
Uncertainty is the result of imperfect knowledge concerning the present or future state of the dam-reservoir system, hazards, factors affecting dam performance, or the magnitude of consequences associated with dam failure. It is important to consider the effect of uncertainty on the risk estimates. Typical sources of uncertainty may include lack of knowledge regarding the dam's construction (e.g., compaction, presence or lack of toe drains, filters, embankment zones, etc.), soil properties, geologic or foundation conditions, and seismic or hydrologic loading, or others. The risk assessment should convey the extent and significance of uncertainty in the technical aspects of the decision process.

## 5 DAM SAFETY EXAMINATIONS AND INSPECTIONS

### 5.1 Overview

In general, on-site dam safety examinations are performed for each Program dam on a recurring basis. In addition, special dam safety examinations are scheduled as appropriate to address specific SOD issues, for normally inaccessible features, or after dam safety modifications. Updates are made to the dam safety examination schedule each year. This schedule identifies the dams and type of examinations that should be performed during that year (see Figure 5.1). Annual inspections are typically performed by the Regional SOD Officer or other selected specialists. Other examinations, such as CR, PR, and post-modification examinations are performed by BIA DSSEM branch personnel or consultants under contract with the BIA. Usually, local tribal and BIA personnel will also attend the examinations.

**Figure 5.1**  
**Generic Dam Safety Examination Schedule**



Routine and non-routine dam safety examinations and reports provide field information on the condition and performance of the dam to support risk management and risk assessments as follows:

- The field examinations provide documentation of the performance of the dam and appurtenant structures under the actual loading conditions, such as seepage behavior under normal reservoir level, hydraulic behavior of the spillway during or immediately after a flood, or structural behavior of the embankment and structures from a recent earthquake.
- The field examinations provide evidence that may point to PFMs, such as evidence of cloudy seepage at the toe of the dam, cracking and deformation of the embankment, or scouring of the spillway discharge channel. Such field evidence may be observed during routine scheduled inspections or during non-routine special examinations.

- The field examinations identify areas requiring improvements in operation and maintenance, such as control of burrowing animals, removal of woody vegetation on the embankment, and replacing deteriorated riprap.
- The CR and PR examinations facilitate review and update of PFMs, consequences, risk estimates, downstream hazard classifications, and emergency management.
- Post-modifications examinations facilitate an update of the pertinent data of the dam, PFMs, residual risk, and the EAP.

Summaries of the recurring and non-recurring program elements within the risk management process for dam safety inspection were discussed previously in this Handbook.

Each field examination performed is documented in an examination report. The level of detail and information vary with the type of examination. The examination reports serve as a valuable record of changing conditions at a dam, provide a review of PFMs, and identify evidence of PFM development. General examination report guidelines for the CR and PR are contained in the BIA “Guidelines for Performing Comprehensive and Periodic Reviews.” Depending on the type of examination performed, the examination reports may contain the following information:

- A discussion of the pertinent features of the dam.
- Conditions on the day of the examination (e.g., reservoir level, outlet works and spillway releases, etc.).
- Inspection checklist of site observations.
- Evaluation of observations and discussions of those observations that are related to PFMs.
- New SOD and O&M recommendations.
- Status of existing SOD and O&M recommendations.
- Color photographs of the observations with captions.
- Discussion of emergency management and preparedness (including EAPs).

Completed dam safety examination reports are sent to the BIA Central Office, Regional SOD Office, and Agency Office, as appropriate. It is essential that the examinations be performed and that the examination reports are completed and distributed as timely as possible in accordance with the schedule. Safety examinations should be performed in accordance with the USBR “Safety Evaluation of Existing Dams Manual” and the BIA “Guidelines for Performing Comprehensive and Periodic Reviews” (for CR and PR examinations).

The BIA performs the following types of dam safety examinations and inspections:

- Initial CR examinations
- CR examinations
- PR examinations
- Annual inspections

- Routine monitoring and observation
- Special examinations
- Post-modification examinations

## **5.2 CR Examination**

The CR is a thorough evaluation of the safety of an existing dam, including a field examination. The results of that field examination are included in the CR report. An Initial CR is performed when the BIA acquires a new Program dam; thereafter, CRs will be scheduled a minimum of once every 10 years. The sections below describe the requirements for performing CR examinations. The overall CR process is discussed in Section 6.2.

### **Initial CR Examination**

An initial CR is performed for dams that are new to the Program. Initial CR examinations are performed in the same manner as recurring CR examinations, with the same report requirements, but with the following differences:

- More field examination time and report time should be allotted to document first-time observations.
- It is possible that inaccessible features such as the outlet works conduit and outlet works intake structures may require future special examinations, and such information may be absent in the Initial CR report.
- There will be no status of previous O&M recommendations in the report.

### **Recurring CR Examination**

A CR examination is scheduled every 10 years. CR examinations are performed by P.E.s experienced in dam inspections. The inspection team includes a Senior Engineer/Team Leader, an Examiner/Inspector, appropriate BIA personnel, and appropriate tribal personnel. A thorough examination of all features of the dam is performed. A copy of the recommended examination checklist is included in the BIA “Guidelines for Performing Comprehensive and Periodic Reviews.” Different examination checklists are used for embankment and concrete dams. Digital photographs are taken to document typical conditions and special observations of the dam and appurtenant structures of the dam.

An Examination Report section is prepared by the Examiner/Inspector and becomes part of the CR Report. The Examination Report section is peer reviewed by an experienced P.E. Further guidance on the CR report is provided in the BIA “Guidelines for Performing Comprehensive and Periodic Reviews.”

### **5.3 PR Examination**

A PR examination is performed for each dam every 10 years, alternating with CRs, so that every five years either a CR or PR is performed. PR examinations are performed by P.E.s experienced in dam inspections, including an Examiner/Inspector, appropriate BIA personnel, and appropriate tribal personnel. A copy of the recommended examination checklist is included in the BIA “Guidelines for Performing Comprehensive and Periodic Reviews.” Digital photographs are taken to document typical conditions and special observations of the dam and appurtenant structures of the dam. A PR report is prepared in accordance with the BIA “Guidelines for Performing Comprehensive and Periodic Reviews.” The PR report must be peer reviewed by an experienced P.E.

### **5.4 Annual Inspection**

The Regional SOD Officer is responsible for ensuring that an adequate inspection of each Program dam is performed annually, except in the year when a CR or PR is scheduled. Annual inspections are performed by personnel trained and experienced in dam safety examinations. A copy of the required inspection checklist is included in the BIA “Guidelines for Performing Comprehensive and Periodic Reviews.” Different inspection checklists are used for embankment and concrete dams. The inspection should assess all aspects of the dam and any concerns or issues found should be promptly reported to the BIA SOD Officer.

### **5.5 Routine Monitoring and Inspection**

Routine monitoring and inspection of each Program dam is performed on a regular basis by the dam operator/dam tender and/or local Agency personnel. The schedule and inspection checklist for this routine monitoring is developed specifically for each dam. A standard Routine Monitoring Checklist (RMC)<sup>11</sup> is provided in Appendix B.

### **5.6 Special Examinations**

Special examinations are performed on an as-needed basis to address a specific issue observed at the dam. Examples of situations which might lead to a special examination include the following:

- Field evidence has been observed which indicates conditions that could potentially lead to the failure of the dam or unsafe operation of the dam. Examples of these conditions include: (1) potentially threatening seepage conditions either in the embankment or along the outlet works conduit, such as large seepage flows, or evidence of material transport; (2) potential embankment instability, including slumps, slides, embankment cracks, or

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<sup>11</sup> For simplification and efficiency of use, the previous Schedule for Periodic Monitoring (L-23) and Ongoing Visual Inspection Checklist (OVIC) forms which were used by the USBR have been combined into a single form for use on BIA dams. The new form is the Routine Monitoring Checklist (RMC), and a standard RMC is provided in Appendix B. The previous L-23 and OVIC forms will be progressively replaced by the streamlined RMC form during the next CR cycle for each dam.

longitudinal cracks; and (3) major equipment problems in the outlet works, which prevent the control of the reservoir level.

- An earthquake has recently occurred near the dam.
- The reservoir has experienced significant inflows, which result in large discharges over the spillway, maximum reservoir surfaces near the crest of the dam, or overtopping of the embankment.

Special dam safety examinations do not address all aspects of the dam and appurtenances; instead they focus only on specific and readily observable concerns and issues. The personnel performing these examinations should have technical expertise commensurate with the nature of the problems. An Examination Report is prepared that is typically consistent with the format and content used in the PR report.

### **Examination of Normally Inaccessible Features**

Some BIA dams have features that are normally inaccessible for visual observation during a routine examination. These features include, but are not limited to:

- Outlet works intake structure under the reservoir.
- Outlet works conduit that is too small for safe entry.
- Toe drain that is too small for entry.
- Outlet works conduit that is underwater.
- Outlet works gatehouse which is unsafe to enter.
- Outlet works or spillway stilling basin that is normally underwater.

Special examinations should be performed to inspect these normally inaccessible features on a regular basis. Inspections of these features must be performed with proper safety provisions, such as confined space entry and/or lock-out tag-out procedures. For conduits less than 36 inches in diameter, it is recommended that conditions be surveyed using Closed Circuit Television (CCTV) equipment. If reservoir drawdown is not practical, then a dive inspection of underwater structures such as outlet works intake structures is required. Outlet works or spillway stilling basins may need to be pumped before inspections are made. An Examination Report is prepared that is typically consistent with the format and content used in the PR report.

### **5.7 Post-Modification Examination**

Dams that have risk-reduction modifications completed to correct verified SOD deficiencies are examined within one year after construction. The reasons for post-modification examination include the following:

- To document the modifications performed at the dam.
- To document the performance of the modified dam while the reservoir is being refilled or has been recently refilled.



- To observe the conditions of the new features or new equipment under operation in the first year.
- To compare the performance of the dam with the expected behavior from the design criteria.
- To identify the level of residual risk remaining after the modification.

Prior to the examination, all of the key design and construction documents are reviewed, as well as the performance data of the dam and reservoir during the initial filling. The post-modification examination is focused on those dam features that have been modified. An Examination Report is prepared that is typically consistent with the format and content used in the PR report.

## 6 DAM SAFETY ENGINEERING

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### 6.1 Overview

The evaluation and analysis activities within the Program provide the engineering basis to identify PFMs, to estimate probabilities of failure in response to various loading conditions, and to design dam modifications to reduce dam failure risks. Dam safety engineering analyses and evaluations are non-routine activities in the Program that provide site characterization data, the basis of assumptions and loading conditions, and details of engineering calculations to support risk management and risk assessments. Examples include the following:

- Collecting geologic, geotechnical, topographic, and hydrologic data to support engineering analysis and evaluations for issue evaluations, risk-reduction conceptual design studies, and risk-reduction final designs.
- Providing a basis to define loading conditions for the PFMs, including normal operating (static), hydrologic, and seismic loading conditions.
- Providing the technical documentation on detailed calculations to evaluate static, hydrologic, and seismic PFMs and potential dam safety deficiencies.
- Formulating and updating PFMs, consequences, risk estimates, downstream hazard classification, and emergency management and preparedness.

### 6.2 Comprehensive Review (CR)

The CR is an intensive and comprehensive evaluation of all dam safety issues for a particular dam performed by a multi-disciplinary team. The CR has replaced the previous Comprehensive Dam Review (CDR). CRs should be performed in accordance with the BIA “Guidelines for Performing Comprehensive and Periodic Reviews.”

Scope of review: A CR includes a thorough review of the design and construction of the dam, and all previous investigations and engineering evaluations. The CR process also includes a site examination, identification of performance parameters, and documentation of the consequences of dam failure. In addition, a screening-level risk analysis is performed for the identified PFMs, resulting in SOD and O&M recommendations.

Risk-informed decisions: A CR includes determination of the need for EAs or modifications to reduce dam safety risk.

Frequency: A CR is typically performed a minimum of once every 10 years.

#### Performance of CRs

Specific guidance for performing CRs is provided in the BIA “Guidelines for Performing Comprehensive and Periodic Reviews.”

## **Post-CR Course of Actions**

If a CR report includes one or more EAs, short-term or interim dam safety actions are needed. Such actions may include temporary breaching, providing additional spillway capacity, instituting a reservoir restriction, or proceeding with an expedited dam modification. The BIA (with tribal consultation) will assess alternatives and decide on the appropriate courses of action. The decision is documented in writing, including signoff by the tribe, BIA Regional SOD Officer, the Superintendent, the Regional Director, and the BIA Central Office SOD Officer. The level of approval should be commensurate with the importance and consequences associated with the decision.

### **6.3 Data Collection**

Data collection is the process of acquiring new field and laboratory data to achieve the following objectives:

- To support IE and other engineering analyses to verify whether a PFM has acceptable or unacceptable risks.
- To provide additional data for identifying and evaluating conceptual design alternatives to reduce risk.
- To provide detailed data needed to support final design of preferred risk-reduction alternatives for a dam.

Field investigations are coordinated with the tribe(s) to minimize cultural, environmental, historical, and access impacts. In addition, all necessary permits and authorizations are secured prior to initiating the investigation. The Program complies with the NEPA, the Historic Preservation Act, the Endangered Species Act, the Clean Water Act, and other applicable statutes and regulations. Project-specific evaluations and assessments are also performed to determine the appropriateness of a Categorical Exclusion (CX), Environmental Assessment, or an Environmental Impact Statement (EIS).

### **Representative Data Collection Work**

The following sections outline representative types of data collection efforts that are used to support dam analysis, risk assessments, and risk-reduction design work in the Program. The need and scope for each activity should be determined on a case-by-case basis for each project. Data collection field work requires tribal permits, communication, and collaboration.

#### Geologic Reconnaissance

A field geologist observes exposed geologic conditions in the areas of dam foundations and abutments, the reservoir rim, and potential borrow areas. Field measurements of exposed geologic features are made to prepare a geologic map. This work is considered non-intrusive, and does not involve any excavations or boreholes. The deliverable is typically a geologic report that should include the following information:

- Description of the regional and site geology.
- Identification of geologic hazards, including local and regional faulting, landslides, and ground subsidence.
- Site geologic map showing geologic units and any structural geology data (strikes and dips of bedrock discontinuities) of the dam, reservoir, and borrow areas measured during field reconnaissance.
- Assessment of suitability of potential borrow areas for project needs.
- Recommendations for subsurface exploration to supplement surface geology information, if appropriate.

### Drilling Exploration

Drilling boreholes into the ground is one method of exploring the subsurface conditions for engineering purposes. There are many reasons for drilling exploration, including:

- Investigating the subsurface conditions in a dam, foundation, abutments, or potential borrow areas.
- Obtaining soil and rock samples for classification and laboratory testing of engineering properties.
- Performing field testing in the boreholes, such as Standard Penetration Testing (SPT), field permeability, down-hole geophysical testing, and field deformation.
- Installing dam instrumentation such as piezometers, observation wells, and inclinometers.

Drilling exploration should be performed in general conformance with the USBR “Earth Manual.” All field work should follow the safety requirements in the USBR “Drilling Safety Manual.” The selection of the method of drilling should be determined based on project requirements. However, special care should be used in drilling into an existing embankment dam to prevent hydro-fracturing and damaging the embankment. The drilling into an existing embankment dam should comply with the guidelines from the USBR “Guidelines for Drilling and Sampling in Embankment Dams.” In general, all boreholes into an existing embankment dam and the underlying foundation should be supported, such as with steel casings, augers, drilling mud, or other approved methods. Drilling of boreholes should be observed and logged continuously by a qualified geologist or geotechnical engineer. All boreholes should be backfilled with a cement grout upon completion, unless the boreholes will be used as dam instrumentation. At the completion of drilling, the locations of all boreholes should be surveyed.

The deliverable for a drilling exploration program is a geotechnical investigation report that should include the following information:

- Location plan of boreholes.
- Description of method of drilling, sampling, and field testing.
- Description of subsurface conditions, field observations, and any problems during drilling.

- Evaluation of subsurface conditions relative to the objectives of the investigation.
- Detailed field logs and simplified drill logs with a legend.
- Results of all field test data, such as SPTs, field permeability, etc.
- Results of all laboratory test data.
- Installation reports for any dam instrumentation such as piezometers and inclinometers.
- Conclusions and recommendations.

### Test Pit Exploration

Excavating open test pits or test trenches is another method of subsurface exploration for engineering purposes. Reasons for test pit exploration include:

- When exploratory boreholes are too small to observe the subsurface features such as overall stratifications of soil and rock deposits, shear and fault zones, sources of seepage, etc.
- Exposing a large cut face for evaluation in a test fill program.
- When large bulk samples are required in a borrow investigation for laboratory testing such as compaction.
- When test pits are more convenient than drilling boreholes.

Test pit excavation should be continuously observed and logged by a qualified geologist or a geotechnical engineer. Test pits deeper than four feet should not be entered without adequate shoring. Upon completion, all test pits should be backfilled to their original ground surface. In a borrow investigation study, the materials excavated from the ground can be used as backfill, and compaction of the backfill is not required. However, backfill in an existing embankment fill should be properly compacted, including any provisions to restore different earthfill zones to the original configuration. The locations of all test pits should be surveyed at completion.

The deliverable for a test pit exploration program is a geotechnical report that includes the following information:

- Location plan of all exploratory test pits.
- Description of method excavation and backfill.
- Description of subsurface conditions, including other field observations such as trench wall stability, groundwater inflow, etc.
- Evaluation of subsurface conditions relative to the objectives of the investigation.
- Detailed field logs and simplified logs with a legend.
- Results of any field testing, such as field densities.
- Results of all laboratory test data.
- Conclusions and recommendations.

## Borrow Investigation

A borrow investigation is a field study to explore potential sources of on-site material sources for dam modification construction. The types of materials that can be borrowed on site may include:

- Earth materials to be used for embankment fill core and shell zones.
- Clean sand and gravel materials that can be processed as filter and drain materials.
- Rock sources that can be used as riprap.
- Rock quarries to provide concrete aggregates for cast-in-place concrete or roller compacted concrete.

A thorough borrow investigation may include geologic reconnaissance, drilling, test pits, and associated laboratory and field testing. In some cases, test blasting may be required to explore riprap sources and concrete aggregate sources. The size and scope of a borrow investigation program is determined based on specific project requirements. The deliverable for a borrow investigation is a borrow investigation report that includes the following information:

- A location plan of potential borrow sources.
- Method(s) of exploration such as boreholes and test pits, and their plan locations.
- Field and laboratory test data.
- Evaluation of the suitability of potential borrow materials and estimated available quantities.
- Construction and environmental considerations to develop these sources.
- Conclusions and recommendations.

## Indirect Investigation Methods

In contrast to subsurface investigation methods such as boreholes and test pits that involve determining subsurface conditions by collecting samples, indirect methods allow subsurface conditions to be investigated without obtaining samples. These methods may include the Cone Penetration Test (CPT), seismic refraction, seismic reflection, electrical resistivity, or other methods. Such indirect methods have the advantage of being capable of providing subsurface information very rapidly and potentially less costly than drilling or test pits, but there are also limitations. For dam safety investigations, indirect investigation methods may be used for:

- Determining geologic structure, such as top of bedrock, or stratigraphic boundaries of different layers.
- Developing a continuous subsurface profile.
- Determining excess pore pressures, CPT tip resistances, and shear wave velocities for use in liquefaction analyses.
- Locating subsurface features such as voids, buried pipes, and channels.
- Determining depth to groundwater or sources of seepage.

Indirect methods are most useful when they are combined with other, more direct methods of subsurface exploration such as boreholes and test pits.

### Topographic Survey

Topographic surveys are typically performed for the following purposes:

- To obtain a topographic base map of the dam, reservoir, and the vicinity for dam safety analysis, design, and construction of dam modifications.
- To locate features of data collection such as boreholes, test pits, borrow areas, wetland limits, etc.
- To install bench marks and survey baselines for dam instrumentation monitoring and construction survey controls.
- To measure configurations of existing structures such as outlet works, spillways, and diversion inlet and outlet canals.
- To measure ground cross sections and key structure elevations downstream of the dam for hazard classification analysis, dam breach inundation analysis, and preparation of inundation maps.

The method and accuracy of the survey is based on the size of the site and project requirements. The deliverable for a topographic survey is a topographic map. A topographic map suitable for design and construction of dam modifications should contain the following information:

- New on-site survey control points with vertical datum referenced to the National Geodetic Vertical Datum, and the horizontal datum referenced to state plane coordinates.
- Topographic contours either in 1- or 2-foot contours, depending on the topographic relief.
- A topographic map prepared in both hard copy and electronic format.
- Key existing features of the dam and appurtenances, such as limits of trees, riprap, dam instrumentation, spillways, outlet works, inlet and outlet conveyances, sinkholes and depressions, exposed utilities, wetland limits, etc.

### Laboratory Testing

Laboratory testing is typically performed for the following purposes:

- To obtain index properties of soil and rock samples to support field descriptions observed in a drilling or test pit exploration.
- To obtain index and engineering properties of the embankment, foundation, and borrow materials for geotechnical analysis and design.
- To evaluate the suitability of concrete aggregates and to obtain concrete design strength data.
- For quality assurance testing of the earthwork and concrete during construction.

The types and scope of laboratory tests are determined based on project requirements. Laboratory tests should be performed in accordance with methods and procedures in the American Society for Testing and Materials (ASTM) or other appropriate standards. Results for these tests should be included in the field investigation report, borrow investigation report, design report, or construction report, depending on the purpose of the testing.

#### **6.4 Static Design Loading Conditions**

The static design loading conditions are generally associated with the normal loading conditions, such as the normal reservoir pool. The hydrostatic load under a normal pool is used to analyze slope stability of the embankment, seepage conditions in the dam and foundation, sizing of the internal filters and drains, and design of hydraulic structures.

#### **6.5 Hydrologic Design Loading Conditions**

The hydrologic loading condition for the analysis of existing dams, design of dam modifications, and new dams is the Inflow Design Flood (IDF). In general, the IDF is the flood with a return frequency of 10,000 years. However, factors such as the population at risk, emergency management, proximity to structures, cultural resources, and operations could result in a larger flood being selected.

For risk-reduction designs, risk analysis can be performed to reduce the IDF below the 10,000-year flood, if it can be demonstrated that the calculated risk under the hydrologic loading conditions is below the guidelines for risk reduction.

#### **6.6 Seismic Design Loading Conditions**

The seismic loading condition for the analysis of existing dams and design of dam modifications and new dams is the design earthquake. In general, for BIA dams with life loss potential, the design earthquake is the probabilistic seismic hazard with a return frequency of 10,000 years. However, factors such as the population at risk, emergency management, proximity to structures, cultural resources, and operations could result in a larger design earthquake being selected.

For dams located in regions with low historic seismicity, a minimum seismic horizontal ground acceleration of 0.05g is used.

For risk-reduction designs, risk analysis can be performed to reduce the design earthquake below the 10,000-year return period if it can be demonstrated that the calculated risk under the seismic loading conditions is below the guidelines for risk reduction.

#### **6.7 Engineering Analyses of Geologic/Geotechnical Issues**

##### **Slope Stability Analysis**

The static stability of an embankment dam is determined by slope stability analysis. Results of the stability analysis are used to evaluate the PFM's associated with the static slope stability of



the dam embankment and foundations. The analysis is performed in conformance with the USBR “Design Standard No. 13, Embankment Dams,” Chapter 4: Static Stability Analysis or similar accepted standards. Representative cross sections of the embankment and foundations are typically analyzed using computer-aided methods, under the following loading conditions:

- Steady-state seepage condition: This loading condition corresponds to the long-term condition with the internal phreatic surface in the embankment fully developed and stabilized under the normal reservoir pool.
- Rapid drawdown condition: This loading condition should be analyzed for the upstream embankment slope if the outlet works is capable of lowering the reservoir faster than 0.5 foot per day.
- End of construction: This loading condition corresponds to the short-term condition in the embankment and foundation at the end of construction, either for risk-reduction modifications or new dam construction. The reservoir pool and phreatic surface under end of construction are determined on a case-by-case basis.

Properly selected material properties of the embankment and foundation should be used in the analysis for the different loading conditions. In general, the shear strengths (both drained and undrained) should be selected based on the rate of loadings, laboratory strength tests, field data, empirical correlations, and/or judgment and experience. The basis of the analyzed cross sections and selection of material properties for the analysis should be documented in a technical memorandum or report.

### **Seepage Analysis**

Seepage analysis is performed to evaluate seepage-related PFMs of the embankment and foundation, and to obtain data for design of seepage control and seepage reduction provisions such as cutoffs, filter, and drains. The analysis should be performed in conformance with the USBR “Design Standard No. 13, Embankment Dams,” Chapter 8: Seepage and Chapter 5: Protective Filters, or similar accepted standards, and typically includes the following:

- Determining internal hydraulic gradients and exit hydraulic gradients from seepage flows in the embankment and foundation.
- Determining the phreatic surface and piezometric pressures in saturated flow zones.
- Determining potential uplift pressures.
- Determining quantities of flows.
- Evaluating and designing seepage cutoffs, seepage barriers, filters, and drains.
- Evaluating filter compatibility and piping potential in the embankment and foundation in saturated flow zones.

Seepage analysis can be performed using computerized numerical methods. In some simple cases, hand-drawn flow nets are an acceptable graphical method. Regardless of the method of analysis, reasonable material parameters should be used, typically supported by laboratory data such as gradation curves and Atterberg Limits to the extent possible.

## Seismic Analysis

Seismic analysis should be performed to evaluate the seismic performance of the dam and foundations during the design earthquake. This seismic analysis should comply with the requirements of USBR “Design Standard No. 13,” Chapter 13: Seismic Design and Analysis or similar accepted standards. Typical seismic analyses include:

Susceptibility to liquefaction: The embankment fill and foundation soils should be evaluated for liquefaction susceptibility during the design earthquake. Potentially liquefiable soils should be identified based on design and construction records, subsurface investigations, laboratory data, and other evidence. In addition, the continuity of potentially liquefiable materials should be determined.

Post-earthquake stability analysis: A slope stability analysis should be performed on dams containing potentially liquefiable embankment and/or foundation materials, or other materials which may experience significant strength loss during an earthquake (e.g., clay or clayey materials). The post-earthquake analysis is a static analysis using estimated residual undrained shear strengths. The post-earthquake residual strengths should be suitably selected to include the loss in shear strengths caused by the earthquake shaking.

Seismic deformation analysis: A seismic deformation analysis should be performed to evaluate permanent deformations of the embankment. Such an analysis is appropriate even when the embankment and foundation would not liquefy sufficiently or otherwise experience sufficient strength loss to cause slope instability. Large seismic deformations may impair safe operation by causing a loss of freeboard which could allow the reservoir to overtop the dam, creating cracks in the dam that would lead to internal erosion, or damaging appurtenant structures.

## 6.8 Engineering Analysis of Hydrologic/Hydraulic Issues

### Estimating the IDF

The IDF is used to evaluate the adequacy of spillway(s) and appurtenant structures. The IDF estimate is typically determined through one of the following methods:

- simplified methods;
- flood frequency analysis of stream gauge data; or
- rainfall runoff analysis.

Simplified methods may include the use of regression equations or envelope curves developed for the region where the dam is constructed. In this case, Annual Exceedance Probabilities (AEPs) are assigned to peak discharge estimates, which are then plotted on a probability graph. The 10,000-year flood peak discharge can then be extrapolated from the graphical data. The simplified methods are often used in ungauged drainage areas and require minimal effort. Analysis based on regional regression equations should consider applicable basin characteristics and the range of confidence limits associated with the equation. Since regression equations can have a large range of confidence limits and do not account for site-specific conditions, the selection of the IDF should generally be conservative.

Flood frequency analysis of stream gauge data is a procedure for computing the AEPs from observed discharge values. Flood frequency analysis can be performed either graphically or numerically using statistical models. The 10,000-year flood peak discharge can then be extrapolated from the flood frequency analysis results. Flood frequency analysis results are site-specific. The type of data and the record length used in the analysis form the primary basis for establishing a range for credible extrapolation of flood estimates. Flood frequency analysis should be performed in conformance with the USBR “Design Standard No. 14,” Chapter 2: Hydrologic Considerations, USACE “Engineering Manual 1110-2-1415, Hydrologic Frequency Analysis,” or similar accepted standards.

Rainfall-runoff analysis is a method where a flood hydrograph is generated by simulating precipitation events and the drainage basin hydrologic and hydraulic processes. IDF estimates using this method represent a severe combination of meteorologic and hydrologic conditions that are considered reasonably possible for a given drainage basin. Rainfall-runoff analysis typically requires the development of several hydrologic parameters, including precipitation depths and distribution, physical basin characteristics, basin unit hydrographs, antecedent conditions, infiltration and other losses, stream baseflow, and stream routing methods. Where possible, rainfall-runoff parameters should be calibrated and verified with historical flood data. Precipitation data can be developed from several sources including site-specific precipitation frequency analysis, National Oceanic and Atmospheric Administration’s (NOAA) National Weather Service documents, or site-specific probable maximum precipitation studies performed by a qualified hydrometeorologist. Rainfall-runoff analysis shall consider snowmelt in areas that are subject to significant snowpack, and rainfall-generated floods that are influenced by snowmelt. Rainfall-runoff analysis shall be performed in general conformance with the USBR “Flood Hydrology Manual,” USACE “Engineering Manual 1110-2-1417,” “Flood Runoff Analysis,” or similar accepted standards.

An incremental flood hazard assessment (IFHA) can be performed to reduce the IDF below the 10,000-year flood in situations where the consequences of dam failure at lesser flood flows are acceptable. An IFHA is acceptable if the analysis can demonstrate no additional life loss or significant property damage exists between a base flow flood and a dam failure flood. The base flow flood is defined as a flood of minimum magnitude (less than the 10,000-year flood) which results in no additional downstream damages without failure of the dam. The dam failure flood is defined as the flood produced by failure of the dam during the base flow flood. In general, the consequences of failure are considered acceptable when the incremental effects of failure on downstream structures are approximately 2 feet or less. However, the 2-foot increment is not an absolute decision-making point. Sensitivity analyses and engineering judgment should be used in making final decisions about the appropriate IDF. Incremental flood hazard assessment should be performed in general conformance with the USBR “ACER Technical Memorandum No. 11,” FEMA “Federal Guidelines for Dam Safety,” FEMA “Selecting and Accommodating Inflow Design Floods for Dams,” or similar accepted standards. The IDF is typically not reduced to lower than the 100-year flood.

For risk-reduction designs, risk analysis can be performed to reduce the IDF below the 10,000-year flood if it can be demonstrated that the calculated risk under the hydrologic loading conditions is below the guidelines for risk reduction.

### **Reservoir Routing of IDF**

Reservoir routing of the IDF is used to determine maximum reservoir water surface elevations and reservoir outflows. Reservoir routing requires accounting for volumes of inflow, storage, and reservoir discharges. The reservoir should be assumed to be full at the beginning of the IDF, with the initial reservoir level at the normal maximum pool elevation or uncontrolled spillway crest elevation. The level-pool reservoir routing method is typically used to determine the time-dependent pool elevations. However, in some cases, dynamic channel routing may be appropriate to account for variations in pool levels along the reservoir length.

Reservoir routing requires the use of a reservoir elevation-storage table and elevation-discharge table(s). Reservoir elevation-storage tables should be based on the best available topographic data or recent bathymetric surveys. Any loss of storage from sedimentation should be accounted for. The reservoir elevation-storage table should include elevations above the normal maximum pool to account for flood surcharge. Reservoir elevation-discharge tables should account for all applicable spillways and release facilities (e.g., outlets, powerhouse, etc.). However, only the uncontrolled spillway(s) and release facilities are allowed to be used to route the IDF through the reservoir. In cases where the reservoir outflow exceeds the spillway(s) discharge capacity, the dam crest should be included in estimating overtopping depths and durations.

### **Spillway Hydraulics and Discharge Capacity**

Discharge capacity of a spillway is determined by hydraulic analysis using manual or computer-based computation methods. Results of the hydraulic analysis are used to develop an elevation-discharge relationship for the spillway(s). The elevation-discharge relationship for the spillway(s) is used in routing the IDF through reservoir to determine the resulting maximum pool elevation. The hydraulic analysis should be performed in conformance with the USBR “Design of Small Dams,” Chapter 9: Spillways, USACE “Engineering Manual 1110-2-1603,” “Hydraulic Design of Spillways,” or similar accepted standards. Hydraulic analysis of spillways typically includes the following:

- approach conditions;
- crest discharge coefficient(s), accounting for crest submergence;
- abutment and pier effects;
- gate operations and obstructions (if applicable);
- hydraulic and energy grade lines;
- flow regimes (critical, subcritical, supercritical, and transitions);
- chute hydraulics;
- terminal structures; and

- tailwater conditions.

Spillway chute analysis should consider the velocity and depth of flow, air entrainment of the flow, pier and abutment waves, floor and wall pressures, superelevation of the flow surface at curves, and standing waves due to the geometry of the chute. Terminal structure analysis should consider site-specific requirements, the magnitude of energy to be dissipated, and the duration and frequency of spillway use. The hydraulic analysis of terminal structures should be performed in conformance with the USBR “Engineering Monograph No. 25,” “Hydraulic Design of Stilling Basins and Energy Dissipators,” or similar accepted standards.

Hydraulic analyses of spillways can be performed using computerized numerical methods. The basis and results of the hydraulic design and selection of design parameters for the analysis are documented in a technical memorandum or report.

### **Outlet Works Hydraulics and Discharge Capacity**

Discharge capacity of an outlet works is determined by hydraulic analysis using manual or computer-based computation methods. Results of the hydraulic analysis are used to develop an elevation-discharge relationship for the outlet works for reservoir control operations and for evacuation analysis. Hydraulic analysis of flow through outlet works should consider two flow conditions: (1) open channel flow in a conduit and (2) pressure flow when the conduit is flowing full. The hydraulic analysis of outlet works should be performed in general conformance with the USBR “Design of Small Dams, Chapter 10: Outlet Works,” USACE “Engineering Manual 1110-2-1602,” “Hydraulic Design of Reservoir Outlet Works,” or similar accepted standards.

Hydraulic analysis of the outlet works should include the following:

- control crest and orifice discharge coefficient(s);
- friction losses;
- minor losses;
- control device losses and discharge coefficients;
- hydraulic and energy grade lines;
- air vents and cavitation;
- terminal structures; and
- tailwater conditions.

Air vents should be included in all outlet works that utilize control devices and are subject to sub-atmospheric pressure. An air vent is required for each control device. The analysis of outlet works air vents and air-water flow should be performed in conformance with the USBR “Engineering Monograph No. 41,” “Air-Water Flow in Hydraulic Structures,” or similar accepted standards.

Terminal structures should be included for all outlet works that have the potential for high velocity discharges. Hydraulic analysis of outlet works terminal structures or energy dissipaters

are generally dependent upon site-specific conditions and the magnitude of energy to be dissipated. The hydraulic analysis of outlet works terminal structures should be performed in conformance with the USBR “Water Resources Technical Publication No. 24,” “Hydraulic Design of Stilling Basins for Pipe or Channel Outlets,” FEMA “P-679 Technical Manual: Outlet Works Energy Dissipators,” or similar accepted standards.

Hydraulic analysis of outlet works can be performed using computerized numerical methods. The basis and results of the hydraulic design and selection of design parameters for the analysis is documented in a technical memorandum or report.

### **Reservoir Evacuation**

Reservoir evacuation analysis is performed to evaluate whether an outlet works is sized adequately to draw down the reservoir within prescribed time periods in the event of emergencies to reduce failure risk. The outlet works should be sized to meet the evacuation requirements outlined in USBR “Technical Memorandum ACER No. 3.” Specifically, the outlet works should be sized to meet both of the following evacuation requirements:

- Ability to lower the top 5 feet of the reservoir in 5 days.
- Ability to lower the top 50 percent of the normal storage volume in 7 days.

For the evacuation analysis, an appropriate outlet works discharge rating curve should be used, depending on the anticipated conditions and reservoir operation.

### **Freeboard and Wave Runup**

The anticipated wave runup should be determined for BIA dams to evaluate the available freeboard for a dam, and to size riprap for wave erosion protection on the upstream slope of the embankment. Guidance on estimating wave runup and recommended freeboard is provided in the USBR “Design of Small Dams Manual.”

Wave runup is influenced by several factors, including wind velocity and duration, wave height and velocity, wind direction with respect to the dam’s orientation, reservoir depth, fetch length, and the characteristics of the upstream face (i.e., slope and type of protection on the upstream face). The basis and results of the wind wave setup and runup and selection of wind properties for the analysis is documented in a technical memorandum or report.

### **Breach Modeling**

Breach parameters are a critical component in hazard classification for a dam is the estimation of dam breach parameters and development of the associated breach outflow hydrograph. Breach parameters should include the parameters needed to physically describe the breach (e.g., breach depth, breach width, and side slope angles) as well as the parameter that defines the time required for the breach formation. Key breach parameters are briefly summarized below and shown on Figure 6.1.

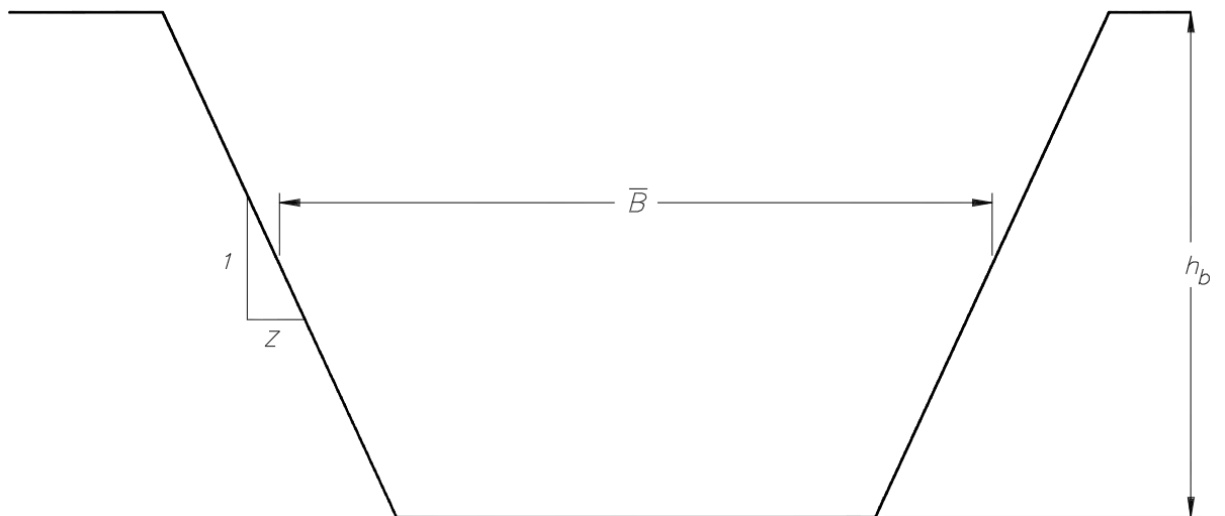
Breach depth,  $h_b$ : This is the vertical extent or height of the breach, measured from the dam crest down to the invert of the breach.

Breach width,  $B$ : Typically reported as the average breach width or the breach width at the top and bottom of the breach opening.

Breach side slope,  $z$ : Typically reported as the horizontal component of the breach side slope.

Breach formation time: The breach formation time (also referred to as time to failure or breach development time) is the duration of time between the first breaching of the upstream face of the dam until the breach is fully formed.

**Figure 6.1**  
**Definition of Breach Parameters**



The selection of final breach parameters used for inundation maps should be based on engineering judgment and site-specific conditions.

### **Downstream Hazard Potential Classification**

A dam's downstream hazard potential classification is a classification of the potential adverse incremental consequences on downstream property and lives that result from the release of water or stored contents due to failure of the dam or mis-operation of the dam or appurtenances. Dams are categorized into one of the following three categories, as illustrated in Table 6.1 and defined by the IDSA and FEMA 333:

1. High-hazard potential dams
2. Significant-hazard potential dams
3. Low-hazard potential dams

Only high- and significant-hazard potential dams are administered as part of the Program.

**Table 6.1**  
**Downstream Hazard Potential Classification Definitions**

<b>Downstream Hazard Potential Classification</b>	<b>Definition</b>
High-Hazard Potential	Probable loss of one or more lives expected; or extensive economic, environmental, or lifeline losses
Significant-Hazard Potential	No expected loss of human life; but significant economic, environmental, cultural assets and resources, or lifeline losses are expected
Low-Hazard Potential	No expected loss of human life; and limited expected economic, environmental, or lifeline losses

Downstream Hazard Potential Classification Studies have been completed for the vast majority of BIA dams. A key component of routine BIA dam inspections is to confirm that the current downstream hazard potential classification for the dam remains appropriate. If at any time the Regional SOD Officer believes that development downstream of a BIA dam has changed, the procedures provided in Handbook Section 8.6, Downstream Hazard Potential Classification Study, must be followed.

### **6.9 Engineering Analysis of Civil/Structural Issues**

Structural analyses of appurtenant structures and concrete gravity dams should be performed to evaluate the internal stresses, sliding stability and overturning stability under usual, unusual, and extreme loading combinations. In general, structural analysis of appurtenant structures and concrete gravity dams should comply with the USBR “Design of Small Dams,” or similar accepted standards. The determination of usual, unusual and extreme loading combinations is based on the static, hydrologic, and seismic loading conditions, as follows:

Usual loading combinations: Hydrostatic load at normal reservoir level, with appropriate dead loads, uplift pressures, sediment, ice, and tailwater.

Unusual loading combinations: Hydrostatic load at maximum reservoir level during the IDF, with appropriate dead loads, uplift pressures, sediment, and tailwater.

Extreme loading combinations: Usual loadings plus the effects of the design earthquake, including hydrodynamic load of the reservoir, and horizontal and/or vertical pseudo-static components of the dead loads.



## **7 RISK REDUCTION**

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### **7.1 Overview**

Risk reduction takes many forms inside the Program and may include expedited or interim actions such as operational and storage restrictions, EWS installation, increased monitoring and observation, and/or temporary or permanent structural modifications to reduce the risks of dam failure. Once a decision has been made to take action, a series of activities are initiated, which may include data collection, conceptual design, final design, and construction.

### **7.2 Expedited and Interim Actions**

When a potential dam safety deficiency is identified, expedited or interim actions may be warranted. Such actions may include breaching, siphons, providing additional spillway capacity, temporary filters and drains, reservoir restrictions, EWS installation, or other actions. When the condition of the dam warrants a short-term or interim action (that is, an EA or other response to serious condition), alternatives are developed and evaluated by a SOD team typically consisting of the Regional SOD Officer, the BIA SOD Officer, and appropriate technical specialists.

If an operational restriction is the appropriate course of action, the Regional SOD Officer will notify the Regional Director, Agency Superintendent, and/or Tribal Government. The Regional SOD Officer will document the implementation of the operational requirement or restriction. All operational changes, restrictions, or modifications should be integrated into the EAP.

### **7.3 Design Guidelines**

Conceptual and final designs for risk reduction should be conducted in accordance with current best practices. For reference, selected design guidelines are listed below:

“Design Standard No. 13, Embankment Dams,” Chapter 8: Seepage (USBR, 2011) and “Filters for Embankment Dams” (FEMA, 2011).

“Design of Gravity Dams” (USBR, 1976). General design guidelines for concrete arch dams shall meet the requirements of “Design of Arch Dams” (USBR, 1977).

“Roller compacted concrete (RCC) dams design.” RCC gravity dams shall meet the general requirements of “Design of Gravity Dams” (USBR, 1976). In addition, RCC design shall meet the general guidelines of “Design Manual for Small RCC Dams” (Portland Cement Association, 2003), and “Manual EM 1110-2-2006” (USACE, 2000).

### **7.4 Conceptual Design**

Conceptual designs are intended to develop, evaluate, and present alternatives to resolve or mitigate SOD deficiencies. During conceptual design, a preferred alternative is selected based on the available information. This may include an assessment of risk, engineering analyses, and an evaluation of the alternatives. The design criteria for conceptual designs are based on current

industry standards and Program policies. All viable alternatives for resolving and mitigating potential dam safety deficiencies are investigated and documented in a Conceptual Design Report.

Risk-reduction alternatives are investigated and documented during conceptual designs. The Conceptual Design Report should present sufficient information on all viable alternatives, including drawing layouts of each concept, proposed construction schedule, key permitting issues, constructability considerations, and conceptual-level cost estimates to enable selection of a preferred alternative for development of final designs. The conceptual designs are developed to define the initial alternatives that will be evaluated during the NEPA process and environmental impacts are addressed in the NEPA compliance document. NEPA compliance may be initiated during this phase of the design process. A VE study, if required, is typically completed during conceptual designs. The results of the VE study should be integrated into the final design.

Key steps in the conceptual design study may include the following:

- Establishing design criteria and loading conditions.
- Formulating and evaluating various modification design alternatives, including design analysis.
- Acquiring field and laboratory test data, as required, to support design alternatives.
- Performing risk-reduction analysis to document that the modifications adequately reduce the risk of dam failure for the identified PFMs.
- Preparing conceptual design drawings and cost estimates for the alternatives.
- Discussing and evaluating the advantages and disadvantages of alternatives.
- Recommending a preferred alternative for final design.
- Preparing a Conceptual Design Report, which documents the design criteria, basis of design, evaluation of alternative concepts, discussion of advantages and disadvantages, risk-reduction analysis, construction cost estimate, and conclusions and recommendations.
- Completing an independent technical review of the conceptual design.
- Performing a VE study, if the estimated construction cost of the modifications exceeds \$2 million.

## **7.5 Construction Cost Estimates**

Construction costs vary based on numerous factors. Because of this cost variation a 5 to 25 percent contingency is typically included in the construction budget. The actual contingency depends on the uncertainties and risk for each particular project.

## **7.6 Independent Technical Reviews**

In accordance with the “Federal Guidelines for Dam Safety,” an independent technical review (ITR) is required for every dam modification or construction project where failure of the

modified or completed dam would result in a significant threat to life or property. The review should be conducted by qualified engineers and other technical experts who are not involved in design of the project. The ITR reviewer(s) should remain involved throughout construction of the project to the extent possible.

ITRs should achieve the following objectives:

- Ensure that all options have been adequately considered and the appropriate solution adopted.
- Evaluate the technical feasibility and identify any fatal flaws of alternative concepts.
- Assess whether the designer has adequately characterized the project site.
- Identify any problems with constructability of proposed construction methods.
- Identify any construction risks associated with construction safety, potential for claims, disputes, and delays.
- Review the estimated construction costs to determine whether they are appropriate.

ITR comments should be responded to by the designer in writing. All review comments should be satisfactorily addressed before finalizing the construction documents. During construction, the ITRs should be engaged and available for consultation to the extent possible.

## **7.7 Value Engineering (VE)**

For risk-reduction modifications that will have an estimated construction cost more than \$2 million, the BIA requires that a VE study be performed. VE is the process of identifying potential cost savings on a particular design feature while meeting the same technical criteria, intent and project objectives used for design of the project. It is important that VE ideas are compared with the original design features (i.e., the baseline). VE studies must meet the requirements of the DOI “Department Manual,” Part 369: Value Analysis, and may be performed in accordance with the USBR “Value Program Handbook” or similar accepted standards. When tribes elect to procure design and construction through Self-Determination (P.L. 93-638), a VE study will be performed for projects with an estimated construction cost of more than \$2 million.

VE studies are performed near the end of conceptual design and prior to the start of final design. Each design concept or alternative is evaluated to identify potential cost savings to the project. The results of the VE study are documented in a report by the review team, and the designer is required to respond to the recommendations given in the report. An accountability report by the designer is prepared prior to initiation of final design, and VE recommendations accepted by the designer should be used in the final design.

Specific steps in the VE study include:

1. Presentation of the conceptual design concepts by the designer to the VE team.
2. Identification and evaluation of VE ideas by the VE team.
3. Preparation of the VE report, and presentation of the VE ideas to the designer.
4. Preparation of the accountability report by the designer on VE recommendations.

## 7.8 Final Design

Final design is the process of preparing construction documents for the preferred alternative. The final design alternative should incorporate the results of the VE study, if one was performed. At the start of final design, additional field and laboratory data may need to be collected to supplement the existing data from previous studies. Required NEPA compliance permitting activities, as well as obtaining other permits (including tribal permits) should be completed during this phase of the work effort, and prior to award of the construction contract.

The construction documents to be prepared during final design include construction drawings, technical specifications, and a bid schedule with bid quantities. A Design Summary report should be completed prior to bidding to document the basis of the design. In addition to the Design Summary, separate Technical Memorandums (TMs) should be completed prior to bidding in order to document the results of the various studies and analyses that were performed during conceptual and final designs. For example, such TMs may include reports on hydrology and geology/geotechnical data, filter analysis and design, slope stability, seismic analyses, etc. BIA projects require that all bidding, award, and contract documents comply with current Federal Acquisition Regulations (FAR), and other applicable laws and regulations. Projects completed through Self-Determination contracts (P.L. 93-638, 25 CFR 900, Subpart J – Construction) should comply with applicable tribal contracting documents.

Typical construction documents prepared during final design include the following:

Bid schedule: The bid schedule is used to solicit prices from construction contractors, and should be established early in the final design process, and then refined and completed during the course of the design. The bid schedule should include a list of all paid items, estimated quantities, and units. Measurement and payment provisions of the bid items should be included in the technical specifications, and coordinated with the bid items. Bid options or bid alternatives may be incorporated into the bid schedule, when appropriate, to obtain additional bid data prior to awarding the contract.

Construction drawings: The construction drawings contain graphical requirements used by the construction contractor to build the dam modifications, and are closely coordinated with the technical specifications. Generally, the construction drawings are developed in three submittals:

- 30-percent design includes all plans and typical sections of key design features.
- 90-percent design includes all substantially completed key design features and is intended for BIA review.
- 100-percent design is the final drawing which is complete and addresses all BIA review comments.

The actual design submittal sequence for each project should be determined based on project schedule. The 100-percent construction drawings shall be stamped and signed by a licensed P.E.

Technical specifications: The technical specifications contain materials, procedural, installation, and other requirements for the construction contractor, and are closely coordinated with the construction drawings and the bid schedule. At a minimum, this document should be prepared during the 90-percent submittal, and then finalized in the 100-percent submittal. The 100-percent technical specifications shall be stamped and signed by a licensed P.E.

The final design process may include:

- Establishing design criteria and loading conditions.
- Incorporating VE study recommendations.
- Acquiring additional field and laboratory test data, as required, to supplement existing data from previous studies.
- Performing risk-reduction analyses to confirm that the modifications will adequately reduce the risk of dam failure by the identified PFM(s).
- Performing final design analyses.
- Preparing construction drawings.
- Preparing technical specifications.
- Preparing bid schedule and construction cost estimate.
- Preparing a Design Summary report, along with appropriate TMs. The Design Summary report along with all TMs shall be stamped and signed by a licensed P.E.
- Completing an independent technical review.

## **7.9 NEPA Compliance and Permitting**

Modifications of BIA dams are considered to be major Federal actions that must be documented in accordance with the NEPA. NEPA compliance for the modification of BIA dams can be addressed by one of the five following methods:

1. Actions exempt from NEPA
2. CXs
3. Actions covered by an existing NEPA environmental document
4. Environmental Assessments
5. EISs

A brief description of each of these NEPA compliance methods is provided in this section, and the simplest method available should be used to minimize the overall project cost and schedule. The Regional SOD Officer is responsible for ensuring that the appropriate NEPA compliance requirements are fulfilled. In addition, the Regional SOD Officer should ensure that there are no other significant local, State, or Federal permits required to implement the dam modifications. If such permits are required, appropriate permitting activities should be carried out as soon as

possible so that the project schedule is not jeopardized. Environmental data collection field activities and permitting for NEPA compliance require tribal coordination, communication, and collaboration. Descriptions of the methods of NEPA compliance are listed below:

Actions exempt from NEPA: There are three major types of actions that are exempt from NEPA. Two of these actions include Congressionally Exempt Actions and Emergency Actions. In addition, an action may be rejected under statutory or regulatory authority without NEPA review.

CX: A CX is a category of Federal actions that are not considered to individually or cumulatively have a significant effect on the human environment. Each BIA regional office should have a procedure for conducting CX review and has a checklist of the activities that qualify for a CX. In most cases, maintenance projects and even significant dam modifications are CXs.

Actions covered by other NEPA documents: Actions that are covered by other existing NEPA environmental documents do not require separate NEPA documentation. This does not apply to most dam modification projects, but this approach should be explored if a project does not qualify for a CX before beginning the environmental assessment process.

Environmental Assessment: An environmental assessment is a concise public document that typically is required if the previously described NEPA compliance approaches are not applicable to the project. The environmental assessment typically involves the preparation of a concise purpose and need statement, a description of alternatives to meet the purpose and need, and a summary of the expected environmental impacts. Environmental assessments require a public comment period and public meetings can be used if necessary. Environmental assessments are concluded with either a Finding of No Significant Impact (FONSI) or a Finding of Significant Impact (FOSI). If the environmental assessment results in a FOSI, an EIS must be prepared. If it is clear that the project will create significant environmental impacts, the environmental assessment process can be bypassed and the NEPA compliance process can go directly to an EIS. Consultation with the BIA regional office NEPA compliance specialist is recommended before initiating any environmental assessment or EIS process for dam modification projects.

EIS: If an EIS is required it will result in a very detailed public involvement process and written analysis of the significant and other environmental impacts associated with the project as required by section 102(2)(c) of the NEPA and parts 1500 through 1508 of the Council on Environmental Quality Regulations for Implementing NEPA Procedures. The details of these procedures are not provided here because modifications of BIA dams are not considered to require EIS documentation except in rare cases. If required, the BIA regional office NEPA compliance specialist should be consulted regarding the required procedures to initiate an EIS.

## **7.10 Other Permitting and Compliance Issues**

Besides NEPA, there are other key Federal permitting and compliance issues that may include the following:

1. Ensuring that there are no impacts to Federally-listed threatened or endangered species as required by section 7 of the Endangered Species Act. Compliance with the Endangered

Species Act is typically addressed by the local Ecological Services unit of the US Fish and Wildlife Service.

2. Ensuring that there are no impacts to cultural resources in accordance with section 106 of the Historic Preservation Act. Compliance with the Historic Preservation Act is typically addressed at the state level by the State Historic Preservation Officer (SHPO).
3. Ensuring that there are no impacts to jurisdictional wetlands in accordance with section 404(b) of the Clean Water Act. Wetlands impacts are typically addressed by the local office of the USACE.

### **7.11 Final Construction Documents**

Upon completion of construction, the following documents should be prepared:

1. Record Drawings—Record drawings should be based on actual, as-built conditions encountered during construction from contractor’s records, designer’s records, and field inspector’s records. All design changes made during construction or new features added during construction should be incorporated.
2. Final Construction Report—this report should include the following information:
  - a. A summary and chronology of the construction.
  - b. Record of approved contractor’s submittals.
  - c. A summary of design modifications and change orders.
  - d. Documentation of foundation conditions and foundation approval.
  - e. Construction photographs documenting typical activities, unusual features encountered and major milestones.
  - f. Compilation of daily and weekly inspection reports.
  - g. A summary of laboratory and field test data of earthfill and concrete materials.
  - h. An explanation of any areas of non-compliance with the plans and specifications, a discussion of the reason(s) for the non-compliance, and an indication of whether the BIA should accept the project as constructed.

### **7.12 Construction Procurement**

Construction procurement is the process of soliciting and evaluating bids from contractors for constructing dam modifications and awarding the construction contract. Construction procurement by the BIA is accomplished in accordance with the FAR and procurement requirements. The method of procurement can vary, depending on the Government requirements and complexity of the construction, including the following:

Competitive bidding: Under this method, the Government is required to award the contract to the bidder with the lowest offered price.

Pre-qualification: This is a two-step process. The first step involves submittal of qualifications. Only pre-qualified contractors will be allowed to submit bids in the second step. Typically, the qualified contractor with the lowest bid will be awarded the contract.

Best-value selection: In this method, the bidder submittal includes both technical qualifications and a bid at the same time. The Government will evaluate the submittals based on a specific scoring system that includes both qualifications and price, and the Government is not required to award the contract to the bidder with the lowest bid.

Sole-source negotiation: The Government will negotiate a bid price with one specific contractor.

### **7.13 Construction-Phase Engineering**

Construction-phase engineering includes typical engineering activities that are performed during construction projects to modify BIA dams or construct new dams. These activities exclude construction management and administration that are performed to manage the construction contract, such as contract administration, meetings, change orders, payments, schedule issues, etc. Only Government contracting officers can perform contract administration. Construction-phase engineering activities can be performed by BIA and tribal personnel, or they can be performed by consultants.

The following is a list of typical construction-phase engineering activities and requirements for dam modifications:

Pre-construction meeting: A pre-construction meeting should be conducted on site after notice to proceed has been issued by the contracting officer. At a minimum, this meeting should be attended by representatives of the BIA, the contractor, and the design engineer, and should address the following construction issues:

- Overall construction schedule and timeline.
- Construction observation plan, including field personnel and testing.
- Contractor personnel and quality assurance/quality control.
- Review of contract requirements and protocol.
- Review of communication protocol, including points of contacts for the BIA, the tribe(s), the contractor, and the design engineer.

The proceedings of the pre-construction meeting should be documented in written minutes.

Progress meetings: Progress meetings should be conducted on site on a regular basis to discuss ongoing construction work, construction problems and solutions, schedule projection and changes, and other contract issues. The frequency of progress meetings should be based on the size and duration of the project, urgency of the construction, and ongoing activities. This meeting should be attended by representatives of the BIA, the construction management team (whether BIA or a consultant), and the contractor; the design engineer and tribal representatives may attend some of the progress meetings as needed. The proceedings of the progress meetings should be documented in written minutes.

Review of contractor submittals: Contractor's administrative submittals are typically reviewed by the construction management team's project manager, but key technical submittals from the contractor should also be reviewed by the design engineer. Key technical submittals may include



excavation, dewatering, demolition, cofferdams, diversion, foundation treatment, earthwork, concrete, rebar shop drawings, fabricated metalwork, hydraulic equipment, and instrumentation. Review of the contractor submittals should be completed within the periods allowed in the contract. The results of the submittal review should be documented in technical memoranda, including recommendations for acceptance or resubmittal.

Response to contractor's Requests for Information (RFI): Whether the RFI is for contract and administrative matters or technical in nature, the response to a contractor's RFI should be completed on a timely basis in order not to cause undue delays to the contractor. The response to technical RFIs should be prepared by the design engineer, and the information should be documented in a technical memorandum.

Design changes: Changes to the original design may be needed during construction if requested by the BIA or if required by unforeseen field conditions. Design changes should be documented in a technical memorandum prepared by the design engineer. These changes should be included in the Record Drawings to be prepared at the end of construction.

Full-time field observations: Full-time field observations by qualified field personnel are required for the following field construction activities:

- Development of the borrow areas, and stockpiling of borrow materials.
- Placement of cofferdam protection and diversion facilities.
- Demolition of existing structures.
- Excavation, including earth excavation, rock excavation, or braced excavation.
- Control of groundwater inflows into the excavation.
- Foundation preparation or treatment, including dental concrete, slush grouting, shaping, pressure grouting, and cleaning.
- Placement of earthfill, including embankment fill materials, filters, drainage blankets, and riprap and bedding.
- Installation of toe drain pipes.
- Placement of cast-in-place concrete in spillways and outlet works structures.
- Installation of outlet works conduits or spillway conduits, including filter collars (or diaphragms, as appropriate) around the conduits that penetrate through the dam.
- Installation of hydraulic equipment such as gates and valves, fabricated metalwork, and electrical and supervisory control and data acquisition (SCADA) equipment.
- Installation of dam instrumentation, including EWS equipment, staff gauges, weirs, piezometers, and inclinometers.

Field inspectors should prepare daily and weekly field observation reports (including photographs) documenting the observations.

Foundation approvals: The foundation subgrades of key features, such as core trenches, spillway crest structures, stilling basins, gate towers, conduits, and intake structures should be inspected and approved by the BIA or approved technical representative. The field inspection and approval of foundation subgrades should be documented in a technical memorandum, in addition to the daily and weekly field reports.

Periodic site visits: The BIA will perform periodic visits to the construction site to observe the construction progress, resolve specific construction problems, inspect foundations, and verify design assumptions. Each periodic site visit is documented in a TM or Travel Report.

Material testing: Earthwork testing and concrete testing is performed for quality assurance by the BIA's technical representative in addition to the quality control testing by the contractor. Specific testing requirements will be based on project requirements, but in general, will consist of the following types of tests:

- Laboratory testing of on-site borrow materials.
- Gradation testing of the contractor's imported earthfill materials such as filter sand, drain gravel, and aggregate base course.
- Field testing of in-place compaction and moisture contents of earthfill.
- Field testing of delivered ready-mix concrete, including slump, air content, and temperature.
- Field fabrication of concrete cylinders from ready-mix concrete.
- Laboratory testing of concrete cylinders.

Test results are used to verify compliance with material and performance specifications. Test data should be included in the final construction report at the end of construction.

Final inspection: The final inspection to verify substantial completion or final completion of the construction should be performed by representatives from the BIA, the BIA's technical representative, the tribe(s), and the contractor. Punch-list items are developed from the inspection for outstanding items that are not yet completed. After these punch-list items are completed, another inspection should be performed to verify that all work has been completed.

#### **7.14 First Filling and Monitoring Plan**

After the dam construction is completed and the construction is accepted by the Government, the partially or fully drawn down reservoir will be filled for the first time. Before first filling of the reservoir, a First Filling and Monitoring Plan should be prepared. This plan should be followed during first filling, and should contain the following information and guidelines:

- Maximum allowable filling rate, in terms of feet per day.
- Identification of one or more intermediate reservoir elevations to be maintained for a period of time for observations and evaluations of performance.
- Schedule of inspection and instrumentation monitoring of the dam.

- Identification of key features of the modified dam and appurtenant structures that should be inspected.
- A long-term instrumentation and monitoring plan, containing the frequency of monitoring, data recording format, and graphical presentation of data. The O&M manual for the dam should be updated to include this plan.

Data and observations from the inspection and monitoring should be documented in writing, and evaluated by the BIA's technical representative. The initial filling is complete when the reservoir level has been stabilized under the normal operating pool.

## **8 OPERATIONS AND MAINTENANCE (O&M)**

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### **8.1 Overview**

Routine maintenance is a key element in reducing the risk of dam failure and ultimately reducing the long-term costs and government expense required to operate dams safely. Monitoring of dam instrumentation is an important Program activity, as it provides field data on the performance of the dam and foundation, and also data for evaluation and analysis. The monitored performance parameters are useful in the identification of PFMs, and are key inputs into issue evaluation and risk analyses.

Each Program dam must have an O&M manual that documents key operations, maintenance, and routine monitoring maintenance guidelines for the dam. The dam operator/dam tender is responsible for ensuring that the dam(s) under their jurisdiction are properly operated, maintained, and monitored in accordance with the O&M manual. The level of detail and instruction contained in the O&M manual will vary depending upon the complexity and appurtenant structures at each individual dam.

### **8.2 General Information**

O&M manuals provide operations guidance for Program dams and reservoirs. One of the most important operational issues at any dam is to keep and maintain a routine schedule for key operational activities such as routine monitoring, special inspections, instrumentation readings, or important maintenance activities. One of the more important scheduled operations is to exercise the outlet works control gates at least annually. Exercising outlet works gates helps ensure that the outlet works controls are operable and the reservoir can be efficiently lowered or drained in the event of an unusual event or emergency incident at the dam. O&M manuals for BIA dams should include the following minimum information:

- A brief description of the purpose and history of the project.
- A description of items of special importance associated with the operation of the dam. Items of special importance could include a description of issues such as the safe downstream channel capacity, maximum allowable outlet gate openings, procedures for exercising the outlet works gates, key annual maintenance activities, safety procedures during key phases of dam operation, and storage location of the logbook and EAP.
- Documentation of who is responsible for key dam O&M activities at the dam.
- Directions and maps for access to the dam.
- A description of the schedule for routine monitoring and communication protocol for unusual observations or operations.
- A description of coordination with other dams or facilities that may be located upstream of downstream of the dam.

### **8.3 Instrumentation and Monitoring**

O&M manuals should document the following instrumentation and monitoring information, if significant instrumentation exists:

- A description of the instrumentation system installed in the dam and documentation of the purpose of the instruments.
- Instrumentation plan, section, and installation detail drawings where available.
- Instrumentation data collection forms where appropriate.
- Instructions for reporting instrumentation data and a description of who is responsible for evaluating the data.
- An instrumentation data collection schedule and routine operator inspection schedule (see Routine Monitoring Checklist in Appendix B).
- A description of abnormal instrumentation reading thresholds and actions to take when the abnormal instrumentation thresholds are exceeded.
- A description of routine maintenance recommended for various instrumentation types.

The minimum instrumentation that is required at all BIA dams is a reservoir staff gauge. It is recommended that reservoir staff gauges extend to the minimum elevation of the dam crest.

### **8.4 Maintenance**

O&M manuals document routine maintenance activities and recommended maintenance procedures that are required at most dams to increase the operational life of the facility. Typical dam maintenance activities include:

- Control of rodents and repair of rodent damage in embankment dams.
- Control of vegetation and repair of vegetation damage in embankment dams.
- Reestablishment of freeboard or camber in embankment dams.
- Repair of erosion damage in embankment dams.
- Repair of cracking in concrete dams or structures.
- Sealing of concrete joints.
- Repair of deteriorated or spalled concrete.
- Lubrication and maintenance of gates and valves.
- Application or reapplication of coatings on gates, valves, and metal work.
- Verification of voltage and amperage or replacement of electrical controls.
- Repair of electrical or instrumentation conduits.
- Repair or replacement of fences, locks, gates, or other security features.
- Improvements or repairs to the dam access road.

- Other maintenance issues.

Manufacturers' O&M manuals for gates, controls, and other specialized equipment should be kept and included as appendices in the BIA's O&M manual.

### **8.5 Unusual and Emergency Operations**

When unusual conditions are observed or abnormal instrumentation readings are made at the dam, there may be a need to move from the normal operations documented in the O&M manual to emergency operations documented in the dam's EAP. The O&M manual provides directions and decision guidance about when and how to evaluate unusual and emergency conditions at dams. The latest version of the decision making guidance tables in the EAP should be referenced in the O&M manual to facilitate a seamless transition to the EAP and into the Incident Command System (ICS) for emergency operations.

### **8.6 Downstream Hazard Potential Classification Study**

Review of the downstream hazard potential classification for all BIA dams occurs on a regular basis. If at any time the Regional SOD Officer believes that the downstream hazard potential classification of a particular BIA dam may have changed, the Regional SOD Officer may request that a Downstream Hazard Potential Classification Study be performed.

Prior to initiating a Downstream Hazard Potential Classification Study, the BIA SOD Officer must approve the hazard classification reevaluation, the proposed methods to reevaluate the hazard classification, and the individual(s) who will be performing the study. Hazard classification reevaluations can be performed by BIA or tribal consultants, BIA staff, or other government agencies. The key analysis assumptions, methods, and results are documented in a Downstream Hazard Potential Classification Study report and the report is reviewed and approved by the BIA SOD Officer before the hazard potential classification of a dam can be changed.

## 9 EMERGENCY MANAGEMENT

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### 9.1 Overview

Emergency management at BIA dams involves prevention and mitigation, preparedness, response, and recovery associated with dam incidents, emergency events, or dam failures at BIA dams. A brief definition of these emergency management terms as they relate to dam safety is provided below.

Prevention and mitigation: Involves understanding the risks associated with the operation and maintenance of BIA dams and taking preventative measures to minimize these risks during normal operations.

Preparedness: Involves preparing and training personnel on emergency procedures and identifying labor, materials, and equipment for use during unusual situations, emergency events, or dam failure at BIA dams.

Response: Involves pre-planned actions taken by dam operators/dam tenders during dam safety incidents to minimize the consequences associated with dam failure. It also involves pre-planned communications with local emergency responders during unusual situations, emergency events, or dam failure at BIA dams.

Recovery: Involves fulfilling the humanitarian needs of people affected by the emergency and can include temporary relocation of the affected downstream population and reconstruction of damaged property affected by the emergency. The recovery phase begins immediately after the threat to downstream life has ended.

The main focus of the BIA's SOD EM program is on preparedness and response to incidents at BIA dams through the preparation and exercising of EAPs. EAPs are required for all Program dams. The Program's EM program is intended to comply with the all applicable Federal and DOI guidelines and policies.

The goal of the Program's EM program is to prepare and train key personnel and emergency responders to assure that all parties involved are prepared for dam safety emergencies so that lives can be saved and damage to property minimized in the event of dam failure.

Dam incidents are much more common than dam failures. Dam safety incidents can include sinkholes, cracks, slides, floods, sand boils, increasing seepage, muddy seepage, earthquakes, or spillway erosion. Many identified dam incidents can develop into dam failures, within hours or days, unless appropriate and timely actions are taken to immediately reduce the risk of dam failure. Dam incidents may be discovered by dam operations and maintenance monitoring personnel, during routine dam safety inspections, or by the general public that may be visiting the dam.

Consistent with the risk-informed decision-making approach in this Handbook, the estimation of potential life loss or property damage is better understood as a result of properly developed and exercised EAPs. When appropriate, the lessons learned during the emergency planning process may be used to review and update the consequences estimate for the dam.

## 9.2 Emergency Action Plans

EAPs are used to help responsible officials protect lives and reduce property damage in the event of flooding caused by a dam failure. EAPs are planning documents that are intended to guide BIA and tribal officials through the steps of detection, decision making, issuing required notifications, and taking preventative actions to prevent dam failure, if possible. In addition, EAPs provide vital information to emergency response personnel regarding inundation areas downstream from the dam. EAPs also include termination and follow-up reporting guidance. EAPs are coordinated with Local Emergency Operations Plans (LEOPs) to the extent possible. Local tribal, municipal, and county emergency management officials are responsible for preparing and implementing their own LEOPs and warning and evacuation plans for their jurisdictions.

Major storm events may result in flooding downstream of BIA dams even if the dam does not fail. These storm events may have the potential for life loss or property damage. To prepare for this scenario, a Non-Dam-Failure (NDF) Advisory Flood Map may be included in the appendix of the EAP to assist downstream communities preparedness of potential consequences associated with high water unrelated to dam failure scenarios. The high water event depicted on the NDF Advisory Flood Map will be determined on a case-by-case basis in collaboration with the BIA SOD Officer. Refer to the Dam Failure Inundation Maps and the NDF Advisory Map sections below for more information.

### Responsibility

The BIA SOD Officer and EM Coordinator have the overall responsibility to make sure that an EAP is prepared for each Program dam and that the EAPs are regularly exercised.

The BIA's EM Coordinator is responsible EAP management, including electronically documenting EAP completion dates (month and year) for each Program dam.

Regional SOD Officers are required to perform annual EAP updates to the Communications Directory for each of their Program dams. These annual updates are due within one year (365 days) from the most recent Tabletop or Functional Exercise date for each of their Program dams. Note that the EM Coordinator is responsible for electronically documenting each Program dam Exercise completion date (month, day, and year), along with recording annual EAP updates (month and year). Refer to Section 9.4 below for more information on the EAP Exercise program.

### Decision Criteria Response Levels

EAPs address the following three emergency Response Levels:

1. Response Level 1: Is a slowly developing, unusual situation at the dam. The potential for adverse impacts is not yet serious, but could progress into a potentially threatening event if it continues or intensifies.



2. Response Level 2: Is a rapidly developing situation, where conditions are more serious than a Response Level 1. The dam is becoming unstable. Populations at risk should be notified to *standby* and prepare to evacuate areas identified on the inundation maps within this EAP.
3. Response Level 3: Is one of the following: (1) dam failure is imminent (it has been determined that the dam will fail), (2) is occurring, or (3) has occurred. Life-threatening flooding will definitely affect populations at risk. Immediate evacuation of the population at risk is recommended.

Regardless of the emergency response level, any unusual situation or emergency at a BIA dam is addressed in the BIA EAPs in the following four key steps:

1. Detection of the Unusual or Emergency Situation
2. Determination of the Response Level using the Decision Criteria Matrix in the EAP
3. Notification/Expected Actions
4. Termination of the Event

### **Certification Page and Final Distribution**

In the EAPs, the Certification Page is a signatory sheet in the preface of the EAP. This page contains the signature blocks for the Regional SOD Officer, the BIA Agency Superintendent or other decision-making entity, and the Tribal SOD Lead, as well as any other key jurisdictional players in a dam safety emergency. When an EAP has been revised and verified through a Tabletop or Functional Exercise, the Certification Page is routed for signature among the signatories. This Certification Page must be signed by all signatories within 120 days of the Exercise. Since the EAP is a BIA document, only the BIA signature is required to make it a valid document, but every effort is made to acquire the approval and signature of the tribal leadership. Once the Certification Page is signed, it is inserted into the Final EAP prior to final distribution.

### **9.3 Dam Failure Inundation Maps and Non-Dam-Failure Advisory Flood Maps**

An important component of the EAP is the Dam Failure Inundation Maps, which are used for planning and execution of emergency response. In general, a dam failure inundation map illustrates the extent of downstream flooding during a simulated dam failure. Dam Failure Inundation Maps should meet the following minimum guidelines:

- Maps should be prepared to a minimum scale where one inch equals 2,000 feet (for 1: 24,000 scaled maps) or one inch equals 677 feet (for 1:8,000 scaled maps, used for aerial photographs).
- Maps should be overlaid on recent topographic data color aerial photography that covers the floodplain downstream of the dam with a small, yet discernable overlap between each map to be sure the full area is covered.
- Dam failure inundation information should be summarized on data tables at key downstream cross sections or reporting points located near important features, such as major road

crossings, schools, hospitals, or other key downstream features. Cross section lines should be drawn perpendicular to the water course.

- The minimum required information provided in the cross section data tables should include:
  - distance downstream of the dam, in miles;
  - maximum flood stage, in feet;
  - arrival time of the leading edge of the flood wave, in hours:minutes;
  - arrival time of the peak flood wave, in hours:minutes;
  - peak flood flow rate, in cubic feet per second (cfs); and
  - maximum velocity in feet per second.
- Flood wave arrival times and times to peak flood stage should be calculated assuming 0.0 hours as the time that the breach initiates in the computer simulation model.
- Dam Failure Inundation Maps should be prepared on 11-inch by 17-inch paper and an index map of all of the Dam Failure Inundation Maps should be provided at the bottom of each map sheet.
- Each map sheet should include a north arrow and the following scale representations: a scale bar for both English and metric units and a dimensionless ratio of the scale represented in text.
- Each map sheet should include a technical summary (including disclaimers). See Dam Failure Inundation Maps, Foundational Data, and NDF Advisory Flood Maps sections below for more information.
- Two dam failure inundation boundary lines are typically shown on Dam Failure Inundation Maps in EAPs. The sunny day and hydrologic dam failure inundation scenarios are shown on the same map, if applicable.

Computer simulation models used to develop the Dam Failure Inundation Maps must be approved by the BIA SOD Officer.

### **Dam Failure Inundation Maps**

Flood modeling data contained within a Dam Failure Inundation Map, as well as the corresponding statistics, are not a reflection of the integrity of the dam. All data and statistics are mathematically modeled and are therefore approximations.

The following technical summary (including disclaimers) appears on each Dam Failure Inundation Map, with the portions in *italics* changing depending on the dam:

This study has been comprised to demonstrate the flooding extents associated with hypothetical failure scenarios of the *dam* (i.e., the *name of the dam*, which should be included here, will change depending on the Dam Failure Inundation Study the particular map is based on). All depictions and information provided within this map should be found in direct support of the *dam's* EAP (include the *name of the dam* in front of EAP). All information contained herein has been developed for the sole intention of facilitating site-specific emergency action planning, and should not be relied upon for additional purposes without written consent of the appropriate BIA official, in service of the corresponding BIA facility.

The flooding scenarios depicted on the Dam Failure Inundation Map provide the inundation areas associated with both the sunny day dam failure and the hydrologic dam failure. The breaching characteristics of the simulated dam failure scenarios were established through the development of complimentary hydrologic and/or hydraulic models within a *hydrologic modeling system* (e.g., Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) or another hydrologic modeling system). These models calculated the outflow hydrograph associated with each event. The sunny day dam failure was determined to have a peak flow rate of approximately *a number of cubic feet per second (cfs)* (include the peak flow rate number, in cfs), and a corresponding total outflow volume of *a specific number of acre-feet* (include the number of acre-feet). The hydrologic dam failure was determined to have a peak flow rate of approximately *a specific number of cfs* (include the peak flow rate number, in cfs), and a corresponding total outflow volume of the *specific number of acre-feet* (include the number of acre-feet).

*Hydraulic models* (include the name of the hydraulic model or models, for example, a two dimensional (2D), unsteady flow hydraulic model) were established using *hydraulic modeling software* (include the name of the hydraulic modeling software, for instance, FLO-2D, MIKE FLOOD, HEC-RAS, or other industry accepted equivalent software) to determine the flooding characteristics associated with the dam failure scenarios. The site-specific models were developed to predict the flood hydraulics throughout a study reach that spanned approximately a *number of river miles* (include the number of river miles) downstream of the dam. It should be noted that the Approximated Flood-Wave Progression Times provided within the above Summary Statistics Table (data tables are included on the Dam Failure Inundation Maps) are estimates regarding downstream flood progression, as provided by the respective model in relation to the initial onset of the modeled dam failure. In a real dam safety emergency, these values of Flood-Wave Progression Times should not be relied upon, unless the initial time of dam failure onset is clearly and distinctly identified.

## **Foundational Data**

The foundational elevation data for the modeling is a key factor in influencing the accuracy of the output results, which depends on the vendor (US Geological Survey, Intermap Technologies®, etc.) and the requirements for the horizontal and vertical resolution. Along with these different sources, the horizontal and vertical accuracy will fluctuate, plus or minus approximately 7 meters for the former and plus or minus approximately 1 meter for the latter. All results for any information generated from this data will have a potential horizontal or vertical displacement within these boundaries.

## **Dam Failure Inundation Mapping Scenarios**

EAPs typically include mapping that depicts both the sunny day and hydrologic dam failure inundation scenarios on the Dam Failure Inundation Maps. Because the difference between the inundation areas of the hydrologic and sunny day scenarios can be small, emergency response planners often plan evacuations based on the worst-case dam failure scenario, which will typically be the hydrologic dam failure inundation scenario. The sunny day dam failure

inundation area is included on each Dam Failure Inundation Map to depict an alternate dam failure scenario.

### **Dam Failure Inundation Mapping Termination Limits**

Dam Failure Inundation Maps should be extended downstream of the dam to a point where the incremental flood flow associated with dam failure no longer creates a hazard to the downstream population or there is adequate time to provide real-time warnings based on the actual flood conditions. At least one of the following conditions should be met to establish the downstream limit of dam failure inundation mapping:

- The dam failure inundation discharge is less than the 100-year flood flow or the defined safe channel capacity.
- The volume of the dam failure inundation hydrograph can be safely stored in a larger downstream reservoir without causing spillway releases from the downstream reservoir that exceed the 100-year flood flow.
- The arrival time of the leading edge of the flood wave exceeds 24 hours after the dam breach is initiated at the dam. The arrival time can be modified at the discretion of the BIA SOD Officer.

The BIA does not prepare evacuation maps downstream of BIA dams because this important emergency planning work is the responsibility of local emergency planners. However, the Dam Failure Inundation Maps, as well as the NDF Advisory Flood Map included in the EAP, can be used by emergency planners and other response agencies to prepare evacuation maps downstream of BIA or tribal dams.

### **NDF Advisory Flood Maps**

NDF Advisory Flood Maps are available in the EAP and in the corresponding Dam Failure Inundation Study. These maps are developed for the principle purpose of providing a depiction of non-dam-safety-related natural flooding within waterways downstream of a dam. These maps should not be relied upon for additional purposes without written consent of the appropriate BIA official, in service of the corresponding BIA facility.

The following technical summary (including disclaimers) will appear on the NDF Advisory Flood Maps, with the portions in *italics* changing depending on the dam:

NDF Advisory Flood Maps demonstrate downstream flooding risks that are associated with the release of natural stormwater runoff from the *dam's* spillway (i.e., the *name of the dam*), which should be included here, will change depending on the Dam Failure Inundation Study the particular NDF Advisory Flood Map is based on). These maps can be used by emergency response planners to advise downstream populations of the magnitude of potential flooding in response to natural rainfall within a dam's watershed.

The NDF Advisory Flood Map provides the inundation area developed by a *hydraulic model* (include the name of the hydraulic model, for example, a two dimensional (2D), unsteady flow hydraulic model) through the use of *hydraulic modeling software* (include the name of

the hydraulic modeling software, for instance, FLO-2D, DHI, or HEC-RAS, or other industry accepted equivalent software) to determine the flooding characteristics associated with a natural flood peak of a *specific number of cubic feet per second (cfs)* (include the natural flood peak number, in cfs) by passing the existing emergency spillway. A site-specific model was developed to predict the flood hydraulics throughout a study reach that spans approximately a *number of river miles* (include the number of river miles) downstream of the dam.

#### **9.4 BIA Dam EAP Exercise Program**

The BIA SOD Officer is responsible for maintaining a program to routinely exercise dam EAPs at all Program dams. The EAP Exercise program is managed by the BIA's EM Coordinator. The objective of the EAP Exercise program is to ensure that the EAPs are maintained as effective preparedness and response tools to help save lives and minimize downstream property damage. Electronic and hard copies of all EAPs are maintained by the EM Coordinator. The EAP Exercise program is focused on plan familiarization exercises to ensure effective responses during a dam incident, emergency event, or dam failure. The exercise program provides valuable training for dam operators/dam tenders, emergency responders, and others who would be involved in an incident at BIA dams. The exercise program also provides a process to continuously improve and update the EAPs to promote effective responses in the event of a dam safety incident at a BIA dam.

The EAP Exercise program includes the following types of exercises:

1. Orientation Meetings
2. Drills
3. Tabletop Exercises
4. Functional Exercises

A definition of each these exercise types is provided in the Definitions section at the end of this Handbook.

#### **Orientation Meetings and Exercises**

The EAP Orientation Meetings are part of the Tabletop Exercise planning process. They include a thorough review and introduction to the EAP and dam incident response. EAP communication drills are conducted as part of the annual EAP update. The Regional SOD Officer is responsible for performing this task. A communication drill involves calling the contacts on the EAP's Notification Chart and the Communications Directory and verifying their current position and contact information, as well as updating information for the Resources, Contractors, Equipment, and Suppliers list. During the communication drill, it is also important to verify that the plan holder has an updated copy of the EAP and knows where it is located. Other aspects of the EAP can also be exercised as part of the communication drill such as testing detections, the Decision Criteria Matrix, or preventative actions. The annual EAP updates will be documented electronically by the EM Coordinator, and hard copy versions sent to all official holders of the EAPs.

The EAP Exercise program involves alternating Tabletop Exercises and Functional Exercises every five years. More frequent exercises can be scheduled based on requests from the tribe, the condition of the dam, or key personnel changes. More frequent exercises should be considered when new people become involved in key operational or emergency response roles at BIA dams. An actual incident or emergency event at the dam is judged to be an acceptable substitute for a Functional Exercise provided that the EAP is implemented and an Incident Report is prepared that documents the incident details, communications made, lessons learned, and recommended corrective actions for the EAP.

The planning, conducting, and reporting of dam EAP Tabletop Exercises and Functional Exercises are conducted in general conformance with Homeland Security Exercise and Evaluation Program (HSEEP) guidelines. Tabletop Exercises are discussion based and Functional exercises are operations based. To maximize exposure and familiarity with EAP procedures, Functional Exercises should be designed in a modified exercise format where all parties involved in the exercise are located in the same location so that all the participants can be involved in all of the associated communications and actions that are tested.

All EAP Tabletop and Functional Exercises include the EM Coordinator as part of the exercise planning team. Exercise objectives should focus on the following elements of the EAP:

1. Detection
2. Decision Making
3. Notification
4. Dam Failure Inundation Maps
5. Communication

The most recent documented PFM reports, instrumentation and monitoring data, and recent incidents reports should be reviewed in the development of exercise scenarios to develop realistic events that could affect populations downstream of the dam. A security scenario involving sabotage or vandalism should be considered at least once during every third exercise.

Note that the Dam Safety Incident Report template is available in Appendix C.

### **After-Action Report and Improvement Plan**

A draft After-Action Report and Improvement Plan (AAR/IP) is prepared within 30 days of any Tabletop Exercise or Functional Exercise or after any incident which results in an EAP activation. The draft AAR/IP is reviewed and approved by the EM Coordinator and finalized within 60 days of the exercise. The EM Coordinator keeps a record of all dam EAPs and exercise or actual incident AAR/IPs. AAR/IPs typically contain the following minimum elements:

1. An Exercise Summary that describes key strengths and areas of improvement for the EAP.
2. An Exercise Overview section that describes the exercise details and participants.
3. An Exercise Design Summary section that describes the exercise objectives and scenarios that were exercised.

4. An Exercise Evaluation section that documents identified issues and the participant's AAR/IP forms.
5. A Conclusions section that documents the overall effectiveness of the exercise.
6. An Improvement Plan section that includes a listing of specific recommendations for corrective actions to improve the exercise and emergency response actions.

The EM Coordinator maintains an electronic and hard copy inventory of all EAPs and keeps electronic records of all Exercise AAR/IPs. After the annual EAP update is complete, the Communications Directory and the Resources, Contractors, Equipment, and Suppliers list are updated and the EM Coordinator maintains electronic and hard copy records of these updates. AAR/IPs will be completed after all Tabletop and Functional Exercises, as well as all actual incidents where the EAP is activated. The Regional SOD Officers will keep electronic records of EAP updates and incident-related AAR/IPs, and provide copies to the EM Coordinator. The EM Coordinator will track and maintain electronic records of all EAP updates, revisions, exercises, and AAR/IPs.

## 9.5 Emergency Management Training Requirements

Anyone involved in the monitoring, operation, or maintenance of Program could become involved in a dam safety incident associated with the dam. This involvement could result from an unusual condition observed at the dam to a rapidly developing emergency situation or dam failure. When the dam EAP is activated, everyone is expected to function under the ICS, as required by the National Incident Management System (NIMS).

Basic training in ICS and NIMS is available from free online training courses offered by FEMA at <http://training.fema.gov/IS/NIMS.aspx>. More advanced ICS training courses are offered at the Emergency Management Institute or from local, tribal, or State emergency management organizations.

Recommended minimum training requirements for key personnel who could be involved in BIA dam EAPs is provided in Table 9.1 below.

**Table 9.1**  
**Recommended Minimum Emergency Management Training**

Course No.	Title	Recommended For
ICS-100	Introduction to Incident Command System	Dam Operators, Facility Managers, BIA Superintendents, Tribal Council Members
ICS-200	Incident Command System for Single Resources and Initial Action Incidents	Dam Operators, Facility Managers, BIA Superintendents, Tribal Council Members
ICS-700	National Incident Management System, An Introduction	Dam Operators, Facility Managers, BIA Superintendents, Tribal Council Members
ICS-300	Intermediate Incident Command System for Expanding Incidents	Facility Managers, BIA Superintendents, Tribal Council Members, other potential ICS Staff
ICS-400	Advanced Incident Command System	Facility Managers, BIA Superintendents, Tribal Council Members, other potential ICS Staff

## 10 EARLY WARNING SYSTEMS

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### 10.1 Overview

Most BIA Program dams are equipped with an automated EWS which continuously monitors reservoir, rainfall, and discharge data. The purpose of an EWS is to provide remote notification of potential hazardous flooding or other significant incidents at the dam which could lead to potential dam failure. An effective EWS is instrumental in increasing available warning time to communities that may be at risk downstream of BIA dams. An EWS provides real-time remote monitoring of reservoir levels, stream levels, and rainfall, which can provide information for the early detection of major flooding, overtopping, or high operational releases at Program dams. An EWS can also provide notification of other dam failure modes (static or seismic) by monitoring rapid decreases in the reservoir level or rapid increases in stream levels downstream of the dam.

There are two important functions that are inherent in each EWS. These functions include detecting a failure event or major flood event and notifying the downstream community of the need to evacuate. The role of EWS in the Program is to serve as an emergency management tool and assist with emergency notification and decision making. It is the BIA's goal to include EWS stations on virtually all of its Program dams and to incorporate real-time precipitation monitoring into each EWS.

More than 2,800 sensors located at more than 270 equipment sites at BIA dams are currently monitored at the BIA's NMC. The NMC is located on the Flathead Indian Reservation in Ronan, Montana. The NMC is staffed 24 hours per day, seven days a week, by personnel from the Confederated Salish and Kootenai Tribes of the Flathead Nation. This chapter also provides information about how alarms and other information detected in the BIA's EWS are integrated into the BIA's EM program and dam EAPs.

### 10.2 EWS Planning

The possible need for additional EWS equipment sites or sensors at a particular dam is evaluated a minimum every five years. This is done in conjunction with the CR and PR process. In many cases, expanding an existing EWS site's sensors or adding a remote monitoring site can be completed more economically than structural modifications and can serve as an effective interim corrective action or expedited corrective action until permanent structural modifications can be funded, designed, and implemented.

There are generally three types of EWS sites that are installed at BIA dams. These EWS types are described as follows:

Stand-alone sites: Monitor data only in the vicinity of the site and transmit the data to the NMC. Stand-alone sites do not collect data from other sites and will usually have a satellite antenna but not a radio antenna. Stand-alone sites utilize commercial satellite communication and usually contain a data logger. A typical stand-alone EWS site is shown in Figure 10.1.



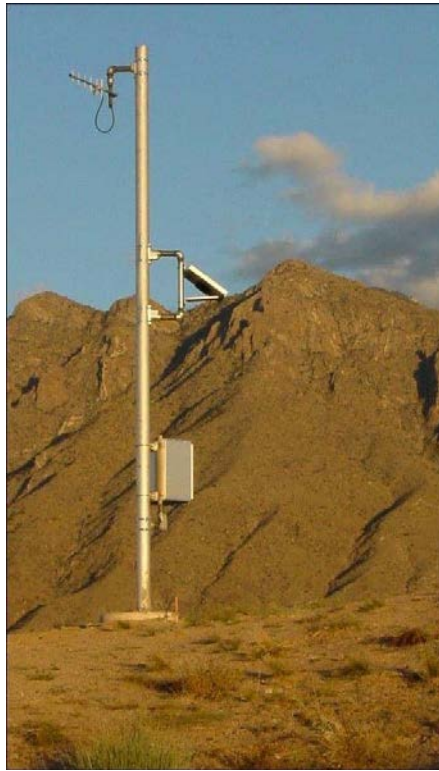
**Figure 10.1**  
**Example of a Stand-alone EWS Site**  
**(Water Tank Dam, New Mexico)**



Master-with-remote sites: Have the functionality of a stand-alone site plus the capability to receive information from nearby remote sites via radio. Master-with-remote sites have both a satellite antenna to transmit data to the NMC and a radio antenna to receive data from remote sites. Master-with-remote sites usually contain a data logger; however, unlike stand-alone sites, master-with-remote sites also utilize spread spectrum radio communication between EWS sites.

Remote sites: Contain only a radio antenna to communicate to the master site. Remote sites are located within two miles of a master site and generally require a clear line of sight to the master site. Remote sites contain only a data logger with a built-in radio. A typical remote site is shown in Figure 10.2.

**Figure 10.2**  
**Example of a Remote EWS Site**  
**(Sandia Pueblo, New Mexico)**



A typical EWS detection system contains monitoring equipment, which includes a pressure transducer that measures the reservoir water surface, up to three float switches, and a tipping bucket rain gauge, which are all recorded in real-time<sup>12</sup> and reported via satellite to the NMC. Other common EWS sensors considered on a case-by-case basis at BIA dams include sensors to measure tailwater depths, flow rates from toe drain discharge locations, piezometer water depths, or other specialized instrumentation. The selection of the types of sensors and the key parameters that are measured should be based on the PFMs that are identified in risk assessments and in issue evaluations completed for the dam.

EWS site designs typically include five levels of alarm trigger points. The first two alarms are not associated with any change in reservoir elevations or dam condition change. The next three alarms are directly related to Response Levels 1, 2, and 3 in the EAP. These alarms send notifications to a list of predetermined individuals listed in the EAP.

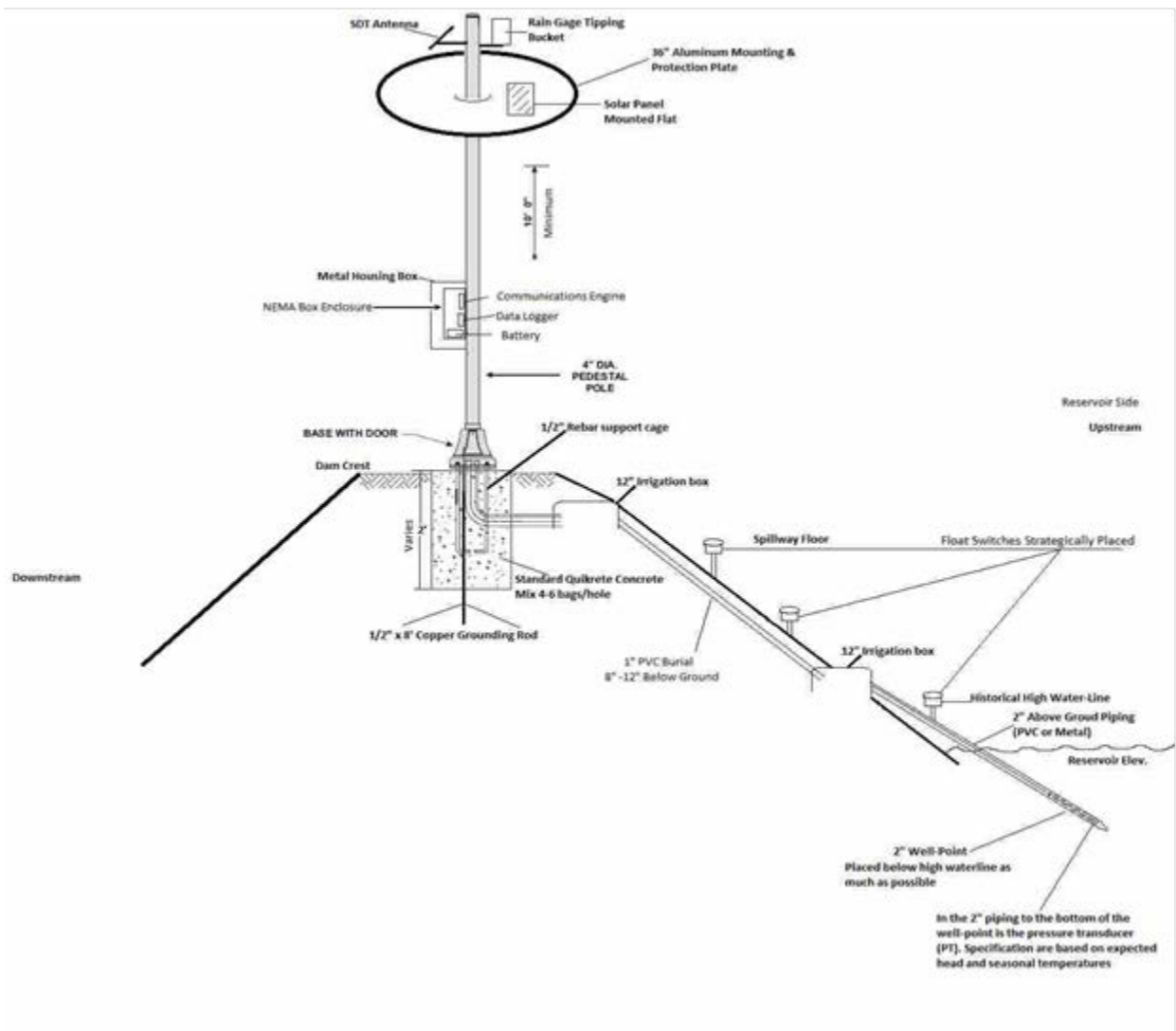
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<sup>12</sup> As used in this chapter, “real-time” refers to a latency of less than one minute.

### 10.3 EWS Design Requirements

The goal of the EWS design is to have a reliable EWS notification system that is integrated with the EAP. Redundancies are built into the system to prevent false reporting. A typical EWS cross section is shown in Figure 10.3.

**Figure 10.3**  
**Typical EWS Site Cross Section**



## General EWS Design Principles

General EWS design principles are listed below:

- Review all of the relevant information related to the particular dam, such as dam drainage basin information, key drawings, vulnerability to seismic and/or hydrologic hazards, and Probable Maximum Floods (PMFs).
- Review the dam's O&M manual, if one has been developed.
- Review the available hydrologic and hydraulic data for the dam.
- The EWS design should be developed in harmony with the EAP Decision Criteria and the Notification List.

## Key EWS Components

EWS installations typically include, but are not limited to, the following:

- Pressure transducer sensors measure reservoir water surface changes to within a tenth of a foot throughout the range of high reservoir levels that can be expected between the normal water surface and the dam crest.
- Redundancy is developed by installing float trigger switches in the reservoir area, as follows:
  - one float trigger is typically installed above the normal water surface of the reservoir, such as at EAP Response Level 1 or other abnormal water level;
  - a second float trigger is typically installed at or near EAP Response Level 2;
  - a third float trigger is typically installed at or near EAP Response Level 3; and
  - additional float triggers may be installed as necessary.
- Rainfall gauges.
- Earthquake monitoring equipment, if necessary.

### 10.4 Benefits of EWS Installation

EWS provide a number of benefits, including:

- Monitoring uncontrolled flow or changes in flow downstream of the dam beyond the normal range of reservoir outflows. A change in flow may indicate initiation of internal erosion.
- Providing notification whenever the safe downstream channel capacity is exceeded, facilitating advance warning to downstream communities.
- Monitoring the upstream tributary above the reservoir to provide early warning of large inflow events.
- Providing real-time and continuous monitoring for rainfall volumes and intensities, if the EWS is equipped with a rain gauge or tipping bucket.

- Providing real-time monitoring for seismic activity through strong motion sensors, if such equipment has been installed at the dam.
- Providing a continuous record of instrumentation data such as reservoir level, even during non-emergency situations.

## 10.5 EWS Operation and Maintenance Considerations

The operation and maintenance of EWS sites is the responsibility of the BIA facility manager. Monthly operational checks are performed by local BIA and/or tribal staff, and annual inspections and maintenance are arranged by the BIA Central Office. The BIA manages future contracts, performs the EWS design and installation, and performs routine maintenance on the EWS sites. The BIA contracts a portion of the maintenance work, the NMC activities, and data services management.

## 10.6 EWS Integration in EAPs

EWS enhance the detection and decision-making functions associated with the EAP. This first step is the detection of unusual or emergency situations at the dam. If unusual or emergency situations are detected by the EWS, alarms are triggered at the BIA's NMC. Once an alarm is activated, it is the responsibility of the NMC to verify by phone that preset notifications have been received. Once these notifications are confirmed, the EAP may be activated at one of the following Response Levels:

Response Level 1: Is a slowly developing, unusual situation at the dam. The potential for adverse impacts is not yet serious, but could progress into a potentially threatening event if it continues or intensifies.

Response Level 2: Is a rapidly developing situation, where conditions are more serious than a Response Level 1. The dam is becoming unstable. Populations at risk should be notified to *standby* and prepare to evacuate areas identified on the inundation maps within this EAP.

Response Level 3: Is one of the following: (1) dam failure is imminent (it has been determined that the dam will fail), (2) is occurring, or (3) has occurred. Life-threatening flooding will definitely affect populations at risk. Immediate evacuation of the population at risk is recommended.

Data from the EWS can be referenced by the dam operator/dam tender or facility manager during an event, but there is generally no other involvement of the NMC personnel in the emergency response. As a result, the EWS are only considered to be an emergency management tool and are not a part of the BIA's formal emergency management system. Reservoir rate of rise elevation information should also be incorporated into EAPs and used during EAP exercises. Alarm threshold levels should be confirmed during EAP exercises and modified as required based on the results of the exercise. Alarm thresholds should also be reviewed and confirmed as part of routine dam inspections or risk assessment updates.

## 10.7 NMC EWS Status Levels

There are five NMC EWS Status Levels, which are listed below:

NMC Level 1: The EWS site is fully operational and all sensors are reporting data within the ranges expected for normal operation. There are no safety concerns for the dam and no emergency actions are required.

NMC Level 2: The EWS site alarm has been triggered. The alarm condition indicates site maintenance may be required or that sensor data is outside the range expected for normal operation. Email and text notification messages are sent by the NMC personnel to Flathead Indian Reservation Operations personnel and national EWS administrators. NMC personnel verify that notifications were received. There are no safety concerns for the dam; therefore, no emergency actions are required.

NMC Level 3: The EWS site alarm has been triggered. The alarm condition indicates emergency action may be required because sensor data is reporting a condition that is at or above the threshold for an EAP Response Level 1 (abnormal condition). Email and text notifications are sent to reservation, regional, and national emergency administrators. NMC personnel verify the notifications were received by phone with reservation and regional emergency administrators.

NMC Level 4: The EWS site alarm has been triggered. The alarm condition indicates emergency action may be required because sensor data is reporting a condition that is at or above the threshold for an EAP Response Level 2 (serious condition). Email and text notifications are sent to reservation, regional, and national emergency administrators. NMC personnel verify the notifications were received by phone with reservation and regional emergency administrators.

NMC Level 5: The EWS site alarm has been triggered. The alarm condition indicates emergency action may be required because sensor data is reporting a condition that is at or above the threshold for an EAP Response Level 3 (evacuation condition). Email and text notifications are sent to reservation, regional, and national emergency administrators. NMC personnel verify the notifications were received by phone. If no contact is made with reservation or regional emergency administrators, the NMC will contact the Flathead Indian Reservation Law Enforcement Dispatch Office, which is open 24 hours a day, seven days a week.

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## 11 DAM SECURITY

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### 11.1 Overview

The BIA Dam Security program is intended to reduce the potential for dam failure or damage to dams due to malevolent attacks on dams and dam appurtenances, such as spillways and outlet works. Replacing valuable resources provided by the dam such as water supply, irrigation water, flood control, hydropower, and recreation can have devastating impacts on local communities that could take years to replace. The BIA Dam Security program is also intended to reduce nuisance vandalism and sabotage damage to BIA dams that would not result in dam failure, but may affect dam operations and could result in costly repairs to the facility.

The majority of BIA dams are embankment dams with a variety of spillways and outlet works. Embankment dams are vulnerable to erosion failure and may be easily attacked and damaged by small backhoes or explosives that can be used to create a crater on the dam crest that may initiate dam failure. As a result, restricting vehicle access to the crest of BIA dams may be one of the most effective security provisions. Other common security threats at BIA dams include nuisance vandalism to hydraulic structures, instrumentation, and outlet controls, if these features are accessible to the public.

The BIA SOD Officer is responsible for implementing, maintaining, and monitoring security programs at BIA dams. The BIA Facility Manager is responsible for implementing security procedures for personnel and real property at each BIA dam. The BIA Dam Security program is intended to be consistent with all applicable U.S. Department of Homeland Security (DHS) and DOI guidance documents.

- “Dam Sector Security Awareness Handbook” (DHS, 2007).
- “Dam Sector Protective Measures Handbook.” (DHS, 2007).
- “Dam Sector Crisis Management Handbook” (DHS, 2008).
- “Department Manual,” Law Enforcement and Security, Part 444: Physical Protection and Facility Security, Chapter 1 and 2 (DOI, February 2, 2012).
- “Presidential Policy Directive—Critical Infrastructure Security and Resilience,” Presidential Policy Directive/PPD-21 (February 12, 2013).

Key elements of the Dam Security program include:

Security awareness: Involves understanding the security risks associated with threats, vulnerabilities, and consequences at BIA dams. Security awareness also involves effectively and appropriately communicating these security issues to the BIA’s stakeholders.

Mitigation: Involves continuous assessment of threats and the development of security, recovery, continuity, and an Emergency Response Plan.

Protective measures: Involves installing physical features or modifying operational procedures to minimize the risk and consequences of potential security threats.

For additional dam security definitions, refer to the Definitions section.

## **11.2 BIA Dam Security Requirements**

### **Security Awareness**

Security awareness involves understanding the threats, vulnerabilities, and consequences of attack at BIA dams. Individuals or organized groups who possess the capability and intent to do harm at BIA dams are considered to be threats. Potential threats can originate from one or more of the following:

- adversary nations;
- domestic and international adversary groups;
- disaffected individuals or groups; or
- disgruntled or former employees.

Malevolent attacks on BIA dams can include physical or cyber attacks that are intended to damage facilities, steal equipment or information, or disrupt the mission or resources provided by the dam.

If applicable, security risk assessment or vulnerability assessment reports (also known as security reviews) are prepared to identify the security risks associated with threats, vulnerabilities, and consequences of attacks on a specific BIA dam. Another important aspect of security awareness is effectively and appropriately communicating security issues to the key BIA stakeholders who need to know this information. Security communication also involves effectively encouraging the general public to report suspicious activity at BIA dams (i.e., “If You See Something, Say Something™” public awareness campaign sponsored by DHS).

### **Mitigation**

Mitigation involves the implementation of programs, plans, and protective measures to minimize the security threat or consequences associated with attacks on BIA dams. The likely threats to BIA dams are typically identified in a Security Vulnerability Assessment Report. After threats have been identified they can be tracked through a continuous threat assessment program. These programs may also help identify new threats that may not have been previously recognized. Other mitigation measures may involve preparing the following plans at key BIA dams:

- Security plans: Document existing security systems, responsibilities, and incremental responses and implementation of additional security systems during periods of higher threat levels.
- EAPs.
- Recovery plans: Document procedures to follow after an attack on a BIA dam has caused substantial damage or dam failure. Recovery plans are intended to reduce damage and



downstream impacts. These plans are also intended to reduce economic loss and restore the functions of the dam as soon as possible.

## **Protective Measures**

There are numerous protective measures that may be implemented to improve the security at BIA dams. Many effective measures are relatively simple and cost effective to implement such as installing locks, fences, and vehicle barriers on key features of the dam. Other protective measures involve security forces, training programs, personnel screening programs, and cyber security programs.

The following list is an example of the types of protective measures that may be implemented at Program dams, if determined to be necessary based on the results of a dam-specific security review:

- Wherever possible, prevent the public from driving vehicles on the crest of the dam by installing locked gates or barriers at each end of the dam crest or at other convenient locations on the access road(s) leading to the dam crest.
- Restrict access to any discharge structure with the capacity to make releases exceeding safe downstream channel capacity using barriers and/or structural hardening as appropriate.
- If applicable, the operating controls for any gates or valves should be located within a locked and secure structure.
- The instructions for operating any gates, valves, or other critical equipment should not be accessible or in view of the public and should be locked within secure structures or containers.
- The exterior doors on structures containing operating equipment should be steel, have interior hinges or protected exterior hinges, and have protected deadbolt locks.
- Exterior windows on structures should be protected with bars placed over the interior of the windows.
- Signs such as "No Trespassing" and "Government Property—Authorized Personnel Only" should be posted where the public is not allowed, as appropriate.
- Use chain-link fencing with locked gates to delineate the areas where the public is to be excluded. Track and document the keys to all locks at the dam to ensure only authorized personnel have keys. A key control plan should be in place to change the locks if keys to critical facilities are lost.
- Provide locks on dam instrumentation manhole covers, piezometer casings, and toe drain cleanout access points.

## 12 DAM SAFETY TRAINING

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### 12.1 Overview

Keeping up with the advances in the state of the practice in dam safety, particularly developments in risk analysis and risk management for dams, is very important for people involved with the operation, maintenance, and evaluation of BIA dams. This chapter discusses required and recommended dam safety training for Regional SOD Officers, DSSEM branch professional staff, and Dam Operators/Dam Tenders. Local BIA personnel, BIA Agency Superintendents, and local Tribal Council members are also encouraged to participate in dam safety programs to enhance their dam safety knowledge. Dam safety training is considered as recurring or routine activities.

### 12.2 Regional SOD Officer and DSSEM Branch Training

It is recommended that Regional SOD Officers and DSSEM branch professional staff complete the following dam safety training courses:

- Review of the online Dam Safety 101 information provided on the Association of State Dam Safety Officials (ASDSO) website at [www.damsafety.org](http://www.damsafety.org). This information provides some very general, basic dam safety training.
- FEMA Training Aids for Dam Safety (TADS) (all 21 modules). These modules can be obtained for no cost from the FEMA website at [www.fema.gov](http://www.fema.gov), under Publication Number 609DVD. The TADS modules are provided in the following three components:
  - Ten (10) modules on Dam Safety Inspections.
  - Five (5) modules on Dam Safety Awareness, Organization, and Implementation.
  - Six (6) modules on Data Review, Investigation and Analysis, and Remedial Action for Dam Safety.
- Attend a Dam Safety Risk Analysis Best Practices Class sponsored by a professional dam safety organization.
- Safety Evaluation of Existing Dams (SEED) seminar, or other comprehensive dam safety training.
- Dam security training sponsored by the DHS, such as E0260: Dam Security and Protection.
- DOI Dam Safety Conference and BIA Tribal/SOD Conference, when these conferences are held.
- Available dam safety courses on DOI Learn.
- Attend at least one other conference or technical seminar per year that is sponsored through a professional dam safety organization is recommended.
- ICS-100: Introduction to ICS.
- ICS-200: ICS for Single Resources and Initial Action Incidents.
- ICS-700: National Incident Management System, An Introduction.

- ICS-300: Intermediate Incident Command System for Expanding Incidents.
- ICS-400: Advanced Incident Command System.

### **12.3 Dam Operator/Dam Tender Training**

Dam Operators/Dam Tenders play a crucial role in maintaining the safety of the dams where they work, identifying potential dam safety issues at these dams, and in responding to dam safety incidents. As such, it is required that they receive dam tender training a minimum of once every two years. This is typically provided by BIA consultants in conjunction with CR and PR examinations, with dam operator/dam tender training sessions being organized throughout the eight BIA regions. Dam Operators/Dam Tenders are invited to attend the session closest to them in order to meet the training requirement of attending a session at least once every two years. The required training program covers the following topics:

- A description of Dam Operator/Dam Tender requirements, including roles, importance, and qualifications.
- Requirements of inspection and monitoring programs and their importance, such as what to look for and when, instrumentation, inspection of embankments and appurtenant structures (e.g., spillway, outlet works, etc.), frequency of monitoring (including periodic inspections such as CRs, PRs, annual inspections, and routine monitoring), and special inspections.
- Maintenance program requirements and their importance.
- Operating program requirements and their importance (e.g., normal operating procedures vs. emergency operating procedures, security and safety issues, etc.).
- Required reporting procedures for all of the programs (inspection and monitoring, maintenance, and operating programs), including required documentation under both normal and emergency conditions and the required distribution of such documentation.
- Training requirements including the importance of keeping updated on any site-specific training pertaining to operating procedures and specific elements of their individual dam(s), as well as attending Dam Operator/Dam Tender training sessions a minimum of once every 2 years.

In addition to the required Dam Operator/Dam Tender training, it is recommended that BIA Dam Operators/Dam Tenders complete the following dam safety training courses:

- Review of the online Dam Safety 101 information provided on the Association of State Dam Safety Officials (ASDSO) website at [www.damsafety.org](http://www.damsafety.org).
- Ten (10) TADS modules on dam safety inspection. These modules can be obtained for no cost from the FEMA website at [www.fema.gov](http://www.fema.gov) under Publication Number 609DVD.
- ICS-100: Introduction to ICS.
- ICS-200: ICS for Single Resources and Initial Action Incidents.
- ICS-700: National Incident Management System, An Introduction.

Basic training in ICS is available from free online training courses offered by FEMA at <http://training.fema.gov/IS/NIMS.aspx>. More advanced ICS training courses are offered at the Emergency Management Institute or from local, tribal, or State emergency management organizations.

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## DEFINITIONS

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**Abutment:** That part of the valley wall against which the dam is constructed. Left and right abutments are defined on the basis of looking in the downstream direction.

**Annualized Failure Probability (AFP):** The probability of a dam failure occurring in any given year. It is the product of the probability of the load and the probability of dam failure given the load. Annualized failure probability is sometimes equated with Individual Risk.

**Annualized Life Loss (ALL):** The product of the annualized failure probability and the life loss that is expected to result from a dam failure. Annualized life loss is sometimes equated with societal risk.

**Appurtenant Structures:** The structures or machinery auxiliary to dams which are built to operate and maintain dams, including outlet works, spillways, gates, valves, channels, diversion facilities, etc.

**Beaching:** The action of water waves in a reservoir by which finer materials are eroded from a slope (perhaps from beneath a riprap layer) and deposited to form a fairly horizontal shelf. Typically occurs at a reservoir's most common elevation.

**Bedrock:** A general term that includes any of the generally indurated or crystalline materials that make up the Earth's crust. Individual stratigraphic units or units significant to engineering geology within bedrock may include poorly or nonindurated materials such as beds, lenses, or intercalations. These may be weak rock units or interbeds consisting of clay, silt, and sand.

**Borrow:** A source of soil or rock materials used in heavy civil construction such as dam construction.

**Cavitation:** The formation of partial vacuums in fast-flowing water that subsequently implode, releasing substantial energy that can cause damage to flow surfaces and adjacent items, typically initiated by obstructions or offsets in flows, and usually accompanied by noise and vibration.

**Closed Circuit Television (CCTV):** A television system that transmits images on a *closed loop*, where images are only available to those directly connected to the transmission system.

**Conduit:** Typically a pipe, box, or horseshoe structure that is constructed by means of *cut and cover*. A conduit can convey water or house other conduits, pipes, cables, wires, etc.

**Consequence:** Loss based on population at risk, economic impact, mission impact, symbolic value, national security impact, interdependencies, and public behavioral impact.

**Core:** In a zoned embankment, the core is the portion of the embankment having the lowest permeability and is intended to limit the quantity of seepage through the embankment to an acceptable amount.

**Crest:** The highest controllable surface of a structure, such as a dam crest or a spillway crest.

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**Critical Infrastructure:** Systems and assets, whether physical or virtual, so vital to the bureau/office mission that the incapacity or destruction of such systems or assets would have a debilitating impact on daily operations, economic security, public health or safety, or any combination thereof.

**Cutoff Trench:** An excavation in the foundation of an embankment dam below the original streambed elevation that is intended to reduce underseepage.

**Cutoff Wall:** A wall of impervious material (e.g., concrete, cement-bentonite, or steel sheet piling) located in the foundation beneath the dam which forms a water barrier to reduce underseepage.

**Dam:** An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material; built for the purpose of storage or control of water.

**Dam Failure:** An uncontrolled release of water from a dam.

**Dam Height:** The vertical difference between the lowest point in the original streambed at the dam axis (or the crest centerline) and the crest of the dam.

**Dam Operator/Dam Tender:** The person responsible for the daily or routine operation and maintenance activities of a dam and its appurtenant structures. The dam operator/tender commonly resides at or near the dam.

**Dam Safety Deficiency:** A dam safety deficiency is an existing condition of a dam that would result in a dam failure under one or more related credible failure modes, and presents enough of a threat to the safety of the downstream public and property to warrant action(s) to address the condition/situation. Dam safety deficiencies evolve from an assessment of a dam's condition, performance, loadings, expected response, and other factors.

**Dead Pool:** Water that cannot be released from the reservoir through spillways, outlet works, power plants, or all other designed appurtenance of the dam because the water lies below the invert elevation of the lowest water release feature at the dam.

**Drain:** A feature designed to collect water and convey it to a discharge location. Typically, a drain is intended to relieve excess water pressures.

**Drill:** A drill is a type of operations based exercise, which is employed to test a single specific operation or function in a single agency. Drills are commonly used to provide training on new equipment, develop or test new policies or procedures, or practice and maintain current skills such as making contacts to check the information included in the Emergency Action Plan's communications directory.

**Dynamic Stability:** The stability of a structure under earthquake loading. For embankments and foundations, dynamic stability is typically evaluated in terms of whether predicted deformations

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or movements that might result from earthquake shaking are significant enough to result in excessive crest settlement, or a liquefaction-type failure.

**Emergency:** A condition that develops unexpectedly, which endangers the structural integrity of a dam or downstream human life or property, and requires immediate action.

**Emergency Action Plan (EAP):** A formal written document for emergency management personnel and dam operators/dam tenders to follow during emergency situations or unusual occurrences at a dam to reduce the potential for downstream life loss and property loss, and to provide proper notification to downstream authorities.

**Emergency Classification:** The act of classifying an emergency at a dam, to determine the severity of the emergency condition, and the proper response to prevent a dam failure; and to reduce life loss and property damage, should the dam fail.

**Expedited Action (EA):** An expedited action situation exists relative to a potential failure mode for a dam when the estimated probability of development of the failure mode and/or the estimated life loss associated with the potential failure mode indicate a situation where BIA risk guidelines are violated by a factor of 10 or more.

**Event Tree:** Progression of logical events in a failure mode analysis, leading ultimately to dam failure.

**Facility:** Structures, buildings, dams, grounds, real property and/or office space occupied by a DOI component whether owned, leased, or controlled by the DOI or BIA.

**Failure Mode:** A specific way a dam could reasonably be expected to fail. The loadings and the unique characteristics of the dam (as it currently exists) and its foundation in response to the loadings are central to the development of potential failure modes.

**Filter:** A material or constructed zone of earth fill that is designed to permit the passage of flowing water through it, but prevents the passage of significant amounts of suspended solids through it by the flowing water.

**Floodplain:** Low area that is inundated by water during flooding.

**Foundation:** Soil or rock materials upon which a dam is built. Foundation materials that are consolidated into rock or rock-like material may be referred to as bedrock, while unconsolidated materials may be referred to as surficial materials.

**Freeboard:** The difference in elevation between the reservoir water surface and the dam crest.

**Full-Scale Exercise:** An activity in which emergency preparedness officials respond in a coordinated manner to a timed, simulated incident but includes the mobilization of field personnel and resources and the actual movement of emergency workers, equipment, and resources required to demonstrate coordination and response capability. This type of exercise is

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intended to evaluate the entire emergency organization or its major parts in an interactive manner over a substantial period of time. It mobilizes emergency officials in an emergency operations center plus the activation of one or more emergency functions outside of the center.

**Functional Exercise:** An activity in which participants respond in a coordinated manner to a timed, simulated incident that parallels a real operational event as closely as possible. This exercise is generally conducted in an emergency operations center or incident command post, and messages are passed to the participants in written form, by telephone (landline or cellular), radio, fax, email, text, or other method of communication. The functional exercise uses information such as emergency plans, maps, charts, and other information available in a real event and creates stress by increasing the frequency of messages, intensity of activity, and complexity of decisions and/or requirements for coordination. It does not involve actual mobilization of emergency response forces in the field. Participants will include management, key agency staff, and personnel from outside organizations as appropriate.

**Groin:** The line of contact between the face of the dam (upstream or downstream) and the abutment.

**Guard Gate:** The first gate in a series of flow controls, remaining open virtually all the time, but closed during some emergencies or maintenance repair.

**Hazard Classification:** The rating for a dam based on the potential consequences of failure. The rating is based on potential threat to life and damage to property or cultural resources that failure of the dam could cause.

**Head:** The vertical difference, typically expressed in feet, between two water surface elevations.

**Head Cutting:** Erosion due to flowing water that drops rapidly from a higher elevation to a lower elevation (and consequently has significant energy to dissipate, thus leading to the erosion), that progresses over time in an upstream direction.

**Hydraulic Height:** The vertical height difference between the lowest point in the original streambed at the dam axis (or the centerline crest of the dam) and the maximum controllable water surface (which often is the crest of an uncontrolled overflow spillway).

**Hydrologic Hazard:** The relationship between flood loading parameters and their probability.

**Hydrograph:** A relationship between flow rate and time during a hydrologic event.

**Individual Risk:** Individual risk is the sum of the risks from all failure modes associated with the hazards that affect a particular person.

**Inflow Design Flood (IDF):** The flood which is used to design a specific dam and its appurtenant structures, particularly for sizing the spillway and for determining surcharge storage requirements.



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**Internal Erosion:** The process of erosion of dam or foundation soils by flowing water, resulting in the loss of embankment fill or foundation soils.

**Inundation Map:** A map of the flooding limits downstream of a dam showing the probable encroachment by water released because of dam failure of the dam.

**Issue Evaluation (IE):** An engineering evaluation and risk analysis process used to determine if a potential failure mode actually represents a dam safety deficiency that needs to be addressed.

**Landslide:** The movement of a mass, debris, or earth down a slope.

**Liquefaction:** A sudden loss of strength in saturated soils caused by an increase in pore pressure during earthquake shaking.

**Logbook:** A dated, written record of performed operation and maintenance items, and observations pertinent to a dam or structure.

**Major Mission Critical (MMC) Dam:** A MMC dam is considered as vital to a specific region of the United States. The inoperability or destruction of these facilities would have a devastating impact on regional security as well as the region's economy, public health, and safety.

**Mitigation:** Activities and/or systems designed to reduce or eliminate risks to persons or property or to lessen the actual or potential effects or consequences of an incident. Mitigation measures may be implemented prior to, during, or after an incident and are often developed in accordance with lessons learned from prior incidents.

**National Critical Infrastructure (NCI) Dam:** NCI dams are considered as facilities so vital to the Nation that incapacity or destruction of such facilities would have a devastating impact on the US economy.

**Outlet Works:** An outlet (conduit or tunnel) in a dam through which normal or emergency releases from the reservoir can be made.

**Overtopping:** Inundation of a structure by rising flood water. When used in an embankment dam, overtopping occurs when the reservoir level is higher than the dam crest.

**Performance Parameters:** Measurable and observable indicators of dam performance specifically related to dam safety and potential failure modes, such as seepage flows, piezometric levels, and ground movements.

**Phreatic Surface:** The top of the zone of saturation in an embankment.

**Physical Protection System:** An integrated system of detection (appropriate law enforcement/security force is notified as soon as possible after a security incident occurs), delay (combination of the security force and physical attributes designed to slow an incident in order to

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provide an effective response time), and response (interdict and neutralize the incident thus eliminating the immediate threat).

**Physical Security:** Measures that prevent or deter the overall risk to DOI assets, systems, networks, or their interconnecting links resulting from exposure, injury, destruction, incapacitation, or exploitation. Physical security includes actions to deter the threat, mitigate vulnerabilities, or minimize consequences associated with a terrorist attack or other incident. These measures can include a wide range of activities, such as hardening facilities/structures, building resiliency and redundancy, incorporating hazard resistance into initial facility design, initiating active or passive countermeasures, installing security systems, promoting workforce security, and implementing cyber security measures, among various others.

**Piezometer:** A device for measuring the pore water pressure at a specific location in earthfill or foundation materials.

**Piping:** The removal of dam embankment or foundation material by flowing water through a continuous opening along the flow path that progresses upstream from a downstream exit location, and can lead to dam failure.

**Population-At-Risk (PAR):** Those people located within the inundation limits resulting from flooding caused by a dam failure.

**Potential Failure Mode (PFM):** Postulated mechanism of physical events that would lead to a failure of a dam.

**Probable Maximum Flood (PMF):** A hypothetical flood for a given drainage basin such that there is virtually no chance of its being exceeded. It is the maximum runoff estimated by combining the most severe meteorological and hydrologic conditions.

**Probability of Failure:** Product of the likelihood of a structural load and the probability of an adverse structural response.

**Punch-List:** List of work remained to be completed that are identified during final inspection at the end of a construction.

**Record Drawings:** Construction drawings prepared after construction showing as-constructed configurations and features.

**Recovery:** Involves fulfilling the humanitarian needs of people affected by the emergency and can include temporary relocation of the affected downstream population and reconstruction of damaged property affected by the emergency. The recovery phase begins immediately after the threat to downstream life has ended.

**Regulating Gate:** A gate used to regulate the rate of flow through an outlet works.

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**Reservoir Evacuation:** The release or draining of a reservoir through an outlet works, spillway, or other evacuation features at the dam.

**Reservoir Restriction:** An operational limitation for a storage reservoir to below the normal operation level to reduce dam failure risk.

**Residual Risk:** The portion of the risk that is leftover after taking corrective action(s).

**Riprap:** Rock fragments, rock, or boulders placed on the upstream slope of a dam to provide erosion from wave action, or in spillways or outlet works to provide scouring protection from flowing water.

**Risk:** The probability of adverse consequences. When viewed in the context of the potential for dam failure due to the occurrence of one or more potential failure modes, it is defined based on the estimated Annualized Failure Probability (AFP) and Annualized Life Loss (ALL) for the potential failure mode(s) in question. When viewed in a dam safety and security context, it refers to the relationship or coexistence between consequences, vulnerabilities, and threats.

**Risk Analysis:** Use of available information to estimate the risk to individuals or populations, property, or to the environment, from hazards.

**Risk Assessment:** Process of making a decision recommendation on whether existing risks are tolerable, including consideration of all important and related cultural, economic, social, environmental, cost and other factors, and present risk control measures that are adequate, and if not, whether alternative risk control measures are justified or should be implemented.

**Risk Control:** Selective application of appropriate techniques and management principles to reduce either the likelihood of an occurrence, or its adverse consequences, or both.

**Risk Estimation:** The process of quantifying probabilities and consequences for all credible and significant failure modes.

**Risk Identification:** The process of determining what can go wrong, why, and how.

**Risk Management:** Systematic application of management policies, procedures and practices to the tasks of identifying, analyzing, assessing, mitigating, and monitoring risk.

**Risk Matrix:** Tool for ranking and displaying components of risk in an array.

**Safe Channel Capacity:** The discharge into the receiving river or stream which threatens inhabited buildings, established recreational areas, or causes overtopping of public use roads.

**Security Assessments:** An evaluation of assets or facilities that includes an analysis of the security and physical protection conditions at an asset/facility/structure in order to identify gaps and overall resiliency to specific hazards.

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**Security Plan:** A written document describing the practices, procedures, responsibilities, and equipment that provide for the security of assets/facilities. A security plan may be a stand-alone document, or may be part of Standard Operating Procedures (SOPs), Operations and Maintenance (O&M) manual, Emergency Action Plans (EAPs), or other similar documents, as appropriate for the facility/structure.

**Seepage:** Flow through a dam, its foundation, abutments, or appurtenant structures.

**Seismic Hazard:** The relationship between earthquake loading parameters and their probability.

**Shell:** A shell zone in a zoned embankment typically is provided upstream and downstream of the core of the embankment to provide stability to the dam embankment.

**Societal Risk:** Probability of adverse consequences from hazards that impact on society as a whole and create a socio-political response because multiple fatalities occur in one event.

**Spillway:** An appurtenant structure in a dam that regulates the normal pool and/or passes flood flows. A dam may have more than one spillway.

**Static Stability:** The stability of a structure under non-seismic operating conditions. Static stability is typically evaluated as a factor of safety against sliding or overturning.

**Stilling Basin:** A component in a hydraulic structure used to dissipate the hydraulic energy.

**Structure:** For the purposes of this Handbook, a structure is a monument, building, dam, grounds, and/or other real property whether owned, leased, or controlled by DOI or BIA that does not fit the definition of a Federal facility or a National Critical Infrastructure (NCI) as defined in 444 DM 1 or 444 DM 2.

**Structural Height:** The vertical distance from the lowest point of the excavated foundation to the crest of the dam.

**Sunny Day Dam Failure:** Mode of dam failure scenarios under normal reservoir operating conditions on a rainless day or night.

**Tabletop Exercise:** An informal activity involving discussions of actions to be taken based on described emergency situations. A tabletop exercise is done without time constraints, which allows the participants to practice emergency situation problem solving, evaluate plans, policies, and procedures, and to resolve questions of coordination and assignment of responsibilities. A series of messages are issued to participants in the exercise, and they respond to the simulated incident in a low stress atmosphere. Participants are encouraged to discuss issues in depth and develop decisions through slow-paced, problem solving rather than the rapid, spontaneous decision making that occurs under actual or simulated emergency conditions. This exercise will involve management, key agency staff, and personnel from outside organizations as appropriate.

**Threat:** An indication of possible violence, harm, or danger.

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**Toe Drain:** Drain pipe located at or near the toe of the dam to collect and convey seepage to a downstream outfall.

**Tolerable Risk:** The risk that society is aware of and is willing to live with in order to enjoy certain benefits because it is confident that the benefits are worth the risk and the risk is being properly monitored and controlled.

**Total Risk:** Sum of the annualized failure probability and annualized life loss for all potential failure modes associated with a structure.

**Value Engineering:** Evaluation process to identify construction cost savings.

**Vulnerability:** The weakness or susceptibility in the physical protection system that could be exploited by an adversary or disrupted by a natural hazard.

**Weir:** A device designed to allow the accurate measurement of the flow rates at a pipe outfall or seepage collected at ground surface.

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## COMMON ABBREVIATIONS AND ACRONYMS

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AAR/IP	After-Action Report and Implementation Plan
A/E	Architects and Engineers
AEP	Annual Exceedence Probability
AFP	Annualized Failure Probability
AISC	American Institute of Steel Construction
ALARP	As Low as Reasonably Practicable
ALL	Annualized Life Loss
ASDSO	Association of State Dam Safety Officials
ASTM	American Society for Testing and Materials
BCR	Benefit Cost Ratio
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
CCTV	Closed Circuit Television
CFS	Cubic Feet per Second
CMP	Corrugated Metal Pipe
CR	Comprehensive Review
CSI	Construction Specification Institute
CSSL	Cost to Save a Statistical Life
CX	Categorical Exclusion
DOC	Designer's Operating Criteria
DOI	US Department of the Interior
DSAT	Dam Safety Advisory Team
DSC	Dam Safety Category
DSPR	Dam Safety Priority Rating
DSSEM	Dam Safety, Security, and Emergency Management
DSUR	Dam Safety Urgency Rating
DWP	Division of Water and Power
EA	Expedited Action
EAP	Emergency Action Plan
EAS	Emergency Alert System
EIS	Environmental Impact Statement
EM	Emergency Management
EOC	Emergency Operations Center
EWS	Early Warning System(s)
FAR	Federal Acquisition Regulations
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FONSI	Findings of Not Significant Findings
FOSI	Findings of Significant Findings
FOUO	For Official Use Only

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FRR	Facility Reliability Rating
GIS	Geographic Information System
GPM	Gallons per Minute
GPRA	Government Performance and Results Act
GRM	Guidelines for Routine Monitoring
HDPE	High Density Polyethylene
HHA	Hydrologic Hazard Analysis
HHC	Hydrologic Hazard Curve
HMR	Hydrometeorological Report
HSEEP	Homeland Security Exercise and Evaluation Program
IC	Incident Command
ICS	Incident Command System
IDF	Inflow Design Flood
IE	Issue Evaluation
ICS	Incident Command System
IFHA	Incremental Flood Hazard Assessment
IPSOD	Irrigation, Power, and Safety of Dams
IRRM	Interim Risk Reduction Measure
L-23	Schedule for Periodic Monitoring (form L-23)
LEOP	Local Emergency Operations Plan
MMC	Major Mission Critical
NCI	National Critical Infrastructure
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NID	National Inventory of Dams
NIMS	National Incident Management System
NMC	National Monitoring Center
NOAA	National Oceanic and Atmospheric Agency
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
O&M	Operations and Maintenance
OMUR	Operation and Maintenance Urgency Rating
OSHA	Occupational Safety and Health Administration
OVIC	Ongoing Visual Inspection Checklist
PAR	Population-At-Risk
PGA	Peak Ground Acceleration
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PFM	Potential Failure Mode
PFMA	Potential Failure Mode Analysis
PIO	Public Information Officer

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POF	Probability of Failure
PR	Periodic Review
PRM	Portfolio Risk Management
PSHA	Probabilistic Seismic Hazard Analysis
PT	Pressure Transducer
RCC	Roller Compacted Concrete
RDSR	Reduce Dam Safety Risk
RFI	Request for Information
RMC	Routine Monitoring Checklist
ROF	Report of Findings
RRI	Risk Reduction Index
RRS	Risk Reduction Study
SEED	Safety Evaluation of Existing Dams
SHPO	State Historical Preservation Office
SOD	Safety of Dams
SLRA	Screening Level Risk Assessment
SPT	Standard Penetration Test
TADS	Training Aids for Dam Safety
TOR	Tolerability of Risk
TRG	Tolerable Risk Guidelines
USACE	US Army Corps of Engineers
USBR	US Bureau of Reclamation
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
USSD	US Society on Dams
VE	Value Engineering



**APPENDIX A QUALITY BASED SELECTION CRITERIA**

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**QUALITY BASED SELECTION CRITERIA  
(RANKING SHEET)**

Note: selection criteria based on (1) evaluations of submitted, (2) review of proposal, or (3) interview with firm.

<b>CRITERIA</b>	<b>WEIGHT (1-10)</b>	<b>RATING (1-4)</b>	<b>SUB-TOTALS</b>
Professional capacity to accomplish the work within a timely manner.		3	
Recent specialized experience and technical competence in SOD Modifications work.		4	
Professional qualification of personnel assigned to this project.		3	
Professional qualification of overall staff.		2	
Past performance on contracts with Government/ Tribal agencies and private industry. Evaluate how many agencies rehired this firm.		2	
Location of firm (located in what State, county, etc.)		1	
Indian preference		1	
Total maximum points = 160	<b>TOTAL</b>		

**Instructions**

Rating: rate A&E firm on a pre-assigned scale of 1-4, with 4 being the highest.

Weight: pre-determined/pre-assigned weights are established with a maximum of 10 points for each category.

# APPENDIX B ROUTINE MONITORING CHECKLIST

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## ROUTINE MONITORING CHECKLIST (RMC)

### GENERAL INFORMATION

DAM: \_\_\_\_\_

PROJECT: \_\_\_\_\_

REGION: \_\_\_\_\_

### SITE CONDITIONS

Observed By: \_\_\_\_\_ Date: \_\_\_\_\_

Reservoir Elev.: \_\_\_\_\_ ft Time: \_\_\_\_\_

Weather: \_\_\_\_\_ Air Temperature: \_\_\_\_\_ °F

Monitoring Method	Monitoring Schedule
Ongoing visual observations (see checklist below)	Check one: <input type="checkbox"/> Annual <input type="checkbox"/> Quarterly <input type="checkbox"/> Monthly <input type="checkbox"/> Weekly <input type="checkbox"/> Daily <input type="checkbox"/> Special:
Seepage flows measurements	Check one: <input type="checkbox"/> Annual <input type="checkbox"/> Quarterly <input type="checkbox"/> Monthly <input type="checkbox"/> Weekly <input type="checkbox"/> Daily <input type="checkbox"/> Special:
Piezometers and observation wells	Check one: <input type="checkbox"/> Annual <input type="checkbox"/> Quarterly <input type="checkbox"/> Monthly <input type="checkbox"/> Weekly <input type="checkbox"/> Daily <input type="checkbox"/> Special:

Monitoring Method	Monitoring Schedule
Movement monuments	Check one: <input type="checkbox"/> Annual <input type="checkbox"/> Quarterly <input type="checkbox"/> Monthly <input type="checkbox"/> Weekly <input type="checkbox"/> Daily <input type="checkbox"/> Special:
Other instrumentation(s):	Check one: <input type="checkbox"/> Annual <input type="checkbox"/> Quarterly <input type="checkbox"/> Monthly <input type="checkbox"/> Weekly <input type="checkbox"/> Daily <input type="checkbox"/> Special:

## **ONGOING VISUAL OBSERVATIONS (see Note 1 and 2 below)**

### **1. Upstream Slope of the Dam:**

- a. Any evidence of significant erosion due to wave action?  No  Yes
- b. Any sinkholes, sloughs, or areas of unusual settlement?  No  Yes
- c. Any evidence of whirlpools in the reservoir?  No  Yes

### **2. Dam Crest:**

- a. Any cracks, either transverse or longitudinal?  No  Yes
- b. Any sinkholes or areas of unusual settlement?  No  Yes

### **3. Downstream Slope of Dam:**

- a. Any new seepage areas or wet areas?  No  Yes
- b. Any evidence of materials being transported by seepage flows (such as discolored seepage water or sediment deposits)?  No  Yes
- c. Any sinkholes, sloughs, new bulges, or areas of unusual settlement?  No  Yes

### **4. Downstream Toe Area, and Areas Downstream of the Dam:**

- a. Any evidence of materials being transported by seepage flows at existing seepage areas (such as discolored seepage water or sediment deposits)?  No  Yes
- b. Any new seepage areas or wet areas?  No  Yes
- c. Any changes in conditions at other existing seepage areas or wet areas?  No  Yes
- d. Any sinkholes, sloughs, or areas of unusual settlement?  No  Yes

### **5. Outlet Works:**

- a. Any new or enlarged cracks, or spalls in concrete?  No  Yes

- b. Any evidence of unusual deformations or displacements?  No  Yes
- c. Any changes in seepage or evidence of sediment transport at cracks, weepholes, or the weir?  No  Yes
- d. Any unusual flow patterns or conditions during releases?  No  Yes
- e. Any operational problem of gates and valves?  No  Yes

**6. Spillway:**

- a. Any new or enlarged cracks, or spalls in concrete?  No  Yes
- b. Any evidence of unusual deformations or displacements?  No  Yes
- c. Any material in the spillway inlet channel due to rockfall or sloughing that would significantly obstruct flow to the spillway?  No  Yes
- d. Any evidence of erosion and scouring caused by recent spillway discharges?  No  Yes
- e. Any new seepage?  No  Yes
- f. Any unusual flow patterns or conditions during discharges?  No  Yes

**7. Additional Information:**

- a. Provide additional information concerning any of the above questions that were answered "YES": \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

- b. Other Observations: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## **NOTES AND REMARKS**

1. A “YES” response should be given to question(s) in the checklist above where observed conditions are different from previously observed conditions. Re-reporting conditions that have previously been reported and currently are unchanged should not be done (a “NO” answer would be appropriate). For any question answered “YES,” please provide additional information describing the situation as completely as possible under item 7, “Additional Information.” Also, take photographs and include them with this report, as appropriate.
2. All descriptions should include specific location information and all other seemingly relevant information. Seepage area descriptions should include: estimated seepage amount and water clarity description (clear, cloudy, muddy, etc.). Crack descriptions should include orientation and dimensions. Descriptions of changes at joints should include the estimated amount of movement, and movement direction. Deteriorated or spalled concrete descriptions should include degree of deterioration and approximate dimensions of the affected area.
3. To the extent possible, perform inspections and obtain instrumentation readings at times when no precipitation has occurred in the preceding 48 hours. If this is not possible, then report the amount and time of the precipitation within the last 48 hours.
4. Perform visual observations following a major earthquake nearby where ground motions can be felt.
5. Perform visual observations at the conclusion of a large flood event that results in a large spillway release, reservoir level near the dam crest, or embankment overtopping.

## **REGIONAL SAFETY OF DAMS (SOD) CONTACTS**

If unusual conditions or emergency situations develop, follow the procedures stated in the Operations and Maintenance (O&M) manual and the Emergency Action Plan (EAP). Contact the Regional SOD Officer immediately to determine appropriate actions and special adjustments to monitoring schedules:

**Regional SOD Officer:** \_\_\_\_\_

**Telephone:** \_\_\_\_\_

**Email:** \_\_\_\_\_

## APPENDIX C DAM SAFETY INCIDENT REPORT TEMPLATE

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### DAM SAFETY INCIDENT REPORT

(Post-incident Final Report)

**Name of Dam:**

**Location:**

**Event Name** (Flood Operations, Earthquake, Structural Problem, etc.):

**Date** (MM/DD/YYYY):

1. **Incident Overview and Purpose of Report**
2. **General Project Description/Background/Reservoir Operating Scheme**
  - a. Dam Location (distance to nearest city/town, residing in which county, tribal nation, etc.).
  - b. Description of Dam and Appurtenant Features including: year built, dam as-built condition and detailed description (height, crest width, crest length, base width, operating mechanisms including maximum discharge capacities of each) storage capacity, purpose of reservoir, description of drainage basin, etc.
  - c. Description of Ownership, Roles and Responsibilities of Operations, and Dam Safety decision making at the dam. Include other operational interests if appropriate.
  - d. Description of the Downstream Safe Channel Capacity.
3. **Description of Event:** Establish the facts for the event and develop a picture of what occurred. This information should provide the reader with a summary/overview of what happened involving the dam, upstream and downstream communities, when it happened, and what was done in response to the incident.
  - a. Hazard description including: flooding, sunny day structural issue at the dam, missed operation, seismic event, etc.
  - b. Event chronology/timeline including: date, notable event, response (include who did what and when they did it).
  - c. Incident/Event control operations:
    - i. Reservoir Operations/Control Scheme including: forecasting (inflow, outflow, etc.), how reservoir forecasting was performed, and how well the operation worked during the incident.
    - ii. Pre-incident measures taken to improve stability of the dam including:

flood response, cleaning wells, armoring seepage areas, removing propane/fuel storage tanks, removing low water crossing over the downstream channel, etc.).

- iii. Response actions for the safety of the dam including: investigations made/forensics, structural remediation, retrofitting, armoring, new construction, etc.
  - iv. Inspection/Monitoring activities: Who, when, was monitoring in accordance with the schedule for monitoring (L-23), ongoing visual inspection checklist (OVIC), or routine monitoring checklist (RMC)? What was the monitoring frequency (daily, 24 hour, weekly, etc.)? What format was used to record monitoring observations? How were those observation conveyed to decision makers for the dam?
  - v. Resource coordination: List internal and external resources required for management of the incident (personnel, facilities—EOC description and location—Mobile Incident Command Post at the dam, heavy equipment, stockpile materials, operators, etc.), planning and coordination meetings internal and external, reporting requirements (format, timeline, etc.).
  - vi. Communications: Identify the communication systems used to manage the incident? Were new or temporary systems installed and used during the event?
  - vii. EAP Activation Levels: Include the dates when Emergency Response Level declarations were made, escalated and terminated, public information meetings held (when, where, and with whom), notifications made, etc.
  - viii. Incident Management: Describe how resources and tasks were managed (e.g., using Incident Command System (ICS) to establish chain of command and unity of command), initial size-up (situation) report, written Incident Action Plans to identify tasks to be completed for a given operational period, including reports and forms, etc.
  - ix. Downstream considerations including: flood fighting efforts, emergency declaration details, evacuations, damages, etc.
4. **Issues, Conclusions, and Action Items:** Identify the issues faced during the incident. Include discussion and conclusions regarding the issue, and any recommended action items needed to resolve the issue.
- a. Analyze cause and effect:
    - i. Focus on WHAT happened, WHAT was done, and WHO took action.
    - ii. Provide progressive refinement for drawing out explanations of what occurred (this will lead into developing possible solutions).

- iii. **Identify Areas for Improvement:** Focus on items you can fix, rather than external forces outside of your control.
  - iv. **Identify Areas to Sustain/Maintain Strengths:** Identify areas where groups, protocol, policies, etc. are performing well and that should be sustained.
5. **General Conclusions about the Incident:** Describe the overall facility performance, effectiveness of the management documents used to manage the incident (EAP, SOP/O&M Manual, Incident Action Plans, Flood Operations Manual, etc.), effectiveness and cooperation among agencies (both internal to the management agency and external with other non-owner agencies), etc.
6. **Post-Incident Improvement Plan:** The improvement plan should be consistent with the agency's Corrective Action Program format including at a minimum: Recommendation No., Action Type (Descriptor), Remedial Action Statement, Responsible Party, and Scheduled Completion Date. Be specific about actions, timelines, and responsibilities.
- a. What changes, additions, or deletions are recommended to EAPs, SOPs, protocol, follow-up investigations, other plans, or training, etc.?
  - b. What issues were not resolved to your satisfaction and need further review?
  - c. New recommendations resulting from the incident should be SMART (Specific, Measurable, Achievable, Realistic, and Time Bound).
7. **Signature Page:** Include Author and Peer Reviewers.
8. **Report Submittal:** This report should be filed in your respective agency official file locations within each of the responsible offices for the dam (Regional Office, Central Office, etc.).
9. **Attachments (suggested list of attachments if available):**
- a. Photo log of the event: photos of the facility and response actions (include date, dam name, and photo caption).
  - b. Incident Action Plans created to manage the incident.
  - c. Reservoir Operations Briefing Reports.
  - d. Media Coverage: newspaper articles, press releases, etc.
  - e. Instrumentation Plots generated during the incident.
  - f. Map of Impacted Area: location maps, incident maps, etc.