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ENGINEERING AND DESIGN

SAFETY OF DAMS - POLICY AND PROCEDURES

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CHAPTER 1

Introduction

1.1 Purpose. The safety of dams is a major concern of the Corps of Engineers, just as it has been since the Corps began building dams in the 1840's. The purpose and intent of this regulation[1] is to ensure that responsible officials at all levels within the Corps of Engineers implement and maintain a strong dam safety program in compliance with *"Federal Guidelines for Dam Safety"*, reference 47. The program ensures that all dams and appurtenant structures are designed, constructed, and operated safely and effectively under all conditions, based on the following definitions of dam safety and dam safety program purposes, as adopted by the Interagency Committee on Dam Safety **(**ICODS**)**.

1.1.1. *Dam Safety:* Dam safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe functioning is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate, to the extent reasonably possible, any unacceptable risks.

1.1.2. *Dam Safety Program:* The purposes of a dam safety program are to protect life, property, and the environment by ensuring that all dams are designed, constructed, operated, and maintained as safely and effectively as is reasonably possible. Accomplishing these purposes require commitments to continually inspect, evaluate, and document the design, construction, operation, maintenance, rehabilitation, and emergency preparedness of each dam and the associated public. It also requires the archiving of documents on the inspections and history of dams and the training of personnel who inspect, evaluate, operate, and maintain them. Programs must instill an awareness of dams and the hazard potential that they may present in the owners, the users, the public, and the local and national decision-makers. On both local and national scales, program purposes also include periodic reporting on the degree of program implementation. Key to accomplishing these purposes is to attract, train, and retain a staff proficient in the art and science of dam design.

1.2 Applicability. This regulation applies to HQUSACE elements, major subordinate commands (MSC), districts, and the Engineer Research and Development Center (ERDC), having responsibility for planning, site selection, design, construction, operation, maintenance,

[1] This regulation supersedes EP 1110-2-13 dated 28 June 1996, ER 1110-2-50 dated 22 August 1975, ER 1110-2-100 dated 1 December 1998, ER 1110-2-101 dated 31 January 1993, ER 1110-2-110 dated 8 July 1985, ER 1110-2-1155 dated 12 September 1997, and ER 1110-2-1156 dated 31 July 1992.

inspection, evaluation, and rehabilitation of dams and appurtenant structures. The portions of this regulation on Reporting Distress, Periodic Inspection and Continuing Evaluation, and Instrumentation also apply to levees, floodwalls, drainage structures, pump stations, and navigation structures not associated with dams.

1.3 References. Required references are listed in Appendix A.

1.4 Glossary. Abbreviations and terms, which may not be familiar to the reader, are defined in Appendix B.

1.5 Scope. This regulation prescribes the policy, organization, responsibilities, and procedures for implementation of dam safety program activities within the Corps of Engineers to ensure continued safety, structural integrity, and operational adequacy of Civil Works water control facilities. The regulation combines a number of previous regulations to provide a single document for the overall dam safety program. The dam safety program is a corporate program involving many organizations within Headquarters U. S. Army Corps of Engineers (HQUSACE), the Major Subordinate Commands (MSC's), the districts, and the Engineer Research and Development Center (ERDC), including engineering, construction, operation and maintenance, and program and project management, throughout the life cycle of applicable projects. Commanders and managers at all levels are responsible to ensure that sufficient highly qualified personnel are available to meet project purposes and that programs related to dam safety are established and funded to achieve compliance with the requirements herein.

CHAPTER 2

General Considerations

2.1 History of Dam Safety. A history of dam safety within the Corps of Engineers, and how it relates to dam safety in the nation, is provided in Appendix C.

2.2 Federal Guidelines for Dam Safety.

2.2.1. *Presidential Memorandum:* In 1977, President Carter issued a memorandum directing three actions:

2.2.1.1. That all Federal agencies having responsibility for dams conduct a thorough review of their practices that could affect the safety of these structures and report their findings to the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET).

2.2.1.2. That FCCSET prepare the "Federal Guidelines for Dam Safety" for use by all Federal agencies.

2.2.1.3. That an Interagency Committee on Dam Safety (ICODS) be established to promote and monitor Federal and state dam safety programs.

2.2.2. *Publication of Guidelines:* In 1979, the "Federal Guidelines for Dam Safety" was published, and ICODS was given oversight responsibility for dam safety. The key management practices outlined in the guidelines (Federal Emergency Management Agency 1979, reference 47) are

Establish a Dam Safety Officer and appropriate staff,
Maintain an updated inventory of dams,
Document design criteria and construction activities,
Prepare initial reservoir filling plans and reservoir regulation criteria,
Prepare operation and maintenance instructions and document activities,
Maintain a training and awareness program,
Prepare and maintain Emergency Action Plans (EAP's) for each dam,
Establish a program of periodic inspections and evaluation of dams, and
Monitor and evaluate the performance of each dam and appurtenant structure and provide remedial construction as necessary.

2.2.3. *Implementation of Guidelines:* The "Federal Guidelines for Dam Safety" requires each agency responsible for the design, construction, operation, or regulation of a dam project to be structured with a single identifiable, technically qualified head responsible for ensuring that all management and technical safety aspects of dam engineering are adequately considered throughout the development and operation of the project. That position must have continuity of guidance and direction, and authority and resources to ensure these responsibilities can be carried out. To comply with this portion of the Guidelines, the Chief of Engineers has designated a

Corps of Engineers Dam Safety Officer by General Order. This regulation further defines the requirements and responsibilities of the Dam Safety Officers at each level of the command.

2.3. Levels of Responsibility for Dams.

2.3.1. *Categories of Dams:* The Corps of Engineers involvement in dams can be categorized as follows:

2.3.1.1. Category 1: Dams the Corps of Engineers owns, operates, and maintains. This includes appurtenant structures such as navigation locks, powerhouses and Corps' owned levees that retain permanent pools, whose failure could potentially yield loss of life, or environmental or economic damage.

2.3.1.2. Category 2: Dams the Corps has designed and constructed, but are operated and maintained by others. Ownership remains with the Corps of Engineers.

2.3.1.3. Category 3: Dams the Corps has designed and constructed, but are operated and maintained by others. Ownership is transferred to the sponsor.

2.3.1.4. Category 4: Dams designed, constructed, operated, maintained, and owned by others where flood control storage is provided at Federal expense under the authority of the 1944 Flood Control Act (Section 7 Dams).

2.3.1.5. Category 5: Dams designed, constructed, operated, maintained, and owned by others and later modified by the Corps for the owner.

2.3.1.6. Category 6: Dams where the Corps has issued permits under its regulatory authority.

2.3.1.7. Category 7: Dams inspected and evaluated by the Corps under the authority of the National Program for the Inspection of Non-Federal Dams, PL 92-367.

2.3.2. *Responsibilities:* In categories 1 and 2, the Corps of Engineers is responsible for dam safety. For dams in category 3, the primary dam safety responsibility is with the agency or sponsor who accepted project ownership. The Corps' responsibility is to fulfill the requirements of the Project Cooperation Agreement (PCA), including periodically inspecting the project to evaluate its performance and maintenance. In category 4 the Corps maintains pertinent data on the project and participates in inspections to ensure that the Federal flood control interest is properly maintained. In category 5 the Corps assumes a legal liability when work is accomplished by the Corps to modify the dam. For categories 6 and 7, the Corps has no legal liability or financial responsibility for dam safety.

CHAPTER 3

Management of Corps of Engineers Dam Safety Program

3.1. General. The Corps of Engineers maintains a three-level decentralized organization, HQUSACE, MSC, and district. Each level shall be staffed with qualified personnel in areas of design, construction, inspection and operations of dams and appurtenant structures, commensurate with the level of risk to the public from a dam failure. Each organizational level shall have a Dam Safety Officer with supporting organization as outlined in this chapter.

3.2. Overall Responsibility for Dam Safety Program. The Commanders at each level of the Corps of Engineers have the ultimate responsibility for the safety of dams within their commands. Each commander shall ensure that the organization has a dam safety program, which complies with the "Federal Guidelines for Dam Safety" and the Corps of Engineers policy and criteria. The commanders exercise this responsibility through officially designated Dam Safety Officers at each level.

3.3. Headquarters, US Army Corps of Engineers.

3.3.1. *Organization:* The Corps of Engineers Dam Safety Officer (DSO) is the Senior Executive Service member (SES) in charge of the Engineering and Construction Community of Practice. A Special Assistant for Dam Safety and the Corps Dam Safety Program Manager support the Corps DSO. The Corps of Engineers Dam Safety Program Management Team (CEDSPMT) and the HQUSACE Dam Safety Committee provide additional advice and support to the Corps DSO concerning the program. The standing HQUSACE Dam Safety Committee includes the USACE Dam Safety Officer, the Special Assistant for Dam Safety, the Corps Dam Safety Program Manager, the National Inventory of Dams Program Manager, plus other members with extensive knowledge and expertise in the programming, planning, design, construction, operations, and maintenance of dams. Other individuals from the various communities of practice within the Corps of Engineers may be included as members of the committee.

3.3.2. *Responsibilities and Qualifications* (reference 51)*:*

3.3.2.1. Corps of Engineers Dam Safety Officer: The Corps of Engineers Dam Safety Officer (DSO) shall be a registered professional engineer. As Corps DSO, this individual is responsible directly to the Chief of Engineers for all dam safety activities. The Corps DSO coordinates dam safety activities with the various elements of the Directorate of Civil Works and informs the Director concerning the condition of Corps dams. The Corps DSO is responsible for ensuring that the Corps of Engineers maintains a proactive dam safety program, implementing all practices and procedures outlined in the "Federal Guidelines for Dam Safety". The Corps DSO is responsible for establishing policy and technical criteria for dam safety, and prioritizing dam safety related work. The Corps DSO or designated representative(s) shall represent the Department of Defense on the National Dam Safety Review Board (NDSRB) and ICODS. The Corps DSO ensures that programs to implement dam safety needs and to monitor the activities at the various levels of the Corps are established. The Corps DSO serves as chair of the HQUSACE Dam Safety Committee. The Corps DSO shall assess the Corps dam safety

activities utilizing the best available techniques and programs, and periodically report to the Director of Civil Works and Chief of Engineers.

3.3.2.2. Special Assistant for Dam Safety: The Special Assistant acts for the USACE Dam Safety Officer in the execution of daily program activities and serves as Chairman of the Corps of Engineers Dam Safety Program Management Team (CEDSPMT). The Special Assistant shall have a civil engineering background, be a registered professional engineer with management abilities, be competent in the areas related to the design, construction, operation, inspection or evaluation of dams and understand adverse dam incidents and the potential causes and consequences of dam failure. The Special Assistant works for and reports directly to the USACE Dam Safety Officer. The Special Assistant represents the Dam Safety Officer in the development of the budget submission, working with the appropriate Business Line Managers to ensure that dam safety priorities are addressed. The Special Assistant serves as the Department of Defense and/or Corps of Engineers representative on various national teams as directed by the USACE Dam Safety Officer.

3.3.2.3. Corps Dam Safety Program Manager: The Dam Safety Program Manager (DSPM) shall be a registered professional engineer with management abilities and have knowledge and experience in the design, construction, operation, inspection, or evaluation of dams. The Dam Safety Program Manager conducts the daily activities for the overall dam safety program and serves as the Recording Secretary of CEDSPMT. The DSPM coordinates the review of dam safety reports and prepares Corps-wide dam safety budget submissions. The Dam Safety Program Manager works in close coordination with the Special Assistant for Dam Safety. The DSPM serves as the Department of Defense and/or Corps of Engineers representative on various national teams as directed by the USACE Dam Safety Officer. The DSPM shall issue, at least annually, an updated membership list for the HQUSACE Dam Safety Committee and the Corps of Engineers Dam Safety Program Management Team.

3.3.2.4. Corps of Engineers Dam Safety Program Management Team: The CEDSPMT shall be organized in accordance with Appendix D of this regulation. The team shall meet as required to review and recommend changes to Corps of Engineers Dam Safety policy. This team periodically reviews and evaluates policy, technical criteria and practices, administrative procedures, and regulatory functions for adequacy to support the agency's dam safety program. Functions include oversight of design, construction, operation, maintenance, inspection, evaluation, and rehabilitation programs to improve internal practices related to dam safety. An annual review of the status of Emergency Action Plans and dam safety training shall be accomplished. This team shall also perform the following functions:

3.3.2.4.1. Review and evaluate USACE dam safety practices, procedures, policies, directives, regulations, technical criteria, administrative procedures, and regulatory functions for consistency and adequacy to support the Corps' dam safety program.

3.3.2.4.2. Review experience and qualifications of dam safety staffing at all levels within the Corps to assess competency and review MSC funding requirements for achieving program requirements.

3.3.2.4.3. Make recommendations for future research and development in areas related to dam safety.

3.3.2.5. HQUSACE Dam Safety Committee: The Committee serves as technical advisors to the Dam Safety Officer and shall meet at least annually or as needed. The Committee members are encouraged to participate in periodic inspections and make field visits as necessary, and shall perform the following functions:

3.3.2.5.1. Review reports and make recommendations on dam safety modifications to the Assistant Secretary of the Army for Civil Works through the USACE Dam Safety Officer.

3.3.2.5.2. Review and evaluate the status of the Corps overall dam safety program and specific issues forwarded to the HQUSACE from MSC's and districts.

3.3.2.5.3. Ensure data for each dam are current in the inventory of dams.

3.3.2.5.4. Review the research and development program to ensure the latest technologies related to dam safety receive consideration and evaluation.

3.4. Major Subordinate Commands (MSC) (Regional Headquarters).

3.4.1. *Organization and Qualifications* (reference 51):

3.4.1.1. Dam Safety Officer: The MSC Dam Safety Officer (DSO) shall be a registered professional engineer reporting directly to the Commander on dam safety issues. The MSC DSO shall have a civil engineering background, be a registered professional engineer with management abilities, be competent in the areas related to the design, construction, operation, inspection or evaluation of dams and understand adverse dam incidents and the potential causes and consequences of dam failure. The MSC Dam Safety Officer normally shall be the SES who is responsible for the engineering elements of the organization. When the SES is not a Registered Professional Engineer, the Commander shall appoint/reassign/recruit a DSO who meets the technical qualifications and experience, for example, the Chief of the Business Technical Division as the MSC Dam Safety Officer. The Dam Safety Officer shall serve as the Chairman of the MSC Dam Safety Committee.

3.4.1.2. Dam Safety Committee: The standing committee shall include the Dam Safety Officer and Dam Safety Program Manager plus additional members as required. The members should include the various technical engineering disciplines from within the MSC headquarters. Other disciplines and areas of expertise may be represented, as required by the Dam Safety Officer or Commander. The MSC Dam Safety Committee should meet at least annually and preferably twice a year.

3.4.1.3. Dam Safety Program Manager: Dam Safety Program Manager shall be a registered professional engineer with management abilities and be knowledgeable and have experience in the design, construction, operation, inspection, or evaluation of dams. The Dam Safety Program Manager conducts the daily activities for the MSC dam safety program. The DSPM coordinates the review of dam safety reports. The DSPM works with the programs budget managers to ensure that dam safety requirements are included and properly prioritized in budget submissions. The DSPM serves on various national teams as requested by the USACE Dam Safety Officer. The DSPM shall issue, at least annually, an updated membership list for the MSC Dam Safety

Committee. The MSC Dam Safety Program Manager shall report directly to the Dam Safety Officer.

3.4.2. *Responsibilities:* The MSC Dam Safety Officer is responsible for quality assurance, coordination, and implementation of the MSC dam safety program in accordance with the MSC Dam Safety Program Management Plan. In this capacity the MSC DSO must establish procedures to ensure that the MSC DSO is fully advised on all dam safety issues. Quality assurance responsibilities include:

3.4.2.1. Ensuring that the organization is staffed with qualified personnel for program implementation and to meet program requirements.

3.4.2.2. Establishing dam safety related work priorities and ensuring that these priorities are addressed during budget development.

3.4.2.3. Ensuring that an independent technical review is conducted of the inspection, evaluation, and design for all features of dam projects.

3.4.2.4. Ensuring, in technically complex cases, that the project development team includes members from the MSC and HQUSACE starting early in the process to ensure that the analytical methods and processes used by the district comply with policy and criteria.

3.4.2.5. Ensuring that adequate exploration and testing is accomplished in all stages of design, construction, operations, and modification of water control projects.

3.4.2.6. Ensuring that adequate performance monitoring and evaluations of all dams are conducted and documented.

3.4.2.7. Ensuring that Emergency Action Plans are maintained and regularly updated.

3.4.2.8. Establishing and monitoring a public awareness program and coordinating with State agencies as required.

3.4.2.9. Ensuring that adequate dam safety training and dam safety exercises are being conducted.

3.4.2.10. Ensuring that accurate data are submitted for the inventory of Corps dams.

3.4.2.11. Monitoring and participating in dam safety exercises.

3.4.2.12. Conducting quality assurance activities for all features of civil works dam projects, including review of district dam safety related plans.

3.4.2.13. Participating in periodic inspections and field visits to ensure that the district programs are conducted in accordance with the district quality control plans and requirements of this regulation. The MSC should also verify that the district inspection team composition is appropriate for the project features, that members of the team are trained, and that the project has a current Emergency Action Plan.

3.4.2.14. Reviewing and approving periodic inspection reports in accordance with Chapter 6 of this regulation.

3.4.2.15. Monitoring the performance of district dam safety programs including DSPMT, upward reporting, and submitting data to HQ for NID and biennial reports to Congress.

3.4.3. *Coordination with District Commands:* District Dam Safety Officers and Dam Safety Program Managers should be invited to MSC Dam Safety Committee meetings for interaction on regional dam safety issues. The MSC Dam Safety Committee should periodically meet at a district or project location. A representative from the MSC Dam Safety Committee should participate in district Dam Safety Committee meetings whenever possible.

3.5. District Commands.

3.5.1. *Organization and Qualifications* (reference 51)*:* The district Dam Safety Officer shall have a civil engineering background, be a registered professional engineer with management abilities, be competent in the areas related to the design, construction, operation, inspection or evaluation of dams and understand adverse dam incidents and the potential causes and consequences of dam failure. The District DSO shall generally be the chief of the engineering organization. The district Dam Safety Officer shall Chair the district Dam Safety Committee. The District Dam Safety Program Manager shall also be a registered professional engineer with knowledge and experience in the design, construction, operation, inspection, or evaluation of dams. The Dam Safety Program Manager shall report directly to the Dam Safety Officer. The Dam Safety Committee includes the Dam Safety Officer and the Dam Safety Program Manager, plus additional members as required. The members should include various technical engineering disciplines from within the District. Other disciplines and areas of expertise may be represented, as required by the Dam Safety Officer or Commander.

3.5.2. *Responsibilities:* The district Dam Safety Officer is responsible for ensuring that the dam safety program is fully implemented and documented, in accordance with the district Dam Safety Program Management Plan. The Dam Safety Committee, advisory to the Dam Safety Officer, should meet at least twice annually and forward meeting minutes electronically in MS-Word format to the MSC. The districts shall notify the MSC Dam Safety Program Manager of the date and time of upcoming committee meetings and invite the MSC to send representative(s) to the meeting. District DSO responsibilities include, but are not limited to:

3.5.2.1. Ensuring that organizational staff of qualified technical and field personnel is sufficient for program implementation.

3.5.2.2. Monitoring and evaluating the performance of all dams and appurtenant structures and recommending remedial measures when necessary. Collecting data for the NID and biennial reports to Congress. Monitoring and reporting dam safety items using the Dam Safety Program Management Tools (DSPMT). A description of the DSPMT database is given in Appendix E.

3.5.2.3. Establishing priorities for dam safety related work. The Dam Safety Officer, as a member of the district Corporate Board, shall defend the list of dam safety work priority items.

Dam safety work items are any work items impacting the safety, operation, and structural integrity of the project. The DSPMT shall be used to track priorities over time.

3.5.2.4. Ensuring that dam safety training of technical staff and project operation and maintenance personnel is conducted.

3.5.2.5. Ensuring each dam has an adequate surveillance plan.

3.5.2.6. Ensuring adequate independent technical reviews for inspection, evaluation, and design for dams and appurtenant structures are accomplished. The Dam Safety Officer shall certify that all design documents and periodic inspection reports have been subjected to an independent technical review and that the documents and reports are technically adequate.

3.5.2.7. Ensuring that adequate exploration and testing are accomplished during design and construction of civil works water control projects.

3.5.2.8. Performing periodic inspections, other inspections, and field visits. Periodically evaluating the district's dams, appurtenant structures, and other water control projects using current criteria.

3.5.2.9. Coordinating and participating with local and State dam safety officials in the inspection and evaluation of non-Federal dams, upon request.

3.5.2.10. Ensuring that dam safety products are developed in accordance with documented district Project Management Business Processes. Quality Assurance/Quality Control shall be performed and certified.

3.5.2.11. Monitoring the dam safety aspects of the district's Water Control Management Program.

3.5.2.12. Monitoring and reporting any evidence of operational restrictions or distress, including earthquake effects, of dams and appurtenant structures.

3.5.2.13. Ensuring that each dam owned by the district has an up-to-date Emergency Action Plan in accordance with Chapter 10 of this ER. Ensuring that annual coordination and review is accomplished, including review of emergency notification procedures. Emergency Action Plans should be distributed to and coordinated with all affected local agencies to use as a basis for preparing their evacuation plans. Identifying and contacting appropriate State or local officials to recommend evacuation plans be developed in accordance with Chapter 10 of this regulation and ER 1130-2-530 (reference 44).

3.5.2.14. Establishing dam safety public awareness programs and coordinating them with local interests. Maintaining emergency notification procedures for utilization in a dam safety emergency situation and for use during dam safety exercises. Public awareness programs shall also be established for all types of levees and water control facilities.

3.5.2.15. Maintaining awareness of security related activities, issues, and initiatives at dams and related structures. Ensuring that the security program and the dam safety program activities and initiatives are coordinated.

3.5.2.16. Monitoring ongoing planning, design, and construction of project modifications for dam safety for adequate funding, and ensuring that they are executed in accordance with this ER or other applicable regulations.

3.5.2.17. Coordinating with city, county, and State dam safety officials concerning their review requirements for projects initiating the design phase. Ensuring completed projects are properly turned over to the local project sponsor with a complete set of project documentation.

3.5.2.18. Reviewing proposed design changes to district water control projects under construction and providing dam safety input at design change meetings.

3.5.2.19. Ensuring that all completed water control projects have a complete set of project documentation as outlined in Appendix F of this regulation.

3.5.2.20. Ensuring that the district has an up-to-date Dam Safety Program Management Plan.

3.5.2.21. Ensuring that each dam safety related report or design has a Quality Control Plan and that the final product is certified with a Quality Control Certificate upon completion.

3.5.2.22. Ensure structural and operational modifications to Corps owned dam projects do not diminish factors of safety or limit the ability to make flood releases.

3.6. Professional Registration. Dam Safety Officers, Dam Safety Program Managers, and various other positions providing final approval of engineering products and services to ensure the protection of life, property and the environment, are required by ER 690-1-1212 (reference 25) to be registered professionally. It is intended and desirable that the Dam Safety Program Manager at every level be a registered professional engineer. However, the Dam Safety Officer may approve the selection of a highly qualified registered professional geologist as the Dam Safety Program Manager when filling the position. Persons holding Dam Safety Program Manager positions without professional registration at the time this regulation takes effect may continue in the position until they move to another position or retire.

CHAPTER 4

Planning and Design Process

4.1. General. The civil works planning and design process for a new dam or for modification of an existing facility is continuous, although the level of technical detail varies with the progression through the different phases of project development and implementation. The phases of the process are reconnaissance, feasibility, pre-construction engineering and design (PED), construction, operation and maintenance[2], and finally decommissioning and removal. Detailed guidance on each phase is given in ER 1110-2-1150 (reference 34). The scope of this chapter and Chapter 5 concern only issues and activities related to dam safety.

4.2. Dam Safety During the Planning Phase.

4.2.1. *During Reconnaissance Phase:* During the reconnaissance phase, the Project Delivery Team (PDT) develops a Management Plan. All Design Documentation Reports (DDR's), manuals, plans, and reports, including the Emergency Action Plan (EAP), Control of Water Plan (during construction), Initial Reservoir Filling Plan, Embankment Surveillance Plan, Project Security Plan, Instrumentation Plan, O&M (or OMRR&R) Plan, Turnover Plan, Water Control Plan (operational), Reservoir Control Report, and post-construction documentation of foundation, materials, and construction shall be identified, scheduled, and resourced in coordination between the PDT and the Dam Safety Officer or his representatives.

4.2.2. *During Feasibility Phase:* During the feasibility phase the project OMRR&R and dam safety requirements shall be discussed with the sponsor and State. The local sponsor shall be informed that they shall be expected to comply with all State and Federal dam safety requirements. A turnover plan for non-Federally operated dams must be prepared to establish definite turnover criteria or date to the sponsor and to identify funding for the first and second periodic inspections. This information shall be documented in the Feasibility Report.

4.2.3. *Project Cooperation Agreement:* Guidance on policy and procedures for the turnover of completed dam projects to local sponsors is given in Policy Guidance Letter No. 39 (reference 59). When the Project Cooperation Agreement is developed during the feasibility phase, the Dam Safety Officer or his representative shall ensure that all dam safety requirements are included in the agreement.

4.2.4. *Water Resources Development Act of 1986 (Section 1202):* All reports to be submitted to Congress for authorization of projects with water impoundment facilities shall include information on the consequences of failure and geologic or design factors which could contribute to the possible failure of such facilities.

4.3. Dam Safety During the Design Phase. During the design phase the Dam Safety Officer, or his representative, shall ensure that the design criteria include the most current dam safety requirements and that the design is properly documented for the project records. Based on

[2] Operation and maintenance is used in this regulation to include both "Operation and Maintenance (O&M)" and "Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)"

experience with existing dams, specific areas of dam safety concerns during the design phase include the following items.

4.3.1. *Design Criteria:* Corps criteria shall be used on all federally funded designs. When the design is being prepared for a sponsor on a cost-reimbursement basis, the district Dam Safety Officer may consider use of state criteria. Deviations from Corps criteria require written concurrence from the Corps Dam Safety Officer.

4.3.2. *Public Safety Awareness:* A policy of public safety awareness shall be adhered to in all phases of design and operation of dam and lake projects to ensure adequate protection for the general public.

4.3.3. *Downstream Lands:* A real estate interest is required in downstream areas where a spillway discharge would create or significantly increase a potentially hazardous condition. Specific guidance on this issue is found in ER 1110-2-1451 (reference 36).

4.3.4. *Low-level Discharge Facilities:* In 1975 a policy was established that all future lakes impounded by Civil Works projects would be provided with low-level discharge facilities capable of lowering the reservoir pool to a safe level within a reasonable time. This feature provides capability for safely responding to unanticipated needs such as repair or major rehabilitation for dam safety purposes. Specific guidance on this issue is found in Chapter 12 of this regulation.

4.3.5. *Instrumentation and Monitoring:* An adequate instrumentation and monitoring system is required by the "Federal Guidelines for Dam Safety" as well as by good engineering practice. The purposes of the instrumentation are to (1) provide data to validate design assumptions, (2) provide information on the continuing behavior of the water control structure, (3) observe the performance of critical features, and (4) advance the state-of-the-art of dam engineering. The rationale for the instrumentation shall be thoroughly documented. An instrumentation plan shall be prepared and documented in the DDR. Although the monitoring system is expected to evolve commensurate with the observed performance of the dam, an initial system shall be designed and constructed to provide a background of data during initial reservoir filling, sufficient to identify problems and to verify design assumptions. Flexibility shall be provided in the program to allow for changes from anticipated foundation conditions that are encountered during construction and/or operations. Specific guidance on design of instrumentation and monitoring systems is given in Chapter 7 of this regulation.

4.3.6. *Operations during Construction:* Safe operation of the dam during the construction of a new dam or modification of an existing dam needs to be considered during the development of the Water Control Plan (ER 1110-2-8156 (reference 40)). These considerations often influence the options selected and may be based on some type of risk assessment conducted by the design teams.

4.3.7. *Initial Reservoir Filling Plan:* The Initial Reservoir Filling Plan (IFP) shall be prepared during construction and documented in the DDR. As a minimum, the documentation on initial reservoir filling shall include:

4.3.7.1. The preferred filling rate and the available options to control the rate of reservoir rise.

4.3.7.2. The surveillance necessary to detect most likely occurring problems.

4.3.7.3. A plan for reading the instruments and evaluating the data.

4.3.7.4. A plan for inspecting the dam and downstream areas.

4.3.7.5. Instructions for observers on conditions or instrumentation readings requiring immediate attention of personnel authorized to make emergency decisions.

4.3.7.6. An emergency plan listing responsibilities, name and/or positions, telephone numbers, and radio frequencies to be used (as appropriate).

4.3.8. *Surveillance Plan:* The Surveillance Plan shall be prepared during construction. As a minimum, the documentation on initial reservoir filling shall include:

4.3.8.1. The surveillance necessary to detect most likely occurring problems.

4.3.8.2. A plan for reading the instruments and evaluating the data.

4.3.8.3. A plan for inspecting the dam and downstream areas.

4.3.8.4. Instructions for observers on conditions or instrumentation readings requiring immediate attention of personnel authorized to make emergency decisions.

4.3.9. *O&M Manual:* The O&M (or OMRR&R) Manual shall be prepared during construction. Specific guidance for preparation of the manual is given in ER 1110-2-401 (reference 33) and ER 1130-2-500, (reference 43),

4.3.10. *Emergency Action Plan:* The EAP shall be prepared during construction. Specific guidance for preparation of the EAP is given in ER 1130-2-530 (reference 44), and in Chapter 10 of this regulation.

4.3.11. *Water Control Plan:* The Water Control Plan (Operational) shall be prepared during construction. Guidance on water control management is available in ER 1110-2-240 (reference 32).

4.4. Cooperation with State Dam Safety Officials. The district shall include state dam safety officials as team members when the new construction or modification will be operated and maintained and/or owned by the local sponsor.

CHAPTER 5

Construction, Operation, and Maintenance Activities

5.1. General. Because significant design changes may occur during construction, it is imperative that the project construction phase be properly documented and that the key designers remain a significant part of the Project Delivery Team until construction is completed. The transition from construction to operation may consist of overlapping activities. Therefore, it is very important that problems encountered during construction be adequately documented and resolved prior to the operational phase. Rigorous and continuous vigilance, checking, and inspection, for as long as the dam is operational, are necessary for dam safety, as problems may occur following many years of trouble-free operation. This is particularly true for untested flood control dams where a significant percentage of the maximum head has not occurred. Guidance on control of construction is available in EM 1110-2-1911 (reference 13). Operations and maintenance policies for flood control operations are covered in ER 1130-2-530 (reference 44).

5.2. Operation and Maintenance Manual. The Operation and Maintenance (O&M) manual provides guidance and instructions to project personnel for proper operation and maintenance of the facility. The O&M manual contains a narrative summary of the critical dam features including design features with safety limits, equipment operating and testing procedures, instrumentation requirements, probable failure modes, a history of problems, and how those problems could adversely affect the structure under stress. The O&M manual shall be prepared during the construction phase and shall be updated as features are added to the project, when equipment is replaced, or when changes in project operations are implemented.

5.3. Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects. ER 1110-1-1901 (reference 28) requires, as part of the permanent project record, documentation of the as-constructed geotechnical and concrete materials aspects of all major, complex and unique engineered projects constructed by USACE, including all subsequent modifications. This report, shall be identified, scheduled, and resourced in the Project Management Plan (PMP). The information and data in this document shall be presented and discussed with the sponsor/owner. The report provides, in a single document, the significant information needed by the sponsor, USACE technical staff, and other team members to become familiar with the project. The report shall facilitate accurate, timely inspections and performance evaluations, and serve as the basis for developing and implementing appropriate and effective modifications, “flood fighting” efforts, and emergency and/or remedial actions to prevent flood damage or required as a result of unanticipated conditions or unsatisfactory performance.

5.4. Instrumentation and Monitoring. All USACE dams and other water control facilities are required to have a level of instrumentation that enables proper monitoring and evaluation of the structure during the construction period and under all operating conditions. Instrumentation systems are also expected to furnish data on structural behavior for application to future designs. Each dam or other water control structure shall have instrumentation to measure hydrostatic pressure, embankment and abutment seepage, foundation underseepage, and displacement of major elements of the structure. Strong motion accelerometers are to be installed in structures located in designated seismic regions in accordance with ER 1110-2-103 (reference 30). After a

project is operational for several years, scheduled maintenance, repair, and replacement of instrumentation shall be part of the normal plan of operation. Instrumentation shall be properly maintained or replaced, as necessary, in order to obtain accurate and timely data. Readings shall be made at scheduled frequency and shall be properly recorded and analyzed. Detailed information on instrumentation for earth and rockfill dams is given in EM 1110-2-2300 (reference 16) and EM 1110-2-1908 (reference 11). Information on instrumentation for concrete dams is given in EM 1110-2-2200 (reference 15) and EM 1110-2-4300 (reference 19). Full reliance shall not be placed on instrumentation alone to find problems or to forecast performance since it is impossible to install sufficient instrumentation to monitor every possible problem area. An extremely important part of the monitoring program is visual observation to determine evidence of distress and unsatisfactory performance (reference 52). Project personnel shall receive training in basic engineering considerations pertaining to major structures, with procedures for surveillance, monitoring, and reporting of potential problems, and with procedures for emergency operations.

5.5. Initial Reservoir Filling.

5.5.1. *General:* Reservoir filling is defined as a deliberate impoundment to meet project purposes and is a continuing process as successively higher pools are attained. The initial reservoir filling is the first test of the dam to perform its design function. To monitor this performance the filling rate should be controlled to the extent feasible, to allow time needed for a predetermined surveillance program including the observation and analysis of instrumentation data (Duscha and Jansen 1988, reference 53).

5.5.2. *Existing Corps Reservoir Projects:* Existing operational projects, where the design maximum pool has not been experienced (thus remaining in initial filling condition), shall be reviewed for compliance with requirements as outlined in paragraph 4.3.7. For those conditions where contingency plans have not been documented and potential danger exists due to filling and/or impounded storage, a Surveillance Plan is required.

5.6. Reporting Distress.

5.6.1. *General:* Evidence of distress in dams, levees, and other water control structures shall be immediately reported to the district Dam Safety Officer. If an engineering evaluation of the evidence of distress indicates the need for immediate remedial action, the Dam Safety Officer shall immediately report such conditions through command channels to the USACE Dam Safety Officer. The USACE Dam Safety Officer shall notify the Director of Civil Works and the USACE Commander, if necessary.

5.6.2. *Procedures:* When evidence of distress is reported to the district Dam Safety Officer, the DSO shall confirm the situation and determine if an engineering evaluation of the condition is needed or remedial measures are required. Initial notification shall be made by telephone (or e-mail for minor distress) to the MSC Dam Safety Officer and Dam Safety Program Manager. The MSC DSO shall notify USACE DSO. If the USACE Dam Safety Officer cannot be contacted, the reporting office shall follow the notification sequence shown in HQUSACE Notification Plan. A narrative summary, with appropriate photographs, endorsed by the MSC Dam Safety

Officer shall follow the initial notification. After actions report shall be prepared and submitted to the MSC and HQUSACE. A post distress inspection shall be performed to evaluate damages or changes caused by any event listed in the following subparagraph. If the distress is significant enough to require operational restrictions, the implementation of restrictions shall be reported as well.

5.6.3. *Evidence of Distress:* Typical evidence of distress to report are:

5.6.3.1. Sloughs, settlement, or slides in embankments such as earth or rockfill dams, levees, and bridge abutments or slopes, spillway slopes or channels, and lock and dam abutments.

5.6.3.2. Evidence of piping or muddy water boils in the area of a structure such as embankments, abutments, dam monoliths, lock walls, or cofferdams.

5.6.3.3. Abnormal increases or decreases of flow from foundation drains, structural joints, or face drains of concrete dams.

5.6.3.4. Any significant increases in seepage quantities through or under embankments or abutments.

5.6.3.5. Any significant change in pore-water pressure in either embankments or their foundations or abutments.

5.6.3.6. Any significant change in uplift pressures under concrete structures.

5.6.3.7. Unusual vertical or horizontal movement or cracking of embankments or abutments.

5.6.3.8. Significant cracking of mass concrete structures, either during construction or after completion.

5.6.3.9. Sinkholes or localized subsidence in the foundation of, or adjacent to, embankments or other pertinent structures critical to the safe operation of the project.

5.6.3.10. Excessive deflection, displacement, or vibration of concrete structures (e.g., tilting or sliding of intake towers, bridge piers, lock walls, or floodwalls).

5.6.3.11. Erratic movement, binding, excessive deflection, or vibration of outlet and spillway gates and large flow control devices.

5.6.3.12. Significant damage to any structure (e.g., barge damage to bridge piers or lock walls or ice flow damage to intake towers and access bridge piers).

5.6.3.13. Significant damage to, or changes in, structures, foundations, reservoir levels, groundwater conditions, and adjacent terrain as a result of seismic events. Special inspections for damages shall be made immediately following the event as described in ER 1110-2-1802 (reference 37).

5.6.3.14. Excessive vibration, binding, unusual noises, movements, or deflections of gate hoist operating equipment.

5.6.3.15. Actual hydraulic equipment operating pressure in excess of 125 percent of the normal operating pressure. Electric motor operating equipment overheating or stalling.

5.6.3.16. Erratic movement or unusual sounds, such as bumping, jumping, or popping of lock miter gates.

5.6.3.17. Wire lifting cables or lifting chains having broken strands or deformed, worn, or severely corroded links.

5.6.3.18. Frequent power interruptions.

5.6.3.19. Excess movement of penstock flexible couplings.

5.6.3.20. Penstocks or turbine spiral cases that show signs of distress such as deformation or cracking.

5.6.3.21. Failure of major mechanical or electrical equipment at local flood protection projects or locks and dams.

5.6.3.22. Any other indications of distress or potential failure that could inhibit the operation of a project or endanger life and property.

5.6.4. *HQUSACE Notification Plan:* The notification plan is published electronically with copies to all Dam Safety Officers and Dam Safety Program Managers. It shall be updated each January, or as needed, to ensure that names and telephone numbers are current and accurate. If none of the individuals on the notification plan can be reached, the HQUSACE Operations Center should be notified at (202) 761-1001.

5.7. Dam Safety Training. The "Federal Guidelines for Dam Safety" requires that field office employees be trained in problem detection, evaluation, and appropriate remedial (emergency and non-emergency) measures. The district Dam Safety Officer must ensure that a sufficient number of personnel are trained to ensure adequate coverage at all times. ER 1130-2-530 (reference 44) provides specific guidance on dam safety training requirements for operations and maintenance personnel and contractors at high hazard potential dams. All new field employees and field contractor personnel shall have a minimum of 6 hours training shortly after starting duty and at least 6 hours refresher training every four years. The project staff, using material provided by the district Dam Safety Officer, should conduct the initial training at the project. Emergency Management and Dam Safety technical experts should conduct the four-year refresher training. All formal training shall be documented. Chapter 11 of this ER provides additional detail on the various types of dam safety training available.

5.8. Modifications to Completed Projects. In general, modifications to completed projects may be made under existing authority for changes in: project operation, real estate interest, physical alteration of a project feature, the addition of project features, or changes in the purposes of a project. However, if the modification serves new purposes or increases the scope of services beyond that intended at the time of authorization, or to extend services to new beneficiaries, the modification requires reauthorization by Congress. All modifications (including those for environmental or other purposes) must be evaluated to ensure there are no adverse impacts to project performance, and must be approved by the Dam Safety Officer.

5.9. Rehabilitation of Dams for Dam Safety. Rehabilitation or modification of Corps of Engineers dams for qualifying dam safety purposes is accomplished through the Dam Safety Assurance Program or the Major Rehabilitation Program. Repairs and modifications not applicable to these programs shall be accomplished under the Operations and Maintenance program.

5.9.1. *Dam Safety Assurance Program:* The Dam Safety Assurance Program provides special cost sharing in accordance with Section 1203 of Water Resources Development Act (WRDA) of 1986 for modification of completed Corps of Engineer dams to eliminate certain safety concerns related to hydrologic and seismic deficiencies. Chapter 8 of this ER provides guidance on the Dam Safety Assurance Program.

5.9.2. *Major Rehabilitation Program:* The Major Rehabilitation Program is designed to accomplish significant, costly, one-time structural rehabilitation or major replacement work. Other repairs related to dam safety are accomplished under the normal Operation and Maintenance program or the Dam Safety Assurance Program. The Major Rehabilitation Program restores the project to its original condition to serve as originally intended. Modifications to improve project operational efficiency can be accomplished under this program. Non-emergency repairs of stability and seepage are also applicable under this program. Specific requirements for this program are found in Chapter 9 of this regulation.

5.9.3. *Operations and Maintenance Program:* Normal repair and rehabilitation work that does not qualify for funding under either the Dam Safety Assurance Program or the Major Rehabilitation Program shall be funded under the regular O&M Program. Work recommended in the Periodic Inspection Report shall be prioritized and funded through this program unless qualifying under another program.

CHAPTER 6

Periodic Inspection and Continuing Evaluation

6.1. Applicability and Policy.

6.1.1. *Applicability:* This chapter on Periodic Inspection and Continuing Evaluation is applicable to all Civil Works structures including dams, navigation structures, levees, flood walls, pump stations, hurricane protection structures and other water control facilities.

6.1.2. *Institutional Knowledge and Technical Expertise:* It is essential that the Corps maintain institutional knowledge and technical expertise in the disciplines related to dam design and safety. An important component of this knowledge is gained by conducting periodic inspections and evaluations by district and MSC engineering, construction, and operations personnel. Lessons learned by multi-disciplinary inspection teams over a long period of observations and analyses could be applied to the design, construction, operation, and maintenance of existing and future projects. Districts are responsible for all decisions made as a result of the inspection program; therefore the periodic inspections of significant and high hazard potential structures shall not be contracted. Where manpower constraints exist, inspections may be augmented, in order of preference, by (1) use of Corps of Engineers personnel from other districts, or other MSC's, on a fully reimbursable basis; or by (2) contracting for qualified personnel as inspection participants and/or for specialized functions, such as underwater diving or camera work, or other tasks requiring special skills or equipment not available in the district. Care must be taken to maintain in-house capability for the on-site conduct of the program and continue to keep the involved disciplines (design, construction, and operations personnel) fully integrated in project inspections. This does not imply the necessity for maintaining all technical disciplines in all districts.

6.1.3. *Inspection Policy:* Civil Works structures whose failure or partial failure could result in loss of life or major damage to permanent structures, utilities, or transportation facilities shall be periodically inspected and evaluated to ensure structural stability, safety, and operational adequacy. This policy is to be accomplished as follows:

6.1.3.1. Appropriate instrumentation programs that provide timely and accurate data for evaluations under all operating conditions shall support inspections and evaluations. During periods when a reservoir is or is expected to be above the maximum pool of record or above a threshold level established from past performance, an appropriate team shall be dispatched to monitor and evaluate performance and verify the adequacy of flood and outlet control gates and other equipment, which facilitate downstream releases. A report of performance outlining the findings and evaluation shall be prepared and documented in a memorandum for record (MFR) with copy furnished to the MSC for information within 30 days after the event. Special inspections shall be performed during and immediately after any unusual loading events. Evaluation reports shall provide a basis for initiating timely remedial or rehabilitation measures.

6.1.3.2. The operating entity is responsible for periodic inspections and evaluations (after the first and second periodic inspections) of facilities constructed by the Corps and turned over to others for operation and maintenance. The Corps may conduct subsequent inspections and write a report on behalf of the Project Sponsor, provided appropriate procedural and financial

reimbursement arrangements are made. Inspections shall be conducted in accordance with appropriate guidance contained in the operation and maintenance manual for the facility and in accordance with applicable portions of this regulation. In addition, any inspection responsibilities established by the Project Cooperation Agreement (PCA) shall be related to the operating entity at the time of their acceptance of the structure. Dams built by the Corps and turned over to others for Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) shall include in the Operation and Maintenance (O&M) manual, a requirement that the Corps conducts the first and second inspections and/or first filling inspection in accordance with this regulation. These inspections are to ensure design/construction quality. The Corps is responsible for the first and second periodic inspections. See Policy Guidance Letter No. 39, (reference 59) for Corps and sponsor responsibilities.

6.1.3.3. Under the authority of ER 1130-2-530 (reference 44), the Corps shall participate in inspections of a sponsor operated and maintained structure (e.g., local flood protection project) to ensure that the structure is conforming to the requirements of the PCA, the agreed upon inspection program, and the operation and maintenance program. The Corps participation in these inspections shall be funded under Inspection of Completed Works.

6.1.3.4. In cases where ownership of major elements of a project are divided between the Corps and other organizations, private sector (e.g. power plants), government or municipal, the Corps shall inspect those features of non-Corps elements that could adversely affect the stability, safety, or operational adequacy of the Corps-owned portion of the project, including features not constructed by the Corps.

6.1.3.5. Non-Federal dams located upstream or downstream of a Corps project may potentially affect the safety of the Corps project. When inspecting a Corps structure or project it may be appropriate to evaluate the safety of the upstream or downstream non-Federal dam(s) and to ascertain operational procedures or emergency situations that could make excessive demands on a Corps project. When failure of an upstream non-Federal structure would cause overtopping or other major damage to the Corps project, the Corps shall obtain and review the current comprehensive inspection report, such as a Federal Energy Regulatory Commission (FERC) or State Dam Safety Agency report for the respective structure. If the non-Federal project has not been inspected in the last five years, the Corps shall coordinate with the owner and the regulatory authority to have the dam inspected. Every effort shall be made to encourage owners of such projects to comply with the inspection requirements in the Model State Dam Safety Program (FEMA Publication 316) (reference 48).

6.1.3.6. Federally owned dams (non-Corps) on a military installation might have a substantial bearing on the safety of life and endanger downstream property. The Corps, on request of the installation, may inspect these dams on a cost reimbursable basis. This policy extends to non-Federally owned dams on a military installation where the safety of life and Federal property are in jeopardy from a failure. These inspections shall be performed and documented in the same manner as the inspections of Corps dams, except that the reports should be forwarded to the Installation Management Agency and to the owner of the dam if not owned by the installation.

6.2. Program Implementation. A Periodic (comprehensive) Inspection schedule shall be established based on the project size, importance, or its hazard potential. Other inspections, including intermediate, informal, and annual inspections, may be conducted between Periodic Inspections. MSC Dam Safety Officers are responsible for management and oversight of the inspection program. District Dam Safety Officers are responsible for implementing the inspection and continuing evaluation program.

6.2.1. *Frequency of Inspections:* Inspections of all water control facilities shall be conducted as outlined below:

6.2.1.1. Dams and Appurtenant Structures: All dams shall be inspected without regard to the hazard potential classification of the dam. The guidance for developing the interval for inspections of dams and appurtenant structures set forth in the following subparagraphs does not preclude other inspection intervals as the situation or structural integrity warrants. Nor does this guidance preclude the surveillance plan for the initial filling of Corps reservoirs as prescribed by ER 1110-2-1150 (reference 34) and chapter 5 of this regulation.

6.2.1.1.1. Initial Periodic Inspection: The first periodic inspection and evaluation of a new earth or rock-fill dam shall be carried out immediately after topping out the embankment and prior to impoundment of the pool. The initial inspection of concrete dams shall be accomplished immediately prior to impoundment of reservoir water. However, if involuntary impoundment occurs before the first inspection of either an embankment dam or a concrete dam is accomplished, the inspection shall be performed at that time.

6.2.1.1.2. Second Periodic Inspection: The second periodic inspection for new dams shall be performed no later than one year after impoundment is initiated.

6.2.1.1.3. Subsequent Periodic Inspections: Subsequent inspections for concrete structures and dams, and earth or rock-fill dams and embankments shall be performed at one-year intervals for the next two years. The next two inspections shall occur at two-year intervals and then be extended to a maximum interval of five-years. Inspection intervals more frequent than indicated above shall be scheduled, if conditions warrant, as approved by the district Dam Safety Officer.

6.2.1.1.4. Intermediate Inspections: For projects on a five-year inspection cycle, an intermediate inspection of all or some of the features may be scheduled, if warranted. Selection shall be based on consequences of failure, age, degree of routine observation, a natural event such as an earthquake, performance record and history of remedial measures. Intermediate inspections shall also be made of any portion of a project exposed during dewatering that could not be accomplished during the scheduled periodic inspection. A summary of the findings from intermediate inspections is to be included in the next periodic inspection report. Annual inspections performed by Operations personnel, in accordance with ER 1130-2-530 (reference 44), are considered intermediate inspections for reporting purposes.

6.2.1.1.5. Informal Inspections: Appropriate employees at the project shall make frequent observations of the dam and appurtenant structures. The purpose is to identify and report abnormal conditions and evidence of distress in accordance with training instructions and

guidance. Any unusual conditions that seem critical or dangerous shall be reported immediately using proper procedures and channels, as required by Chapter 5, paragraph 5.6, of this regulation.

6.2.1.2. Navigation Structures: The guidance for developing inspection intervals for dams with locks, set forth in the following subparagraphs differs from flood control dams because of the levels of risk involved. Normally the risk of a navigation dam failure is an economic consequence from loss of the navigation pool, and not the risks to human life in downstream communities. This guidance does not preclude other intervals of inspection as the situation or structural integrity warrants.

6.2.1.2.1. Initial Periodic Inspection: The initial periodic inspection of navigation projects shall be made immediately prior to flooding of cofferdams, culverts or chambers.

6.2.1.2.2. Second Periodic Inspection: A second inspection of new or major-rehabilitated navigation projects shall be made no later than one year after the new operating pool has been attained.

6.2.1.2.3. Subsequent Periodic Inspections: Subsequent inspections are not to exceed five years, without obtaining prior approval of the USACE Dam Safety Officer.

6.2.1.2.4. Intermediate Inspections: Intermediate inspections shall be performed for any portion of a project exposed during dewatering that could not be accomplished during the scheduled periodic inspection. The intermediate inspection reports shall be included in the next periodic inspection report.

6.2.1.3. Other Structures: The district is responsible for establishing periodic inspection intervals, not to exceed five years, for other Corps-owned and -operated structures, including, but not limited to, major levees, floodwalls, channels, pumping stations, and conduits. Inspection intervals must be defined in the project Operation and Maintenance (O&M) manual. Projects designed and constructed by the Corps, but operated and maintained by the sponsor, shall also have inspection intervals defined in the O&M manual.

6.2.1.4. Hydraulic Steel Structures (HSS): ER 1110-2-8157 (reference 41) requires fracture critical members to be inspected every five years and that all HSS be inspected every 25 years, even if dewatering is required. Hydraulic Steel Structures include lock gates, dam spillway gates, tainter valves, flood protection gates, stoplogs, bulkheads, and lifting beams used for installing other Hydraulic Steel Structures.

6.2.1.5. Stilling basins: When feasible, stilling basins shall be dewatered for inspection for each five-year periodic inspection if there have been significant releases through the stilling basin or potential damage or wear is suspected. If no significant releases through the stilling basin have occurred, or there is no suspicion of damage or wear, the dewatering may be deferred until the next five-year periodic inspection. The district Dam Safety Officer may require a diver inspection or hydro-acoustic survey to verify that there is no significant debris in the basin or damage to the structure. When stilling basins cannot feasibly be dewatered, except for

emergency repairs, diver inspections or hydro-acoustic surveys shall be performed at five-year intervals. If there is a need, due to acceleration in erosion damage, then surveys may be necessary every year. Changes in the operational release patterns for environmental or other purposes may warrant more frequent inspections of the stilling basin. After there have been significant releases through the stilling basin or potential damage or wear is suspected, the stilling basin shall be dewatered for a special inspection or an underwater inspection shall be performed immediately after the event.

6.2.2. *Report:* A formal technical report of inspection shall be prepared for permanent record and for reference for needed remedial work for all periodic inspections. This report shall be based on a detailed, systematic technical inspection and evaluation of each structure and its individual components regarding its safety, stability, structural integrity and operational adequacy. Intermediate inspection reports shall be included in an appendix. See Appendix F for report content and format.

6.2.2.1. Inspections or routine observations indicating that the safety of a structure is in jeopardy shall be reported in accordance with Chapter 5, paragraph 5.6, of this regulation.

6.2.2.2. Inspections indicating necessity for project modifications, major repairs, rehabilitation, replacement or need for further study beyond the scope of normal maintenance shall be reported to the MSC Dam Safety Officer in the memorandum transmitting the report. Inspection reports of conditions requiring major modification shall contain a statement as to whether studies shall be pursued under authority of the Major Rehabilitation Program, or the Dam Safety Assurance Program.

6.2.2.3. The Executive Summary of the periodic inspection report shall be provided electronically to HQUSACE Dam Safety Program Manager and the MSC Dam Safety Program Manager within 90 days of completion of the formal inspection. See Appendix F of this regulation for information on preparing and submitting the Executive Summary. The Executive Summary shall also be entered into the Dam Safety Program Management Tools (DSPMT) database.

6.2.3. *Report Completion and Submittal Schedule:* At least two copies of the certified periodic inspection report, including documentation of the independent technical review, shall be submitted by the district to the MSC Dam Safety Officer within 90 days after the inspection. The district shall establish completion and tracking standards for the review of periodic inspection and evaluation reports. The submission shall include all independent technical review comments and the resolution of the comments. The District Dam Safety Officer shall certify the independent technical review and the inspection report prior to submittal to the MSC Dam Safety Officer. Reports Control Symbol (RCS) is exempt based on AR 335-15 (reference 3).

6.2.4. *Report Approval:* The MSC Dam Safety Officer is responsible for approval of the inspection report.

6.2.5. *Obligation to Others:* In cases where ownership of major elements is divided between the Corps and others, information pertinent to the condition of project elements owned by others, as

observed by the Corps inspection team, shall be furnished to the co-owner. The district Dam Safety Officer shall furnish this information to the FERC, when hydroelectric power projects are under the purview of the Federal Power Act (41 Stat. 1063, U.S.C. 791-823) 10 June 1920, as amended (FPA). Owners of such FERC licensed facilities shall be advised that the information made available by the Corps shall not be presented as representing results of inspections performed for the licensee by the Corps and is not a substitute for the FERC inspection under the FPA.

6.3. Instrumentation. Instrumentation shall be continually monitored and data analyzed between inspections to detect changing conditions in the facility. A written evaluation of the instrumentation data shall be included in the periodic inspection report.

6.4. Responsibilities.

6.4.1. *District Dam Safety Officer:* The District Dam Safety Officer shall be responsible for:

6.4.1.1. Formulating the inspection plans, conducting the inspections, processing and analyzing the results of the instrument observations, evaluating the condition of the structures, recommending the schedule of the next inspection, and preparing and submitting the periodic inspection and evaluation reports.

6.4.1.2. Coordinating with the district Operations and Programs & Project Management (PPM) Divisions to ensure sufficient funding for inspections and remedial measures is budgeted in the Operations and Maintenance, General account**,** prioritizing recommended remedial measures as necessary.

6.4.1.3. Notifying Operations Division personnel of scheduled inspections and requesting their assistance and participation. For projects or structures being inspected for the first time, personnel from the Construction Division shall be invited to participate. The appropriate State Dam Safety official(s) shall be invited to attend the inspection. If hydropower is a feature of the project and the project is licensed by FERC, FERC and the licensee shall be invited. The district Operations Division Chief shall ensure that the project staff is prepared during the periodic inspection to operate those project components whose failure to operate properly could impair the operational capability and/or usability of the structure. Where the operation of these components is vital to the safe operation of the project under emergency conditions, the components shall be operated using emergency power to ensure the inspection team that all critical project features will function under emergency conditions or in the absence of the normal source of power. Testing of the emergency power source shall require, if possible, the maximum power demand expected under emergency conditions. Additional details and requirements are described in Appendix F.

6.4.1.4. Forwarding the approved periodic inspection and evaluation report to the district Operations Division for implementation of recommendations. The Dam Safety Officer shall coordinate with Programs and Project Management (PPMD) and Operations Divisions to develop schedule and funding prioritization.

6.4.1.5. Ensuring the inspection team is comprised of expertise necessary to execute a thorough and technically sound inspection. Lacking district expertise, the Dam Safety Officer shall obtain assistance from HQUSACE, MSC, other districts, or by contract. HQUSACE personnel will not normally participate in inspections unless requested or when project conditions dictate. See Appendix F for further details.

6.4.1.6. Ensuring all recommendations made in the inspection report are resolved.

6.4.2. *District Operations Division:* The district Operations Division shall be responsible for:

6.4.2.1. Accompanying the inspection team on the inspection and providing the support required for the inspection.

6.4.2.2. Performing required preliminary inspections, such as Gate Operability and Capability Inspections, and furnishing completed reports to the inspection team.

6.4.2.3. Acting on inspection recommendations in a timely manner in accordance with the deficiency classification table in Appendix F.

6.4.2.4. Completing an annual inspection of all water control projects.

6.4.2.5. Maintaining assurances that sponsors with OMRR&R responsibilities are performing as required under the PCA agreements.

6.4.3. *District Programs and Project Management Division:* The Programs and Project Management Division shall be responsible for supporting the program with proper funding and shall coordinate and cooperate with the project sponsor as needed.

6.4.4. *MSC Dam Safety Officer:* The MSC Dam Safety Officer shall provide quality assurance, oversight and management for this program. As a minimum, the MSC Dam Safety Officer shall:

6.4.4.1. Provide representation at the first and second periodic inspections, the inspection of high hazard potential structures, and the inspection of structures whose condition or performance has warranted more frequent attention.

6.4.4.2. Provide oversight for the monitoring of data collection, processing, evaluation, and inspection activity.

6.4.4.3. Retain approval authority for the frequency and scope of future inspections, and maintain the inspection schedule. Inspection intervals in excess of 5 years require written request and approval by USACE Dam Safety Officer.

6.4.4.4. Establish and maintain an MSC regional database using DSPMT to include periodic inspection schedules and history of project remedial measures, unless this information is otherwise recorded in an official database. The history of remedial measures shall include such

items as project deficiencies, status of deficiencies, completion status and dates, estimates and actual expenditures, funding sources, priority levels, responsible elements, and report number.

6.5. Program Review. At the end of each fiscal year, the district Dam Safety Officer shall review and set priorities for the recommended remedial actions for the next budget submission. The funding priority level codes defined in Appendix F shall be used.

6.6. Reporting Distress. Refer to Chapter 5, paragraph 5.6, of this regulation for procedures when reporting evidence of distress.

6.7. Funding. Periodic inspections and reports shall be budgeted in the minimum funding level of the district's fiscal year budget request for project operation and maintenance. Costs incurred by HQUSACE and MSC's shall be funded from the General Expense appropriation.

6.7.1. *Funding During Construction:* Funding for the inspection and evaluation program during the period of construction shall be under Cost Code 51, Appropriation 96X3122, Construction, General. The term "period of construction" is defined as the period from the issuance of the solicitation for the first construction contract to the date the District Commander notifies the sponsor in writing of the government's determination that construction is complete; or, to the date the Government takes beneficial occupancy (for solely Corps-retained projects).

6.7.2. *Funding During Operations:* Funding for the inspection and evaluation program after the project components are placed in operation shall be under Appropriation 96X3123, Operation and Maintenance, General. Funding for periodic inspections shall be included in the minimum program of the Operations and Maintenance budget submission.

CHAPTER 7

Instrumentation for Safety Evaluations of Civil Works Structures

7.1. Policy. All Civil Works water control projects shall have an adequate level of instrumentation to enable design engineers to monitor and evaluate the safe performance of the structures during the construction period and under all operating conditions. The term "project" includes all dams, appurtenant structures, facilities, levees and any other feature whose failure or malfunction would cause loss of life, severe property damage, or inability to perform the authorized purpose. The district Dam Safety Officer in coordination with the MSC Dam Safety Officer shall ensure that an appropriate level of instrumentation exists at each project, that adequate maintenance is programmed and accomplished, that sufficient effort and funding is devoted to the monitoring program, that timely reduction, interpretation and evaluation of the data occurs and that the technical level of performance evaluation is appropriate.

7.2. General. The planning, design, and layout of an instrumentation program are integral parts of the project design. Instrumentation data are an extremely valuable asset that supplies an insight into the actual behavior of the structure relative to design intent for all operating conditions, establishes performance that is uniquely characteristic to the structure, and provides a basis for predicting future behavior. As structures age and new design criteria are developed, the historical data are relied upon to evaluate the safety of the structure with respect to current standards and criteria. Older structures may require additional instrumentation to gain a satisfactory level of confidence in assessing safe performance. Instrumentation data can be of benefit only if the instruments consistently function reliably and the data values are compared to the documented design limits and historical behavior and the data are received and evaluated in a timely manner. Automation of dam safety instrumentation is a proven, reliable approach to obtaining instrumentation data and other related condition information in a timely manner that allows a more complete and thorough analysis than was previously possible. Automated instrumentation must be periodically calibrated and verified manually. Automation can be valuable when investigating and analyzing performance conditions that require frequent, timely and accurate information. Assistance for instrument automation is available through ER 1110-1-8158 (reference 29).

7.3. Planning.

7.3.1. *Planning Instrumentation:* The design and construction of new projects as well as the rehabilitation, dam safety modifications, and normal maintenance of older projects present opportunities for planning instrumentation systems for the future engineering analyses of structural performance. Careful attention and detail shall be incorporated into the planning of instrumentation systems and programs to ensure that the required information is obtained. Once the parameters that are critical to satisfactory performance are determined by the design, appropriate instrument devices are selected to provide the engineering measurements to the magnitude and precision, and response time necessary to evaluate the parameters. Generally, the types of measurements are:

Horizontal and vertical movement.
Alignment and plumb.
Stresses and strains in soil and rock-fill.
Pore pressure.
Uplift pressure.
Phreatic surfaces.
Seismic effects.
Seepage clarity and quantity.

ER 1110-2-103 (reference 30) gives guidance on instrumentation for seismic effects, including instrumentation, automation, and determination of performance parameters. EM 1110-1-1004 (reference 5) gives guidance on monitoring horizontal and vertical movements. EM 1110-2-2300 (reference 16) provides information on design and construction of earth and rock-fill embankments. EM 1110-2-4300 (reference 19) provides information on instrumentation requirements for concrete structures. EM 1110-2-1908 (reference 11) provides detailed information on all aspects of instrumentation, including staffing qualifications, data management, analysis and long-term reassessments. EM 1110-2-1901 (reference 10) provides information on analysis of seepage.

7.3.2. *Instrumentation System Requirements:* In all circumstances, background information that may affect the validity of the data or the analysis of the performance shall be documented and baseline instrument data for each type of measurement shall be obtained for future comparison. Other considerations include the potential damage during construction, effects of a severe environment on the instruments, maintenance and personnel requirements for data collection and evaluation. Automated systems have additional requirements as follows:

7.3.2.1. Each instrument must maintain the ability to be read manually.

7.3.2.2. Each instrument shall have the capability to be read electronically prior to entering the automated net.

7.3.2.3. The system shall use a microcomputer to act as the network monitor station to collect, process, display and produce a hard copy of the data at the project office or other designated point. This network monitor station must also be capable of performing a quality control check of instrument readings, respond to a preset threshold level, interface with existing project hardware and software applications and have the ability to be queried from the district or other remote location.

7.3.2.4. A backup communication link to the district shall be provided for the data transmission.

7.3.2.5. The automated system does not relieve or replace the normal visual inspection schedule of the project features to include the instrumentation.

7.3.3. In addition to these primary automation requirements, consideration shall also be given to backup power supply, lightning protection, maintenance, vandalism, system diagnosis, and software versatility. It is not recommended that automation be accomplished for all instrument

requirements, but only to achieve those monitoring objectives that require the characteristics of automation, such as the need for remote data acquisition, the need for frequent observation, etc.

7.4. Performance Prediction. During the initial project design, or reevaluation in the case of existing structures, the physical properties of the construction materials, design data, loading conditions and the appropriate factors of safety shall be utilized to determine the desired threshold limits for each performance parameter. Quantitative values shall be established for these limits that can be accurately translated into measurements that are easily and readily obtained in the field, which will enable the designers and operators to evaluate the behavior and performance of the structure. A detailed discussion of the design assumptions shall be presented in the design documentation report (DDR) for new or modified features. The threshold limits along with the predicted performance levels shall be addressed in the project instrumentation DDR and in detailed instructions to project personnel and any other personnel involved with the instrumentation.

7.5. Installation and Maintenance.

7.5.1. *New Projects:* Instrumentation for a project shall be included in the design phase, during construction, and throughout the life of the project as conditions warrant. After a project has been operational for several years, appropriate maintenance, repair, and replacement of instrumentation must be accomplished during the normal operation to ensure continuous data acquisition and analyses of critical performance parameters. Specialized expertise may be required to install and maintain instrumentation.

7.5.2. *Existing Projects:* Existing projects shall be evaluated to ensure that the original instrumentation is functioning as intended and is still appropriate. Threshold limits determined for original design conditions shall be examined, and reviewed against current criteria. The instrumentation plan may require modification to delete some instruments and to add other instruments in area on the project where additional monitoring is required. Changes to the instrumentation should be budgeted through normal operations and maintenance funding procedures.

7.6. Data Collection, Interpretation and Evaluation. The frequency with which instrumentation data are obtained must be tailored to the instrument purpose, period of construction, investigation or other interest, and project operating conditions. In all cases, sufficient calibration and background data shall be obtained to ensure that a reliable database is available to facilitate subsequent comparisons. The subsequent reading of instruments during construction and operating conditions shall be based on an anticipated rate of loading or changes in reservoir levels to be determined by a dam safety engineer familiar with the design and performance parameters of the project. The timely reduction and interpretation of instrumentation data are essential for a responsive safety evaluation of the project. For all Corps projects, this reduction and interpretation shall occur as soon as conditions warrant from the time that the data were obtained. The evaluation of the data shall follow immediately. As a minimum, all data shall be plotted as instrument response with respect to time, as well as to reservoir level or other range of loading. All instrumentation data shall be interpreted and evaluated not less than annually.

More detailed guidance for data acquisition, interpretation and presentation can be found in EM 1110-2-1908 (reference 11) and EM 1100-2-4300 (reference 15).

7.7. Reporting.

7.7.1. Upon completion of new projects or significant modifications to projects, the instrumentation data along with the written evaluation shall be consolidated and submitted to the MSC Dam Safety Officer in accordance with ER 1110-1-1901 (reference 28).

7.7.2. The District Dam Safety Officer shall provide a written summary and evaluation of the district's instrumentation program annually to the MSC Dam Safety Officer. The project information obtained annually shall be included in the periodic inspection report of the project.

7.8. Funding. The appropriate funding (General Investigation, Construction, General and/or Operation and Maintenance, General appropriations) shall be utilized to accomplish the level of instrumentation outlined in this regulation within the time indicated. Funding for maintenance of instrumentation, for data collection, and for data analysis shall be included in the minimum program of the annual Operations and Maintenance budget submission.

CHAPTER 8

Dam Safety Assurance Program

8.1. Dam Safety Assurance Program.

8.1.1. *Section 1203,WRDA, 1986:* The Dam Safety Assurance Program provides for special cost-sharing in accordance with Section 1203 of the Water Resources Development Act of 1986 (reference 67) for modification of completed Corps of Engineers dam projects that are potential safety hazards in light of current engineering standards and criteria. The problems that meet the approval criteria generally fall into two categories: hydrologic and seismic. A third category, changes in the state-of-the-art, could be available if approved by the Assistant Secretary of the Army for Civil Works. The program is intended to facilitate upgrading of those project features that have hydrologic and/or seismic deficiencies related to dam safety in order to permit the project to function safely and effectively. The Dam Safety Assurance Program may also be used to modify dams built by the Corps of Engineers and turned over to local interests to operate, maintain, repair, rehabilitate, and replace.

8.1.2. *Eligibility Requirements:* In order to qualify, the modifications must be within the Chief of Engineers' discretionary authority to rectify, plus meet the eligibility requirements described below. Projects approved under the Dam Safety Assurance Program shall require a Dam Safety Assurance Program Evaluation Report, budget justification, and other supporting data in accordance with the annual budget Engineer Circular as described in ER 5-1-11 (reference 22). Generally, existing project authorities are considered sufficient to permit improvements to the project for safety purposes, if such improvements do not alter the scope or function of the project, or substantially change any of its specifically authorized purposes. The Dam Safety Assurance Program Evaluation Report is a feasibility type report and as such must include all National Environmental Program Act (NEPA) requirements with a record of decision (ROD) when required. In addition, the report shall address the ability or inability of the project to accommodate both current hydrologic/hydraulic and seismic loads. The seismic safety of many existing embankment dams shall be evaluated or re-evaluated in accordance with requirements in ER 1110-2-1806 (reference 38).

8.1.3. *Additional Authorization:* Project modifications that require additional authorization may be studied under the authority of Section 216 of the Rivers and Harbors Act of 1970 (reference 61), following the guidance in Chapter 2 of ER 1105-2-100, (reference 26).

8.1.4. *Other Modifications:* Modifications to project features that do not qualify under this regulation shall be accomplished under the programs funded by the Operations and Maintenance, General, or Flood Control, Mississippi River and Tributaries (FC, MR&T) appropriations, as appropriate.

8.2 Eligibility.

8.2.1. *Eligible Features:* Examples of project features eligible for modification under the Dam Safety Assurance Program are as follows:

8.2.1.1. Modifying existing or constructing new facilities to provide stable and adequate discharge capability to safely pass the Inflow Design Flood (IDF), as defined in ER 1110-8-2(FR) (reference 42).

8.2.1.2. Raising the dam height to prevent overtopping during occurrence of the IDF.

8.2.1.3. Increasing structural stability of the dam, foundation, abutments, and equipment support or other structures to withstand current hydrologic, hydraulic, and/or seismic loading.

8.2.2. *Dams Operated and Maintained by Others:* Dams designed and/or constructed by the Corps of Engineers and turned over to others for operations and maintenance may be modified under this program.

8.2.3. *High Priority List:* Modifications to projects may be proposed for inclusion in the Dam Safety Assurance Program by submitting a letter requesting that the project be placed on the HQUSACE high priority list if all of the below conditions exist. The request shall include a write-up describing the dam safety problem and a summary of the proposed remedial measures and a pertinent data sheet.

8.2.3.1. The work is required for continued safe operation of the project for its authorized purposes.

8.2.3.2. The work does not include additions or betterments, which constitute a change in project, scope, function, or authorized purposes.

8.2.3.3. The work meets applicable criteria, as specified for Dam Safety Assurance projects in the budget EC for the budget year in which it is to be initiated.

8.2.4. *Costs/Benefits:* The total average annual benefits of the existing project shall be greater than the annual costs of the modification plus additional operation, maintenance, repair, replacement and rehabilitation (OMRR&R), if any. In the event that the benefits do not exceed the costs, consideration shall be given to breaching the dam and the rationale for not selecting the breaching option shall be provided if improvement is recommended. Include an economic analysis if the estimated cost of the recommended work is greater than $10 million, or is greater than 25% of the replacement cost of the total project. The economic analysis is to be conducted on a sunk cost basis, i.e., all annual costs associated with the modification would be compared with the total project annual benefits. The results of this analysis shall provide some perspective on the economics of providing the proposed work; however, where there is a significant question of safety, a benefit-to-cost ratio need not be calculated.

8.3 Policy on Hydrologic Criteria. The following policy is used as a basis to make decisions on the merits of dam safety modifications to meet current hydrologic criteria:

8.3.1. *General:* Dam safety modifications related to hydrologic deficiencies shall be recommended to meet or exceed the Base Safety Condition (BSC). The BSC is met when a dam

failure related to hydrologic capacity will result in no increase in downstream hazard potential over the hazard that would have existed if the dam had not failed. Recommendations for any modifications that would accommodate floods larger than the flood identified as the BSC must be supported by an analysis that presents the incremental costs and benefits of the enhanced design in a manner that demonstrates the merits of the recommendation.

8.3.2. *Discussion:*

8.3.2.1. Planning for dam safety assurance program modifications shall consider combinations of structural design modifications as well as nonstructural measures, including downstream actions and changes in water control plans or other influential operating factors. The recommended plan, except when circumstances noted in paragraph 8.3.3.3. below apply, shall be for the dam safety modification that meets or exceeds the BSC. Recommendations for modifications that would accommodate floods larger than the flood identified as the BSC shall require additional analysis as described in paragraph 8.3.2.4. and 8.3.3.2. below.

8.3.2.2. Determination of the flood that identifies the BSC shall require definition of the relationship between flood flows and adverse impacts with and without dam failure for a range of floods that fully utilize the existing structure up to the Probable Maximum Flood (PMF). Selection of a BSC predicated on the potential hazard to life from dam failure requires supporting information to demonstrate that the safety of the population would actually be threatened. The evaluation shall distinguish between total population downstream of a dam and the population that would likely be in a life threatening situation given the extent of pre-failure flooding, warning time available, evacuation opportunities, and other factors that might affect the occupancy of the incrementally inundated area at the time the failure occurs. Appropriate freeboard necessary to accommodate potential wind and wave conditions shall be included for all flood evaluations.

8.3.2.3. The evaluation report shall include a comparative hazard analysis in which the Threshold Flood (TF) and the BSC are established (Phase I). The TF is the flood that fully utilizes the existing dam, i.e., the flood that just exceeds the design maximum water surface elevation at the dam (top of the dam minus freeboard). The BSC is determined by comparing the loss of life and economic damages for various floods, expressed as percentages of the PMF, with and without dam failure. PMF is determined in accordance with standard hydrometeorological procedures. The flood, expressed, as a percentage of PMF, for which loss of life is not different for with-and-without dam failure conditions, is the BSC, but shall never be more than 100% of the PMF.

8.3.2.4. When the evaluation report recommends dam safety modifications for a flood greater that the BSC, a risk-cost analysis (Phase II) is required. This is the more traditional risk analysis where the costs of making the improvements are balanced against the economic losses expected from collapse of the structure. Those losses include the cost of additional downstream damage, the cost of repairing the dam, and the cost associated with the loss of project services.

8.3.3. *Policy Implementation:*

8.3.3.1. A detailed description of the Phase I analysis, including examples, is given in reference 54. The organization and display of the data are vital components of this "comparative hazard analysis" phase, enabling a comprehensive overview of the key considerations and decision variables.

8.3.3.2. The Phase II risk analysis is like a multi-objective decision problem. The justification for increasing the level of dam safety beyond the BSC as a design criterion shall be based on a more subjective weighing and trading off of a number of intangibles and engineering reliability and social factors. These may include, but are not limited to, unique location and population concentration factors, and unique national interest of the specific area that would be affected. The justification for increments of additional safety beyond the BSC requires that the additional risk reduction be explicitly balanced against increased costs. It is imperative that the display of data and weighing rationale is clear so that others in the decision chain can reach an independent conclusion.

8.3.3.3. Selection of a recommended level of modification shall also reflect traditional concerns for economy. Modification costs in the vicinity of the scale of improvement identified as the BSC shall be examined for sudden increases in the cost/scale of improvement relationship. This type of change could occur, for instance, when costly highway relocation is encountered near the scale of improvement identified as the BSC. An adjustment in the level of fix recommended may be warranted under these conditions. On the other hand, the large increase in costs may be justified if a significant reduction in the hazard potential with dam failure versus without dam failure is achieved.

8.3.3.4. Conduct of the analysis shall require careful application of professional judgment for determining those parameters where data and modeling capability are limited. Therefore, the importance of documenting the logic of the assumptions that are critical to the conclusions and recommendations drawn from the analysis cannot be overemphasized. Also, the evaluation will produce a significant amount of information that can be used throughout the decision-making process, particularly in those cases where it is appropriate to proceed beyond the BSC. The information shall be displayed in a format that assists the decision maker when evaluating the important trade-offs involved.

8.3.3.5. Additional information on Hydrologic Criteria is available in EM 1110-2-1420 (reference 6), EM 1110-2-1464 (reference 7), EM 1110-2-1603 (reference 8), EM 1110-2-1619 (reference 9), EM 1110-2-2400 (reference 17), EM 1110-2-3600 (reference 18), ER 1105-2-101 (reference 27) and ER 1110-8-2 (FR) (reference 42).

8.4. Policy on Seismic Criteria. The policy given in ER 1110-2-1806 (reference38) shall be used to make decisions on the merits of dam safety modifications related to current earthquake design criteria:

8.4.1. *General.* Projects that retain or have the potential to retain a pool, failure of which would result in loss of life, are required to survive and remain safe during and following the maximum credible earthquake (MCE) event. Such projects must also be capable of remaining operational with only minor repair during and after an operating basis earthquake (OBE). Minor repair is that

which can be accomplished within operation and maintenance limitations. In those instances where a combination of events is required before failure would occur (e.g., both an earthquake and a flood), a combined risk analysis shall be prepared.

8.4.2. *Discussion:*

8.4.2.1. Technical requirements for selecting seismic design values and performing design analyses are periodically updated in engineering guidance documents such as Engineering Circulars, Engineering Technical Letters, or Engineering Manuals. . These criteria, along with current state-of-the-art techniques, shall be used in such studies and analyses. Criteria levels, safety factors, and design methods are the same as that for new projects unless specifically noted as being different in technical guidance documents or by written direction from HQUSACE.

8.4.2.2. Since judgment of ground motion parameters for design is based on geologic and seismic history, future strong seismic events may raise the design values against which stability is analyzed. Should such a situation occur, the district, if convinced that the ground motion parameters have changed significantly enough to affect safety of the project, shall prepare an evaluation report as provided for in paragraph 8.7 and in Part II or III of Appendix I of this regulation.

8.4.2.3. Strong motion accelerometers placed on or around Corps of Engineers dams are intended to record ground motion at the site and verify the seismic design of the structure. If these instruments record ground motion parameters that (after analysis) are found to be below the values used in design, but yet the structure received damage, the occurrence and recommendations for action need to be documented. If no action is recommended, a letter report shall be prepared and submitted through the MSC to HQUSACE, ATTN: Dam Safety Officer. If action is anticipated, an evaluation report shall be prepared and submitted in accordance with the guidance herein.

8.4.2.4. Seismic stability of auxiliary structures and devices, such as regulating outlets, regulating outlet towers, spillway gates, retaining walls, hydraulic equipment, and electric supply, both permanent and standby, shall be analyzed and modified in accordance with ER 1110-2-1806 (reference 38), where necessary to provide for the dam safety policy of subparagraph 8.4.1. above, including requirements for dams to remain operational following the OBE. Auxiliary structures that do not affect dam or operational safety shall be judged for modification on economic or other grounds.

8.4.2.5. Seismic stability assessment for dam safety may also involve reservoir rim slides, critical retaining walls, foundation or abutment changes, or any other feature that might contribute to dam failure.

8.5 Policy on Changes in State-of-the-Art Design or Construction Criteria. Modifications required on a project due to state-of-the-art changes, but not related to hydrologic or seismic deficiencies as discussed in paragraphs 8.3 and 8.4 above shall be decided on a case-by-case basis. Correction of seepage through an embankment, or an inadequate structural feature shall be submitted under the Major Rehabilitation Program or the Operation and Maintenance Program.

8.6 Policy on Cost Sharing.

8.6.1. *Legislation:* Section 1203 of WRDA 1986 (reference 67) requires that costs incurred in modifications for dam safety assurance shall be recovered in accordance with provisions of the statute. Repayment of costs, except for irrigation, may be made, with interest, over a period not to exceed 30 years in accordance with provisions of subsection (a)(2) of the legislation. Costs assigned to irrigation shall be recovered by the Secretary of Interior in accordance with Public Law 98-404 (reference 60).

8.6.2. *Sponsor Identification:*

8.6.2.1. Requirements for cost sharing sponsorship, and the identification of non-Federal sponsors shall occur early in the study process to ensure that the non-Federal interests are willing cost sharing partners. Uncertainty about sponsorship and lack of meaningful sponsor involvement in the scope and extent of dam safety repairs will delay dam safety assurance work. Before initiating discussions with project sponsors on cost sharing, an interpretation on the need for sponsorship and the application of the generic guidance contained in this regulation shall be forwarded to HQUSACE, ATTN: Dam Safety Officer, for approval.

8.6.2.2. Dam safety assurance evaluation reports shall include documentation of substantive involvement and coordination with non-Federal sponsors, and expressions of their willingness to cost share in the dam safety assurance work.

8.6.3. *Fifteen Percent Factor:* Fifteen percent of the cost of the dam safety modification shall be allocated among purposes and shared with the appropriate project sponsors. General procedures for determining the amount of sponsor cost are outlined in the following subparagraphs:

8.6.3.1. Projects with a Formal Cost Allocation: In this case, 15% of the cost of the modification for dam safety assurance shall be allocated among project purposes in the same percent as the construction expenditures in joint-use facilities are allocated in the cost allocation currently in effect. The cost allocated to each project purpose shall then be shared in the same percentage as when the project was constructed, or when the purpose was added, whichever is appropriate. For large reservoir projects, it is likely that the cost assigned to flood control is 100% Federal. The cost assigned to power generation is most likely 100% non-Federal (to be reimbursed by the sale of the power). Costs may have been allocated to water supply or to conservation. Costs allocated directly to water supply are 100% non-Federal costs. Where costs have been allocated to conservation, water supply users may have contracted for a portion or all of the conservation storage. In such cases, the contract may need to be modified if it does not include provisions of payment for the proposed work. For illustrative purposes, assume a dam safety modification cost of $15 million, and a formal cost allocation that assigns 60% of the construction costs to hydropower, (with 45% as the hydropower joint-use construction costs); and 40% of the construction costs to flood control. Under this example, hydropower interests would have to repay $1,012,500 [($15,000,000 x 0.15) x 0.45]. If there was no sharing of the initial construction costs allocated to flood control, all of the modification costs assigned to flood

control would be Federal. If a sponsor shared in the initial construction costs allocated to flood control, the dam safety costs assigned to flood control would be shared on the same percentage basis. In cases where storage is reallocated from flood control to another purpose, the sponsor for the added purpose is responsible for repaying a share of the dam safety modification costs. For example, if a contract were executed for water supply that assigned 1.5% of the joint-use cost of major replacements to a water supply sponsor, this sponsor would be required to repay $33,750 of the dam safety costs [($15,000,000 x 0.15) x 0.015].

8.6.3.2. Projects without a Formal Cost Allocation, but with a Signed Project or Local Cooperation Agreement: A cooperation agreement for the initial project construction may contain an allocation or assignment of costs among project purposes. For projects with this type of agreement, 15% of the cost of the dam safety modification shall be assigned to project purposes in the same manner as costs were allocated for the project or local cooperation agreement, and shared in the same percentage according to the terms of the agreement. The percent joint-use facilities cost shall be used if available; otherwise, the assignment is based on percent of total cost. As before, assume a dam safety modification of $15,000,000; a local cooperation agreement requiring a sponsor to provide a one-time payment of $3,000,000 (5%) toward the construction of a project with an actual initial construction cost of $60,000,000. The sponsor in this example would be required to repay $112,500 [($15,000,000 x 0.15) x 0.05].

8.7. Reporting Requirements. In order to identify and process work under the Dam Safety Assurance Program, a report must be prepared that documents the analysis and evaluation processes that were made for those work items meeting the policy requirements of this regulation. The content of the report is set forth in the following subparagraphs:

8.7.1. *Report:* The report shall be called Dam Safety Assurance Program Evaluation Report. It shall be prepared following the format shown in Part I of Appendix G. This report is the decision document that shall be approved in accordance with paragraph 8.8 before initiation of detailed design leading to the preparation of the plans and specifications. The procedure and contents of the geotechnical investigation for embankment dams shall be conducted in accordance with Part II, Appendix G. The structural section shall be prepared in accordance with Part III. Both shall be appended to the report. Detailed field investigations and office studies shall be limited to those necessary to evaluate the need to modify a dam and related facilities, and to recommend further action. The report should be designed to develop a basis for decision on: (1) the need for and justification of the proposed modification for dam safety; (2) the appropriateness of funding under the Dam Safety Assurance Program; (3) whether the work requires additional authorization; (4) whether the work is subject to cost-sharing, and identification of the cost sharing partner, and the potential sponsor's willingness to cost share; (5) the scope and cost of design requirements; and (6) the estimated cost for construction. In those instances where there is need for a special engineering investigation required by detailed design effort, i.e., hydraulic modeling, structural modeling and testing, they shall be identified in the report. A plan of study and cost estimate for these special efforts shall be included. See paragraph 8.12.1. for funding guidance on the evaluation investigation and report preparation.

8.7.2. *Engineering Investigations:* Engineering investigations required to support the proposed modification for dam safety are set forth in the following subparagraphs:

8.7.2.1. Hydrologic/Hydraulic Investigations: Hydrologic/hydraulic investigations are accomplished to determine the design that will meet the dam safety requirements. Investigations generally include hydrologic modeling, hydrograph routings, determination of the probable maximum flood and base safety condition, freeboard design requirements and other site-specific hydrologic/hydraulic investigations. Documentation of these investigations shall be included in the Hydrologic and Hydraulic Section of the report.

8.7.2.2. Geotechnical/Structural Investigations: In order to provide a rational, cost-effective approach to the requirements of ER 1110-2-1806 (reference 38), a study shall be performed in three parts consistent with the regulation. Phases I and II shall be included as appendices to the Dam Safety Assurance Evaluation Report and performed with Operations and Maintenance funds. Phase III study activities are normally performed with Construction General funds from the Seepage/Stability Correction and Dam Safety Assurance Program line item (commonly known as "Wedge funds") after approval of the Report, as part of detailed engineering and design activities leading to the preparation of the plans and specifications. The Phase I report develops information needed to assess the potential for seismic instability and to provide a basis for requesting approval to continue with a detailed study of seismic stability (Phase II) using state-of-the-art dynamic methods. Phase III consists of preparing design documents, plans and specifications for remedial measures, if warranted.

8.8. Approval of Dam Safety Assurance Program Reports. The Corps Dam Safety Officer is the responsible approval official for Dam Safety Assurance Program reports submitted in accordance with this regulation. The Corps Dam Safety Officer has further delegated the review and approval of Dam Safety Assurance Program reports to the MSC Dam Safety Officers. The MSC Dam Safety Officer shall establish engineering, review, and management procedures and processes, including the qualifications and experience of the reviewers, and submit a plan to the Corps Dam Safety Officer at HQUSACE (CECW-CE) for concurrence. The plan shall include the major types of dam safety problems expected to be addressed in the near future and the relative priority for addressing these problems. The review plan shall be updated every five years or if needed or if the MSC Dam Safety Officer changes. After approval of a Dam Safety Assurance Program report, the MSC Dam Safety Officer shall notify the Corps Dam Safety Officer of the approval and certify that the report meets technical, policy, and legal compliance with an affirmative statement.

8.9. Transmittal and Review of the Dam Safety Assurance Program Evaluation Report.

8.9.1. *Review and concurrence Transmittal:* Ten copies of the report shall be transmitted by the district, after a rigorous independent technical review, to the MSC Dam Safety Officer for review. Four copies shall be transmitted to HQUSACE (CECW-CE) for concurrence. The transmittals should include the review checklists as given in Appendices H and I.

8.9.1.1. Once the report is transmitted, further work on the project shall be accomplished only after consultation with the MSC and Corps Dam Safety Officers concerning project funding.

8.9.1.2. In the event that the report is approved by the MSC Dam Safety Officer subject to specific comments by either the HQUSACE or the MSC, the district shall provide the MSC and the HQUSACE acceptable documentation during the design phase of the project to show compliance with the comments.

8.9.2. *MSC Dam Safety Officer Approval:* After the MSC Dam Safety Officer has approved the report, the MSC will notify the Corps Dam Safety Office of the report approval and provide four copies of the approved report to HQUSACE (CECW-CE).

8.9.3. *ASA(CW) Notification:* The Corps Dam Safety Officer will notify ASA(CW) of report approvals and provide two copies of the approved reports to ASA(CW).

8.9.4. *Initial Construction Funding (Wedge Funds):* Following report approval, the district may request Construction, General funds from the Dam Safety Assurance and Seepage/Stability Program to proceed with engineering and design activities. The district shall also budget for construction new start funds under the Construction, General appropriation. Refer to paragraph 8.12 for additional funding guidance, including information on the Mississippi River and Tributaries appropriation.

8.10. Design Documentation Report. Design documentation shall follow the guidance in ER 1110-2-1150 (reference 34) and Appendix I of this regulation.

8.11. Plans and Specifications. Plans and specifications will be prepared in accordance with the requirements of ER 1110-2-1150 (reference 34).

8.12. Funding.

8.12.1. *Evaluation Reports:* For projects maintained by the Corps of Engineers, the report shall be funded from project operating funds and shall be charged to the Dam Safety Assurance Studies feature in the O&M, General appropriation or the maintenance portion of the Flood Control, Mississippi River and Tributaries (FC,MR&T) appropriation. For projects designed and/or constructed by the Corps of Engineers but turned over to others for operation and maintenance the Inspection of Completed Works Project shall fund the report.

8.12.2. *Engineering Investigations:* All Phase I and II investigations will be funded in the same manner described above.

8.12.3. *Design and Plans and Specifications:* Following approval of the report, and based on the schedule of recommended work in the evaluation report, funds from the Construction, General or the maintenance portion of the FC, MR&T appropriation shall be used to continue design and complete plans and specifications (Phase III for structural/ seismic investigations).

8.12.4. *Construction:* A district shall request funding for the construction of an approved dam safety project through the normal budgetary process. Construction or land acquisition may not commence until construction funds have been specifically allocated for the required work, and a project cooperation agreement or amendment has been executed, if required. Dam Safety

Assurance Program construction projects will be funded under the Construction, General appropriation title or the construction portion of the FC, MR&T account.

8.13. Hazard Potential Classification. Appendix I of this regulation shows the hazard potential (low, significant, high) losses posed by dams to life, property, lifeline, and the environment.

CHAPTER 9

Dam Safety Modifications Under the Major Rehabilitation Program

9.1. Purpose. The purpose of the Major Rehabilitation Program is to permit construction of infrequent, costly, structural rehabilitation or major replacement works that are intended to extend the useful life of a project or a principal feature thereof at projects operated and maintained by the Corps of Engineers. Major dam safety modifications that do not qualify under the Dam Safety Assurance Program may qualify under the Major Rehabilitation Program. Major rehabilitation projects for seepage or stability corrections may receive funds from the Dam Safety and Seepage/Stability Correction Program line item in the Construction, General appropriation upon approval of the rehabilitation evaluation report.

9.2. Policy and Procedures. The basic policy and procedures for the Major Rehabilitation Program are found in ER 1130-2-500 (reference 43) and EP 1130-2-500 (reference 21).

9.2.1. *General Limitations and Requirements:*

9.2.1.1. Project costs must exceed the amount shown in the annual budget circular.

9.2.1.2. Project must require two construction seasons.

9.2.1.3. Rehabilitation evaluation report required.

9.2.2. *Budget and Funding Procedures.*

9.2.2.1. Rehabilitation evaluation report funded through the O&M appropriation.

9.2.2.2. Work is budgeted for design and construction as a Construction, General new start in the regular budget cycle. (Except for seepage/stability as discussed in paragraphs 9.3 and 9.4.)

9.3. Dam Safety and Seepage/Stability Correction Program. A subset of the Major Rehabilitation Program is the Dam Safety and Seepage/Stability Correction Program. The purpose of the Seepage/Stability Correction Program is to address seepage and static stability of dams and other water control structures owned and operated by the Corps of Engineers. In addition to the normal economic analysis, projects under the Seepage/Stability Correction Program shall consider loss of life and other losses that would occur in the event of a dam failure. The same funding limits, as stated in the annual budget EC, that apply to regular Major Rehabilitation Program projects apply to the Seepage/Stability Correction Program projects.

9.4. Approval of Seepage/Stability Correction Program Major Rehabilitation Reports. The Corps Dam Safety Officer is the responsible approval official for Seepage/Stability Correction Program reports submitted in accordance with this regulation. The Corps Dam Safety Officer has further delegated the review and approval of Seepage/Stability Correction Program reports to the MSC Dam Safety Officers. The MSC Dam Safety Officer shall establish engineering,

review, and management procedures and processes, including the qualifications and experience of the reviewers, and submit a review plan to the Corps Dam Safety Officer at HQUSACE (CECW-CE) for concurrence. The plan shall include the major types of dam safety problems expected to be addressed in the near future and the relative priority for addressing these problems. The plan shall be updated every five years or if needed or if the MSC Dam Safety Officer changes. After approval of a Seepage/Stability Correction Program report, the MSC Dam Safety Officer shall notify the Corps Dam Safety Officer of the approval and certify that the report meets technical, policy, and legal compliance with an affirmative statement.

9.5. Transmittal and Review of Seepage/Stability Correction Program Major Rehabilitation Reports.

9.5.1. *Review and Concurrence Transmittal:* Ten copies of the report shall be transmitted by the district, after a rigorous independent technical review, to the MSC Dam Safety Officer for review. Four copies shall be transmitted to HQUSACE (CECW-CE) for concurrence. The transmittals should include the review checklists as given in Appendices H and I.

9.5.1.1. Once the report is transmitted, further work on the project shall be accomplished only after consultation with the MSC and Corps Dam Safety Officers concerning project funding.

9.5.1.2. In the event that the report is approved by the MSC Dam Safety Officer subject to specific comments by either the HQUSACE or the MSC, the district shall provide the MSC and the HQUSACE acceptable documentation during the design phase of the project to show compliance with the comments.

9.5.2. *MSC Dam Safety Officer Approval:* After the MSC Dam Safety Officer has approved the report, the MSC will notify the Corps Dam Safety Office of the report approval and provide four copies of the approved report to HQUSACE (CECW-CE).

9.5.3. *ASA(CW) Notification:* The Corps Dam Safety Officer will notify ASA(CW) of report approvals and provide two copies of the approved reports to ASA(CW).

9.5.4. *Initial Construction Funding (Wedge Funds):* Following report approval, the district may request Construction, General funds from the Dam Safety Assurance and Seepage/Stability Program to proceed with engineering and design activities. The district shall also budget for construction new start funds under the Construction, General appropriation.

9.6. Funding. The cost of preparation of the Evaluation Report for a Major Rehabilitation Project shall be funded by the project Operations and Maintenance work allowance. Once the report is approved, further work on the modifications shall be funded from the Operations and Maintenance account until the work is budgeted and funded by the Construction, General appropriations. The Seepage/Stability Correction Program is an exception to funding future work with Operations and Maintenance funds. Under the Seepage/Stability Correction Program, the Major Rehabilitation project is funded the same as a Dam Safety Assurance Program project. The Corps Dam Safety Officer notifies ASA(CW) of the approval, and further engineering and

design work is funded from the Construction, General appropriation, under the Dam Safety and Seepage/Stability Correction Program.

CHAPTER 10

Emergency Preparedness

10.1. Emergency Planning. An emergency situation is a condition that develops unexpectedly, endangers the structural integrity of the dam and/or downstream property and human life, and requires immediate action. Such a situation cannot be properly responded to unless plans and preparations have been made well in advance. Preparation for dealing with an emergency situation is the heart of emergency planning, and it includes preparation of an Emergency Action Plan and proper training of the field and office forces in proper implementation of the plan. District dam safety personnel should team with the district emergency management personnel in preparation of the Emergency Action Plan to include training and exercises. An Emergency Action Plan is a plan of action to reduce the potential for property damage and loss of life in an area affected or about to be affected by a dam failure or large flood. It also includes the local evacuation plan prepared by non-Federal interests. It is important that Corps field personnel interface with downstream officials and local responders on an annual basis to discuss the Emergency Action Plan and the local evacuation plan.

10.2. Background. Corps of Engineers major subordinate commands were instructed in March 1978 to begin preparation of flood Emergency Action Plans for dams under their jurisdiction. Initially the effort was directed to delineating the areas downstream from the dams that would be flooded in the event of dam failure or large release of floodwater without dam failure. In June 1980 the Corps of Engineers issued detailed instructions for the preparation of flood Emergency Action Plans (references 62, 63). Subsequently, in August 1983, the Corps of Engineers distributed case studies of an Emergency Action Plan and evacuation plan to field offices (references 64, 65). Guidance (reference 62) has been provided for preparation of Emergency Action Plans to deal with potential emergencies caused by spillway discharges sufficiently large to cause flooding in downstream areas, flooding upstream of dams due to backwater effects or high pool levels, or dam failure. To supplement the “Federal Guidelines for Dam Safety”, ICODS published FEMA 64, reference 49.

10.3. Emergency Action Plans and Emergency Exercises. Procedures for preparation of Emergency Action Plans and Emergency Exercises are included in Appendix J. Notification lists for Emergency Action Plans shall be updated annually and emergency exercises shall be performed to validate the Emergency Action Plans.

CHAPTER 11

Dam Safety Training

11.1. Overview. The Corps of Engineers has an extensive program for training personnel in all matters related to its mission in water resources development. Much of the training is directly or indirectly related to dam safety. A comprehensive training program is conducted for dam operation and maintenance personnel. This program is designed to acquaint project personnel with basic engineering considerations pertaining to the major structures, with procedures for surveillance, monitoring and reporting of potential problems, and with emergency operations. In addition, the technical staff at the district office requires training to build expertise and ability to respond to emergencies. The Corps of Engineers has a training course on "Dam Safety in the Corps of Engineers" and has supported the development of the Training Aids for Dam Safety (TADS) Program. In 1991, the Federal Energy Regulatory Commission initiated a training course on "Emergency Action Plan". ASDSO maintains a list of currently scheduled dam safety training courses on the web site at http://www.damsafety.org.

11.2. Corps of Engineers Training Course on Dam Safety. The Corps of Engineers Proponent Sponsored Engineer Corps Training (PROSPECT) program offers a course titled "Dam Safety in the Corps of Engineers". Through lectures, case histories, and structured student discussions, the course covers all aspects of a dam safety program. The course outlines technical considerations (hydrologic, seismic, geotechnical, electrical/mechanical and structural) as well as the operational requirements (operation, maintenance, surveillance, preparedness, training, and notification). The scope and implementation details of the Dam Safety Assurance Program are covered in detail. Presentations, video modules, case histories, and a walk-through inspection are used to effectively present a multidiscipline approach to the successful monitoring and evaluation of Corps of Engineers dams.

11.3. National Dam Safety Conferences. National dam safety conferences, such as the Association of State Dam Safety Officials annual conference, the United States Society on Dams annual conference, the Corps of Engineers Infrastructure Conference, and conferences sponsored by other agencies, have speakers who are involved in state-of-the-art dam safety evaluations and remediations. These conferences are a great opportunity to share the technology and experiences of dam safety with people from other agencies, and within the Corps of Engineers. Participation in these conferences can be valuable training in dam safety activities.

11.4. Exchange Training – District to District. Participation in other district's dam safety training, periodic inspections, and emergency exercises can be good training in dam safety and can spread the good things learned in one district to other districts. Other districts should be invited to attend periodic inspections, dam safety training, and emergency exercises, and whenever feasible, dam safety personnel should participate in those activities in other districts. There is a lot of information and experience available that could be beneficially shared within districts, and both districts could gain from the activities.

11.5. Training Program for Operations and Maintenance Personnel.

11.5.1. *Dam Safety:* Recognizing the important role that onsite operations and maintenance personnel have in dam safety, MSC commanders were directed in 1978 to develop a training program that addresses the following items:

Discussion of basic typical design considerations for various types of construction, including hydraulic considerations and foundation factors.

Procedures for monitoring potential problem areas.

Dam safety features in design and construction.

Normal operation, surveillance, monitoring, and reporting procedures.

Emergency operations, surveillance, monitoring, and reporting procedures.

Project specific features and history of problems and potential problems.

11.5.2. *Training Frequency:* All new field employees and field contractor personnel shall have a minimum of 6 hours training shortly after starting duty and at least 6 hours refresher training every four years.

11.5.3. *Records:* The Operations Project Manager shall document all formal training. These records shall be kept on file at the employee's project office and shall be available to the periodic inspection team and readily accessible for emergency response.

11.5.4. *Exercises:* Upon completion of the initial safety training at a new project, EAP exercises are developed based on the most probable emergency situations that might occur on each major dam feature.

11.6. Sample Dam Safety Training Course Outline for Project Personnel.

11.6.1. *Purpose of Training Program* – basic objectives, history of dam failures, and films or slides depicting dam safety problems or failures.

11.6.2. *Dam Safety Features in Design and Construction* – design philosophy for dams, design assumptions, construction history, salient features and regulating philosophy for the project, and past monitoring, experiences and performance for projects.

11.6.3. *Normal Operation, Surveillance, Monitoring and Reporting Procedures* – the value and use of instrumentation, effect of pool rises on monitoring requirements, reservoir regulation manuals, day-to-day surveillance, documentation of plans, records, reports, etc, generalizations on what is and what is not critical to safety of the structure, public relations with local communities, and coordination and notification to downstream water users and recreationists on controlled releases and flushing operations.

11.6.4. *Emergency Operation, Surveillance, Monitoring and Reporting Procedures* – observations of evidence of distress, methods of treating obvious safety problems, knowledge of

potential flood area downstream, alerting Corps of Engineer offices to emergency conditions, and alerting police and local civil defense groups to emergency conditions.

11.7. Bureau of Reclamation Safety Evaluation of Existing Dams (SEED). The Bureau of Reclamation has a dam safety training course for their personnel. In some cases it is more cost effective for Corps personnel in the western portion of the country to attend these courses than the PROSPECT courses. This training is another option that should be considered when selecting training for Corps personnel in dam safety.

11.8. Training Aids for Dam Safety.

11.8.1. *Background:* In 1986, the Corps of Engineers, along with 13 other Federal Agencies, all members of the Interagency Committee on Dam Safety, joined forces to develop a professionally prepared TADS Program. The TADS materials, as shown in Table 11-1, are arranged in three components that cover dam safety inspections, dam safety awareness and program development, and evaluations and remedial actions (references 50, 66).

11.8.2. *Structure:* The entire package consists of 21 self-paced individual instruction modules that focus on performance of job tasks. Each module features a workbook text. The material is presented in a straightforward, easy-to-manage manner. Each workbook contains a glossary of terms and a list of references from which to obtain additional information. Some modules are supplemented with videotapes that illustrate certain concepts. Because the modules are self-contained, individuals may tailor a learning program to meet specific work requirements or personal needs.

11.8.3. *Utilization of the program:* The TADS Program offers a standardized approach to dam safety training. The Corps of Engineers, as one of the primary sponsors of the TADS Program, distributes the TADS materials to each Corps of Engineers field office through the Engineering and Construction, Directorate of Civil Works, HQUSACE. All MSC's and districts shall maintain a complete set of modules including the videotape supplements.

Table 11-1
Training Aids for Dam Safety Modules

Safety Inspection of Dams (for engineers with little or no inspection experience and technicians with some familiarity with dams)

Preparing to Conduct a Dam Safety Inspection
Documenting and Reporting Findings From a Dam Safety Inspection
Inspection of Embankment Dams *
Inspection of Concrete and Masonry Dams*
Inspection of the Foundation, Abutments, and Reservoir Rim
Inspection of Spillways and Outlet Works *
Inspection and Testing of Gates, Valves, and Other Mechanical Systems
Instrumentation for Embankment and Concrete Dams *
Identification of Material Deficiencies
Evaluation of Facility Emergency Preparedness

Dam Safety Awareness, Organization, and Implementation (for dam owners and operators, with some applicability for inexperienced engineers, technicians, administrators, and the general public)

Dam Safety Awareness*
How to Organize a Dam Safety Program
How to Organize an Operation and Maintenance Program
How to Develop and Implement an Emergency Action Plan *
Identification of Visual Dam Safety Deficiencies

Data Review, Investigation and Analysis, and Remedial Action for Dam Safety (for engineers with some applicability for dam owners and operators)

The Dam Safety Process
Evaluation of Hydrologic Adequacy
Evaluation of Hydraulic Adequacy
Evaluation of Concrete Dams Stability
Evaluation of Embankment Dams Stability and Deformation
Evaluation of Seepage Conditions

* Modules have videotape supplements.

CHAPTER 12

Low Level Discharge Facilities for Drawdown of Impoundments

12.1. Purpose. This chapter provides policy, objectives, and procedures in regard to facilities for drawdown of lakes to be impounded by Civil Works projects.

12.2. Policy. It is the policy of the Chief of Engineers that all lakes impounded by Civil Works projects have low level discharge facilities to meet the criteria for drawdown set forth herein. Low-level discharge facilities, capable of essentially emptying the lake, provide flexibility in future project operation for unanticipated needs such as major structure repair, environmental controls or changes in reservoir regulation. The criteria set forth herein govern the majority of impoundment projects. However, if impracticable to provide drawdown capability because of size (unusually small or large) or because of a unique function, projects may be exempt from the criteria upon presentation of information in accordance with paragraph 12.4, below.

12.3. Design Criteria. As a minimum, low-level discharge facilities shall be sized to reduce pool level within four months to the higher of the following pool levels a pool level that is within 20 feet of the pre-project "full channel" elevation, or a pool level resulting in storage in the reservoir equal to 10 percent of the beginning pool level. The beginning pool level for drawdown is at spillway crest for uncontrolled spillways and at top of spillway gates for controlled spillways. Inflow into the lake during the drawdown period shall be the historical average flow for each month of the year. The drawdown period inflow shall be equivalent to the average flow of the highest consecutive four-month period.

12.4. Design Study and Reporting Requirements. Feasibility (survey) reports and subsequent pertinent Design Documentation Reports (DDR's) shall include the results of studies made to determine facilities required for drawdown of impoundments. The discharge capacity required to satisfy project purposes and diversion requirements during construction may be sufficient to meet the drawdown criteria set forth in paragraph 12.3, above. Where additional capacity is required an analysis of the most practical and economical means of increasing the capacity to meet the drawdown criteria shall be performed. A synopsis of the alternatives considered and details of the recommended plan shall be included in the DDR. The report shall include the effects of the required discharge capacity on project costs, on existing downstream projects, and on the potential for downstream damage. When, due to specific project conditions, a drawdown capacity is recommended that does not meet the criteria set forth in paragraph 12.3, above, the following information shall be presented:

12.4.1. *Drawdown Period:* The drawdown period using the maximum drawdown capability of the proposed project facilities, under the situation described in paragraph 12.3, above. Information shall be included on the pool elevation and corresponding storage volume at end of the period.

12.4.2. *Proposed Drawdown Facility:* Information on facilities that would be required to meet the design criteria for drawdown, including the estimated first cost and annual cost of these

facilities. If the estimated cost for such facilities is significantly greater than for the proposed project facilities, similar information on intermediate facilities shall be provided. Reporting subsequent to the DDR shall include related discharge rating curves; hydrographs with inflow, outflow and pool stage plots; lake regulation plans needed for project purposes and needed to satisfy the drawdown criteria; and other data essential in evaluating the study.

CHAPTER 13

Risk Assessment

This Chapter is being developed to provide guidance and procedures concerning the use of risk analyses in preparing studies and reports for the Dam Safety Assurance Program or the Major Rehabilitation Program (Seepage/Stability).

CHAPTER 14

Security for Dams

14.1 Policy. All Dams within the USACE shall maintain an adequate security posture so as to allow the project to be operated in a safe and secure manner. The safety of employees, project visitors, and area residents is paramount. All project employees shall be familiar with all applicable security regulations, standard operating procedures, and regulatory guidance and be capable of discharging their duties on the project site relative to security matters. The District Engineer is ultimately responsible for the security of the project site and personnel within in the area of responsibility (AOR).

14.2 General. All USACE dams shall maintain an adequate security posture so as to be operated in a safe and secure manner. It shall be realized that the baseline security posture for day-to-day operations will vary from project to project. While the baseline security posture at one dam may call for "armed security guards", another project may have no visible signs of security. The baseline security posture for USACE dams will be based the completion of on-site project specific Vulnerability Assessment (VA) and Risk Analysis which take into account project consequences (criticality), threats (national, regional and local), current physical security posture and law enforcement response capabilities.

14.3 Crime Prevention. Crime Prevention is a command responsibility. A successful program requires continuing command emphasis; criminal activity should not be allowed to detract from mission accomplishment.

14.4 Physical Security Program. All dams shall implement an appropriate vertical physical security program designed to ensure effective and efficient uses of resources, meeting the needs of the command in protecting its assets against aggressors that are a threat to the project critical assets and hostile intelligence operations. The physical security program is required to include a project specific physical security plan, physical security inspections, and security systems designed and constructed in accordance with the appropriate chapters of AR 190-11 (reference 1) and AR 190-13 (reference 2), TM 5-853 "Security Engineering" vols. 1 thru 4, ECB 2004-7 "Security Design for New Civil Works Projects"

14.5 Antiterrorism: All USACE dams shall have a viable, project specific Antiterrorism and Force Protection Plan in place and in accordance with Department of Defense (DoD) Directive Number 2000.12 "DoD Antiterrorism (AT) Program," (18AUG03), DoD Instruction Number 2000.16, "DoD Antiterrorism Standards," (14JUN01) and DoD O-2000.12-H, "Protection of DoD Personnel and Activities Against Acts of Terrorism and Political Turbulence," (19FEB93) that allows for the elevation and decrease of Force Protection Condition Measures as detailed in Chapter B, AR 525-13 (reference 4).

14.6 Vulnerability Analysis (VA). One tool, which provides an effective means of conducting a vulnerability analysis specific to dams, is the Risk Assessment Methodology – Dams (Ram-D). RAM-D is a tool that was developed by the Interagency Forum on Infrastructure Protection (IFIP), of which USACE was a Charter Member, to assess the vulnerability of dams regardless

of the nature of its operation (production of hydro-electric power; navigation; flood control, etc.). All USACE dams shall undergo an initial assessment by a qualified RAM-D certified (i.e. trained) team using the RAM-D process. At a minimum, a re-validation of the initial RAM-D VA will occur every two years for dams identified as "USACE Critical", while other re-validations shall occur every five years and held in conjunction with the Project's Dam Safety Periodic Inspection. Additionally, in cases where there has been "change" at the project (change in the threat, new construction, change of mission, change in criticality of a project asset, change in condition of security systems, change in project operation, etc.) the re-validation should be implemented immediately by the District to document any change(s) and impact it would have on the initial, or subsequent, RAM-D (risk) analysis.

FOR THE COMMANDER:

10 Appendices
(See Table of Contents)

MICHAEL J. WALSH
Colonel, Corps of Engineers
Chief of Staff

APPENDIX A

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APPENDIX B

Glossary

B-1. Abbreviations.

ADAS.....Automated Data Acquisition System

ASDSO.....Association of State Dam Safety Officials

BOR.....Bureau of Reclamation

BSC.....Base Safety Condition

CEDSPMT…Corps of Engineers Dam Safety Program Management Team

COE.....Corps of Engineers

CQC.....Contractor Quality Control

DA.....Department of the Army

DDR.....Design Documentation Report

DHS..... Department of Homeland Security

DSAP.....Dam Safety Assurance Program

DSO.....Dam Safety Officer

DSPMT….Dam Safety Program Management Tools

DSPPM .....Dam Safety Program Performance Measures

EAP.....Emergency Action Plan

ERDC.....Engineer Research and Development Center

EIS.....Environmental Impact Statement

EPRI.....Electric Power Research Institute

FCCSET.....Federal Coordinating Council for Science, Engineering, and Technology

FC, MR&T...Flood Control, Mississippi River and Tributaries

FCSA.....Feasibility Cost Sharing Agreement

FEMA.....Federal Emergency Management Agency

FERC.....Federal Energy Regulatory Commission

HQUSACE...Headquarters, U.S. Army Corps of Engineers

HSS.....Hydraulic Steel Structures

HTRW.....Hazardous, Toxic and Radioactive Waste

ICODS.....Interagency Committee on Dam Safety

ICOLD.....International Commission on Large Dams

IDF.....Inflow Design Flood

IPMP.....Initial Project Management Plan

IRC.....Issue Resolution Conference

ITR.....Independent technical review

LCA.....Local Cooperation Agreement

MCACES...Micro Computer Aided Cost Engineering System

MCE.....Maximum Credible Earthquake

MDE.....Maximum Design Earthquake

MSC.....Major Subordinate Commands

NDSRB....National Dam Safety Review Board

NEPA……National Environmental Program Act

O&M.....Operation and Maintenance

OBE.....Operating Basis Earthquake

OMRR&R...Operation, Maintenance, Repair, Replacement and Rehabilitation

P&S.....Plans and Specifications

PCA.....Project Cooperation Agreement

PCCR.....Policy Compliance & Criteria Review

PDT.....Project Delivery Team

PED.....Preconstruction Engineering and Design

PGM.....Project Guidance Memo

PMF.....Probable Maximum Flood

PMP.....Probable Maximum Precipitation
PMP.....Project Management Plan

PPMD.....Programs and Project Management Division

PROSPECT...Proponent-Sponsored Engineer Corps Training

QA.....Quality Assurance

RAM-D Risk Assessment Methodology for Dams

REMR.....Repair, Evaluation, Maintenance, and Rehabilitation

SDF.....Spillway Design Flood

SEE.....Safety Evaluation Earthquake

SEF.....Safety Evaluation Flood

SES……Senior Executive Service

SSR.....Seismic Safety Review

TADS.....Training Aids for Dam Safety

TF.....Threshold Flood

TRC.....Technical Review Conference

USACE.....United States Army Corps of Engineers

USCOLD...U.S. Committee on Large Dams
(renamed United States Society on Dams, USSD)

USSD.....United States Society on Dams

VE.....Value Engineering

WES.....U.S. Army Engineer Waterways Experiment Station

WRDA.....Water Resources Development Act

B-2. Terms.

Abutment
That part of the valley side against which the dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section to take the thrust of an arch dam where there is no suitable natural abutment. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction, unless otherwise indicated.

Acre-foot
A unit of volumetric measure that would cover 1 acre to a depth of 1 foot. It is equal to 43,560 cubic feet.

Adit
A nearly horizontal underground excavation in an abutment having an opening in only one end. An opening in the face of a dam for access to galleries or operating chambers.

Appurtenant structure
Ancillary features of a dam such as inlet and outlet works, spillways, tunnels, or powerplants.

Axis of dam
The vertical plane or curved surface, chosen by a designer, appearing as a line, in plan, or in cross-section, to which the horizontal dimensions of the dam are referenced.

Baffle block
A block, usually of concrete, constructed in a channel or stilling basin to dissipate the energy of water flowing at high velocity.

Base thickness
Also referred to as base width. The maximum thickness or width of the dam measured horizontally between upstream and downstream faces and normal to the axis of the dam, but excluding projections for outlets, or other appurtenant structures.

Batter
Angle of inclination from the vertical.

Bedrock
The consolidated body of natural solid mineral matter which underlies the overburden soils.

Berm
A nearly horizontal step in the sloping profile of an embankment dam. Also a step in a rock or earth cut.

Borrow area
The area from which material for an embankment is excavated.

Breach
An eroded opening through a dam, which drains the reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening, which allows uncontrolled discharge from the reservoir.

Catastrophe
A sudden and great disaster causing misfortune, destruction, or irreplaceable loss extensive enough to cripple activities in an area.

Channel
A general term for any natural or artificial facility for conveying water.

Cofferdam
A temporary structure enclosing all or part of the construction area so that construction can proceed in the dry. A diversion cofferdam diverts a river into a pipe, channel, or tunnel.

Compaction
Mechanical action, which increases the density by reducing the voids in a material.

Conduit
A closed channel to convey water through, around, or under a dam.

Conservation pool
The permanent pool that lies just below the flood storage pool in a reservoir.

Construction joint
The interface between two successive placings or pours of concrete where bond, and not permanent separation, is intended.

Contact grouting
Filling, with cement grout, any voids existing at the contact of two zones of different materials, e.g., between a concrete tunnel lining and the surrounding
rock.

Contractor Quality Control (CQC)
The construction contractor's system to manage, control, and document his own, his supplier's, and his subcontractor's activities to comply with contract requirements.

Core
A zone of low permeability material in an embankment dam. The core is sometimes referred to as central core, inclined core, puddle clay core, rolled clay core, or impervious zone.

Core wall
A wall built of relatively impervious material, usually of concrete or asphaltic concrete, in the body of an embankment dam to prevent seepage.

Crest of dam
See top of dam.

Cross section
An elevation view of a dam formed by passing a plane through the dam perpendicular to the axis.

Cutoff trench
A foundation excavation later to be filled with impervious material so as to limit seepage beneath a dam.

Cutoff wall
A wall of impervious material usually of concrete, asphaltic concrete, or steel sheet piling constructed in the foundation and abutments to reduce seepage beneath and adjacent to the dam.

Dam
A barrier constructed across a watercourse for the purpose of storage, control, or diversion of water.

a. Afterbay dam. See regulating dam.

b. Ambursen dam. A buttress dam in which the upstream part is a relatively thin flat slab usually made of reinforced concrete.

*c. Arch dam. A c*oncrete or masonry dam, which is curved upstream so as to transmit the major part of the water load to the abutments.

d. Buttress dam. A dam consisting of a watertight part supported at intervals on the downstream side by a series of buttresses. A buttress dam can take many forms, such as a flat slab or a massive head buttress.

e. Cofferdam. A temporary structure enclosing all or part of the construction area so that construction can proceed in the dry. A diversion cofferdam diverts a stream into a pipe, channel, tunnel, or other watercourse.

f. Crib dam. A gravity dam built up of boxes, crossed timbers, or gabions filled with earth or rock.

g. Diversion dam. A dam built to divert water from a waterway or stream into a different watercourse.

h. Double curvature arch dam. An arch dam, which is curved vertically as well as horizontally.

i. Earth dam. An embankment dam in which more than 50 percent of the total volume is formed of compacted earth material generally smaller than 3-inch size.

j. Embankment dam. Any dam constructed of excavated natural materials or of industrial waste materials.

k. Gravity dam. A dam constructed of concrete and/or masonry, which relies on its weight and internal strength for stability.

1. Hollow gravity dam. A dam constructed of concrete and/or masonry on the outside but having a hollow interior and relying on its weight for stability.

m. Hydraulic fill dam. An earth dam constructed of materials, often dredged, which are conveyed and placed by suspension in flowing water.

n. Industrial waste dam. An embankment dam, usually built in stages, to create storage for the~ disposal of waste products from an industrial process. The waste products are conveyed as fine material suspended in water to the reservoir impounded by the embankment. The embankment may be built of conventional materials but sometimes incorporates suitable waste products.

o. *Masonry dam.* Any dam constructed mainly of stone, brick, or concrete blocks jointed with mortar. A dam having only a masonry facing should not be referred to as a masonry dam.

p. Mine tailings dam. An industrial waste dam in which the waste materials come from mining operations or mineral processing.

q. Multiple arch dam. A buttress dam composed of a series of arches for the upstream face.

r. Overflow dam. A dam designed to be overtopped.

s. Regulating dam. A dam impounding a reservoir from which water is released to regulate the flow downstream.

t. Rockfill dam. An embankment dam in which more than 50 percent of the total volume is composed of compacted or dumped cobbles, boulders, rock fragments, or quarried rock generally larger than 3-inch size.

u. Roller-compacted concrete dam. A concrete gravity dam constructed by the use of a dry mix concrete transported by conventional construction equipment and compacted by rolling, usually with vibratory rollers.

v. Rubble dam. A stone masonry dam in which the stones are unshaped or uncoursed.

w. Saddle dam (or dike). A subsidiary dam of any type constructed across a saddle or low point on the perimeter of a reservoir.

x. Tailings dam. See mine tailings dam.

Dam failure
The uncontrolled release of impounded water. 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. They are, however, normally amenable to corrective action.

Dam Safety:
Dam safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe functioning is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate to the extent reasonably possible any unacceptable risks.

Dam Safety Officer
The highest-ranking Registered Professional Engineer in each level of the Corps of Engineers responsible for implementing the dam safety program of that organization.

Dam Safety Program
The purposes of a dam safety program are to protect life, property, and the environment by ensuring that all dams are designed, constructed, operated, and maintained as safely and effectively as is reasonably possible. Accomplishing these purposes require commitments to continually inspect, evaluate, and document the design, construction, operations, maintenance, rehabilitation, and emergency preparedness of each dam and the associated public. It also requires the archiving of documents on the inspections and history of dams and the training of

personnel who inspect, evaluate, operate, and maintain them. Programs must instill an awareness of dams and the potential hazard that they may present in the owners, the users, the public, and the local and national decision-makers. On both local and national scales, program purposes also include periodic reporting on the degree of program implementation. Key to accomplishing these purposes is to attract, train, and retain a staff proficient in the art and science of dam design.

Dam safety preparedness
The quality or state of being prepared to deal with emergency conditions which endanger the structural integrity of the dam and/or downstream property and human life.

Design water level
The maximum water elevation including the flood surcharge that a dam is designed to withstand.

Design wind
The most severe wind that is reasonably possible at a particular reservoir for generating wind setup and runup. The determination will generally include the results of meteorological studies, which combine wind velocity, duration, direction, and seasonal distribution characteristics in a realistic manner.

Diaphragm wall (membrane)
A sheet, thin zone, or facing made of an impervious material such as concrete, steel, wood, or plastic.
Also see core wall.

Dike
See Dam, w. saddle dam.

Diversion channel, canal, or tunnel
A waterway used to divert water from its natural course. The term is generally applied to a temporary arrangement, e.g., to by-pass water around a dam site during construction. “Channel” is normally used instead of “canal” when the waterway is short.

Drain, blanket
A layer of pervious material placed to facilitate drainage of the foundation and/or embankment**.**

Drain, chimney
A vertical or inclined layer of pervious material in an embankment to facilitate and control drainage of the embankment fill.

Drain, toe
A system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet.

Drainage area
The area, which drains to a particular point on a river or stream.

Drainage curtain
Also called drainage wells or relief wells. A line of vertical wells or boreholes to facilitate drainage of the foundation and abutments and to reduce water pressure.

Drawdown
The difference between a water level and a lower water level in a reservoir within a particular time. Used as a verb, it is the lowering of the water surface.

Earthquake
A sudden motion or trembling in the earth caused by the abrupt release of accumulated stress along a fault.

Earthquake, Maximum Credible (MCE)
The most severe earthquake that is considered reasonably possible to occur at a given site on the basis of geologic and seismological evidence.

Earthquake, Maximum Design (MDE)
A postulated seismic event, specified in terms of specific bedrock motion parameters at a given site, which is used to evaluate the seismic resistance of man-made structures or other features at the site.

Earthquake, Operating Basis (OBE)
The earthquake(s) for which the structure is designed to resist and remain operational. It reflects the level of earthquake protection desired for operational or economic reasons and may be determined on a probabilistic basis considering the regional and local geology and seismology.

Earthquake, Safety Evaluation (SEE)
The earthquake, expressed in terms of magnitude and closest distance from the dam site or in terms of the characteristics of the time history of free-field ground motions, for which the safety of the dam and critical structures associated with the dam are to be evaluated. In many cases, this earthquake will be the maximum~ credible earthquake to which the dam will be exposed. However, in other cases where the possible sources of ground motion are not easily apparent, it may be a motion with prescribed characteristics selected on the basis of a probabilistic assessment of the ground motions that may occur in the vicinity of the dam. To be considered safe, it should be demonstrated that the dam can withstand this level of earthquake shaking without release of water from the reservoir.

Earthquake, synthetic
Earthquake time history records developed from mathematical models that use white noise, filtered white noise, and stationary and nonstationary filtered white noise, or theoretical seismic source models of failure in the fault zone. (White noise is random energy containing all frequency components in equal proportions. Stationary white noise is random energy with statistical characteristics that do not vary with time).

Embankment
A raised structure to hold back water or to carry a roadway.

Emergency
An emergency, in terms of dam operation, is a condition, which develops unexpectedly, endangers the structural integrity of the dam and/or downstream property and human life, and requires immediate action.

Emergency Action Plan (EAP)
A plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood.

Energy dissipater
A device constructed in a waterway to reduce the kinetic energy of fast flowing water.

Epicenter
The point on the earth's surface located vertically above the point of origin of an earthquake.

Fault
A fracture or fracture zone in the earth crust along which there has been displacement of the two sides relative to one another.

Fault, active
A fault which, because of its present tectonic setting, can undergo movement from time to time in the immediate geologic future.

Fault, capable
An active fault that is judged capable of producing macro earthquakes and exhibits one or more of the following characteristics:

a. Movement at or near the ground surface at least once within the past 35,000 years.

b. Macroseismicity (3.5 magnitude Richter or greater) instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault.

c. A structural relationship to a capable fault such that movement on one fault could be reasonably expected to cause movement on the other.

d. Established patterns of microseismicity, which define a fault, with historic macroseismicity that can reasonably, be associated with the fault.

Fetch
The straight-line distance across a body of water subject to wind forces. The fetch is one of the factors used in calculating wave heights in a reservoir.

Filter (filter zone)
One or more layers of granular material graded (either naturally or by selection) so as to allow seepage through or within the layers while preventing the migration of material from adjacent zones.

Flashboards
Structural members of timber, concrete, or steel placed in channels or on the crest of a spillway to raise the reservoir water level but that may be quickly removed in the event of a flood.

Flip bucket
An energy dissipater located at the downstream end of a spillway and shaped so that water flowing at a high velocity is deflected upwards in a trajectory away from the foundation of the spillway.

Flood
A temporary rise in water levels resulting in inundation of areas not normally covered by water. May be expressed in terms of probability, of exceedance per year such as one percent chance flood or expressed as a fraction of the probable maximum flood or other reference flood.

Flood routing
A process of determining progressively over time the amplitude of a floodwave as it moves past a dam or downstream to successive points along a river or stream.

Flood, antecedent
A flood or series of floods assumed to occur prior to the occurrence of an inflow design flood.

Flood, base safety standard (BSS)
The inflow design flood where there is no significant increase in adverse consequences from dam failure compared to non-failure adverse consequences.

Flood, Safety Evaluation (SEF)
The largest flood for which the safety of a dam and appurtenant structure is to be evaluated.

Flood, Inflow Design (IDF)
The flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Flood, Probable Maximum (PMF)
The most severe flood that is considered reasonably possible at a site as a result of meteorological and hydrologic conditions.

Floodplain
An area adjoining a body of water or natural stream that has been or may be covered by floodwater.

Freeboard
Vertical distance between the design water level and the top of dam. (An anachronism term that is no longer used by USACE)

Full pool
The reservoir level that would be attained when the reservoir is fully utilized for all project purposes, including flood control.

Gallery
A passageway in the body of a dam used for inspection, foundation grouting, and/or drainage.

Gantry crane
A fixed or traveling bent-supported crane for handling heavy equipment.

Gate
A movable, watertight barrier for the control of water in a waterway.

a. *Bascule gate.* See flap gate.

b. Bulkhead gate. A gate used either for temporary closure of a channel or conduit before dewatering it for inspection or maintenance or for closure against flowing water when the head difference is small, e.g., for diversion tunnel closure.

c. Crest gate (spillway gate). A gate on the crest of a spillway to control the discharge or reservoir water level.

d. Drum gate. A type of spillway gate consisting of a long hollow drum. The drum may be held in its raised position by the water pressure in a flotation chamber beneath the dam.

e. Emergency gate. A standby or auxiliary gate used when the normal means of water control is not available. Sometimes referred to as guard gate.

f. Fixed wheel gate (fixed roller gate or fixed axle gate). A gate having wheels or rollers mounted on the end posts of the gate. The wheels bear against rails fixed in side grooves or gate guides.

g. Flap gate. A gate hinged along one edge, usually either the top or bottom edge. Examples of bottom-hinged flap gates are tilting gates and fish belly gates so called from their shape in cross section.

h. Flood gate. A gate to control flood release from a reservoir.

i. Outlet gate. A gate controlling the flow of water through a reservoir outlet.

j. Radial gate (tainter gate). A gate with a curved upstream plate and radial arms hinged to piers or other supporting structure.

k. Regulating gate (regulating valve). A gate or valve that operates under full pressure flow conditions to regulate the rate of discharge.

l. Roller drum gate. See drum gate.

m Roller gate (stoney gate). A gate for large openings that bears on a train of rollers in each gate guide.

n. Skimmer gate. A gate at the spillway crest whose prime purpose is to control the release of debris and logs with a limited amount of water. It is usually a bottom hinged flap or Bascule gate.

o. Slide gate (sluice gate). A gate that can be opened or closed by sliding in supporting guides.

Gate chamber
Also called valve chamber. A room from which a gate or valve can be operated, or sometimes in which the gate is located.

Geotextiles
Any fabric or textile (natural or synthetic) when used as an engineering material in conjunction with soil, foundations, or rock. Geotextiles have the following uses: drainage, filtration, separation of materials, reinforcement, moisture barriers, and erosion protection.

Groin
The area along the contact (or intersection) of the face of a dam with the abutments.

Grout
A fluidized material that is injected into soil, rock, concrete, or other construction material to seal openings and to lower the permeability and/or provide additional structural strength. There are four major types of grouting materials: chemical, cement, clay, and bitumen.

Grout curtain
One or more zones, usually thin, in the foundation into which grout is injected to reduce seepage

under or around a dam.

Grout blanket
An area of the foundation systematically grouted to a uniform shallow depth.

Grout cap
A concrete pad constructed to facilitate subsequent pressure grouting of the grout curtain.

Hazard potential classification
The rating for a dam based on the potential consequences of failure. The rating is based on potential for loss of life and damage to property that failure of that dam could cause. Such classification is related to the amount of development downstream of a dam.

Head, **static**
The vertical distance between two points in a fluid.

Head, velocity
The vertical distance that would statically result from the velocity of a moving fluid.

Headrace
A free-flow tunnel or open channel that conveys water to the upper end of a penstock; hence, the terms “headrace tunnel” and ‘headrace Canal.”

Heel
The junction of the upstream face of a gravity or arch dam with the ground surface. For an embankment dam the junction is referred to as the upstream toe of the dam.

Height, above ground
The maximum height from natural ground surface to the top of a dam.

Height, hydraulic
The vertical difference between the maximum design water level and the lowest point in the original streambed.

Height, structural
The vertical distance between the lowest point of the excavated foundation to the top of the dam.

Inclinometer
An instrument, usually consisting of a metal or plastic tube inserted in a drill hole and a sensitized monitor either lowered into the tube or fixed within the tube. This measures at different points the tube’s inclination to the vertical. By integration, the lateral position at different Levels of the tube may be found relative to a point, usually the top or bottom of the tube, assumed to be fixed. The system may be used to measure settlement during embankment construction (Bartholomew, Murray, and Goins 1987). A reference benchmark is used to establish the top of the inclinometer casing. The instrument probe is lowered to each slip joint in the casing, and the depth to each joint is read directly off the tape. Settlement measurements are made as each section of casing is added during embankment construction.

Initial reservoir filling

A deliberate impoundment to meet project purposes (a continuing process as successively higher pools are attained for flood control projects).

Instrumentation

An arrangement of devices installed into or near dams (i.e., piezometers, inclinometers, strain gages, measurement points, etc.), which provide for measurements that can be used to evaluate the structural behavior and performance parameters of the structure.

Intake
Any structure in a reservoir, dam, or river through which water can be discharged.

Inundation map
A map delineating the area that would be flooded by a particular flood event.

Length of dam
The length along the top of the dam. This also includes the spillway, powerplant, navigation lock, fish pass, etc., where these form part of the length of the dam. If detached from the dam these structures should not be included.

Levee
An embankment whose primary purpose is to furnish flood protection from seasonal high water. Embankments that are subject to water loading for prolonged periods or permanently should be designed in accordance with earth dam criteria.

Liquefaction
A condition whereby soil undergoes continued deformation at a constant low residual stress or with low residual resistance, due to the buildup and maintenance of high pore water pressures, which reduces the effective confining pressure to a very low value. Pore pressure buildup Leading to liquefaction may be due either to static or cyclic stress applications and the possibility of its occurrence will depend on the void ratio or relative density of a cohesionless or slightly cohesive soil and the confining pressure.

Logboom
A chain of logs, drums, or pontoons secured end-to-end and floating on the surface of a reservoir so as to divert floating debris, trash, and logs.

Maximum flood control level
The highest elevation of the flood control storage.

Maximum pool
The highest pool elevation resulting from the inflow design flood.

Maximum wave
The highest wave in a wave group.

Minimum operating level
The lowest level to which the reservoir is drawn down under normal operating conditions.

Observation well
A hole used to observe the groundwater surface at atmospheric pressure within soil or rock.

Outlet
An opening through which water can be discharged.

Outlet works
A device to provide controlled releases from a reservoir.

Parapet wall
A solid wall built along the top of a dam (upstream or downstream edge) used for ornamentation, for safety of vehicles and pedestrians, or to prevent overtopping caused by wave runup.

Penstock
A pressurized pipeline or shaft between the reservoir and hydraulic machinery.

Phreatic surface
The free surface of water seeping at atmospheric pressure through soil or rock.

Piezometer
An instrument used for measuring fluid pressure (air or water) within soil, rock, or concrete.

Piping
The progressive development of internal erosion by seepage.

Plunge pool
A natural or artificially created pool that dissipates the energy of free falling water.

Pore water pressure
The interstitial water pressure within a mass of soil, rock, or concrete.

Probability
The likelihood of an event occurring.

Probable Maximum Precipitation (PMP) Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location.

Pumped storage reservoir
A reservoir filled entirely or mainly with water pumped from outside its natural drainage area.

Quality (as related to construction)
Conformance to properly developed requirements.

Quality Assurance (QA)
The procedure by which the Government fulfills its responsibility to be certain the contractors' quality control is functioning and the specified end product is realized.

Quality Management
All control and assurance activities instituted to achieve the product quality established by the contract requirements

Reservoir
A body of water impounded by a dam and in which water can be stored.

Reservoir regulation (or operating) procedure
Operating procedures that govern reservoir storage and releases.

Reservoir surface area
The area covered by a reservoir when filled to a specified level.

Riprap
A layer of large uncoursed stone, precast blocks, bags of cement, or other suitable material, generally placed on the upstream slopes of an embankment or along a watercourse as protection against wave action, erosion, or scour. Riprap is usually placed by dumping or other mechanical methods and in some cases is hand placed. It consists of pieces of relatively large size as distinguished from a gravel blanket. Also known as stone slope protection.

Risk
The relationship between the consequences resulting from an adverse event and its probability of occurrence.

Risk assessment
As applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action.

Rock anchor
A steel rod or cable placed in a hole drilled in rock, held in position by grout, mechanical means, or both. In principle, the same as a rock bolt, but usually the rock anchor is more than 4 meters long.

Rock bolt
A steel rod placed in a hole drilled in rock, held in position by grout, mechanical means, or both. A rock bolt can be tensioned.

Runup
The vertical distance above the setup that the rush of water reaches when a wave breaks on the dam embankment.

Seepage
The interstitial movement of water that may take place through a dam, its foundation, or its abutments.

Significant wave height
The average height of the one-third highest waves of a given wave group.

Sill
A submerged structure across a river to control the water level upstream. The crest of a spillway. A horizontal gate seating, made of wood, stone, concrete, or metal at the invert of any opening or gap in a structure; hence, the expressions “gate sill” and “stoplog sill.”

Slope
Inclination from the horizontal. Sometimes referred to as batter when measured from vertical.

Sluice
An opening for releasing water from below the static head elevation.

Spillway
A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means such as gates, it is considered a controlled spillway. If the

geometry of the spillway is the only control, it is considered an uncontrolled spillway.

Spillway, auxiliary
Any secondary spillway, which is designed to be operated very infrequently and possibly in anticipation of some degree of structural damage or erosion to the spillway during operation.

Spillway, primary (or service)
A spillway designed to provide continuous or frequent releases from a reservoir without significant damage to either the dam or its appurtenant structures.

Spillway Design Flood (SDF)
See Flood, Inflow Design.

Spillway channel
An open channel or closed conduit conveying water from the spillway inlet downstream.

Spillway chute
A steeply sloping spillway channel that conveys discharges at supercritical velocities.

Spillway crest
The lowest level at which water can flow over or through the spillway.
Spillway, fuse plug
A form of auxiliary spillway consisting of a low embankment designed to be overtopped and washed away during an exceptionally large flood.

Spillway, shaft
A vertical or inclined shaft into which water spills and then is conveyed through, under, or around a dam by means of a conduit or tunnel. If the upper part of the shaft is splayed cut and terminates in a circular horizontal weir, it is termed a bellmouth or morning glory spillway.

Stilling basin
A basin constructed to dissipate the energy of rapidly. flowing water, e.g., from a spillway or outlet, and to protect the riverbed from erosion.

Stoplogs
Large logs, timbers, metal beams, or metal frames placed on top of each other with their ends held in guides on each side of a channel or conduit so as to provide a cheaper or more easily handled means of temporary closure than a bulkhead gate.

Storage
The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel. Definitions of specific types of storage in reservoirs are:

a. Dead storage. The storage that lies below the invert of the lowest outlet and that, therefore, cannot readily be withdrawn from the reservoir.

b. Inactive storage. The storage volume
of a reservoir between the crest of the invert of the lowest outlet and the minimum operating level.

c. Active storage. The volume of the reservoir that is available for some use such as power generation, irrigation, flood control, or water supply. The bottom elevation is the minimum

operating level.

d. Live storage. The sum of the active and the inactive storage.

e. Reservoir capacity. The sum of the dead and live storage of the reservoir.

f. Flood surcharge. The storage volume between the top of the active storage and the design water level.

Surcharge
Any storage above the full pool.

Tailrace
The tunnel, channel, or conduit that conveys the discharge from the turbine to the river; hence, the terms "tailrace tunnel" and "tailrace canal."

Tailwater level
The level of water in the tailrace at the nearest free surface to the turbine or in the discharge channel immediately downstream of the dam.

Threshold Flood
The flood that fully utilizes the existing dam, i.e., the flood that just exceeds the design maximum water surface elevation at the dam.

Thrust block
A massive block of concrete built to withstand a thrust or pull.

Toe of dam
The junction of the face of a dam with the ground surface. For concrete dams, see heel.

Top thickness (top width)
The thickness or width of a dam at the level of the top of dam (excluding corbels or parapets). In general, the term thickness is used for gravity and arch dams, and width is used for other dams.

Top of dam
The elevation of the uppermost surface of a dam, usually a road or walkway excluding any parapet wall, railing, etc.

Trashrack
A device located at an intake to prevent floating or submerged debris from entering the intake.

Tunnel
A long underground excavation with two or more openings to the surface, usually having a uniform cross section used for access, conveying flows, etc.

Uplift
The uplift pressure in the pores of a material
(interstitial pressure) or on the base of a structure.

Upstream blanket
An impervious blanket placed on the reservoir floor and abutments upstream of a dam. For an

embankment dam, the blanket may be connected to the core.

Valve
A device fitted to a pipeline or orifice in which the closure member is either rotated or moved transversely or longitudinally in the waterway so as to control or stop the flow. .

a. Hollow jet valve. A device for regulating high-pressure outlets. Essentially, it is half a needle valve in which the needle closure member moves upstream toward the inlet end of the valve to shut off flow. As there is no convergence at the outlet end, the flow emerges in the form of an annular cylinder, segmented by several splitter ribs for admitting air into the jet interior to prevent jet instability.

b. Regulating sleeve valve. **A** valve for regulating high-pressure outlets and ensuring energy dissipation. Inside the valve there is a fixed-cone, pointed upstream, which ensures dispersion of the jet. Outside the valve a cylindrical sleeve moves downstream to shut off flow by sealing on the periphery of the cone.

Volume of dam
The total space occupied by the materials forming the dam structure computed between abutments and from top to bottom of dam. No deduction is made for small openings such as galleries, adits, tunnels, and operating chambers within the dam structure. Portions of powerplants, locks, spillway, etc., should be included only if they are necessary for the structural stability of the dam.

Watershed divide
The divide or boundary between catchment areas (or drainage areas).

Waterstop
A strip of metal, rubber, or other material used to prevent leakage through joints between adjacent sections of concrete.

Wave runup
Vertical height above the stillwater level to which water from a specific wave will run up the face of a structure or embankment.

Weir
A notch of regular form through which water flows.

a. Weir, broad-crested. An overflow structure on which the nappe is supported for an appreciable length in the direction of flow.

b. Weir, measuring. A device for measuring the rate of flow of water. It generally consists of a rectangular, trapezoidal, triangular, or other shaped notch, located in a vertical, thin plate over which water flows. The height of water above the weir crest is used to determine the rate of flow.

c. Weir, ogee. A reverse curve, shaped like an elongated letter “S.” The downstream faces of overflow spillways are often made to this shape.

Wind setup
The vertical rise in the stillwater level at the face of a structure or embankment caused by wind stresses on the surface of the water.

APPENDIX C

Dam Safety in the Corps of Engineers

C-1. Background.

C-1.1. *Corps Dam Safety:* The safety of dams has been a major concern of the Corps of Engineers since it began building dams in the 1840's. As part of the flood control development of the Muskingum River in the 1930's, the Corps started a multiple level of review requirement for dam design. This is currently being performed by an independent technical review at the district level. As designers, owners, and operators, USACE retains responsibility and accountability for the continued safe performance of our applicable dams and appurtenant structures, under the full range of anticipated loading conditions. For many years the Corps has made extensive use of experts to consult and advise on unusual and difficult designs. Advisory boards have been helpful in establishing design criteria and standards. Experience gained from the 1938 slide in the embankment of Fort Peck Dam led the Corps to adhere to the highest design standards and comprehensive inspection and testing for construction. The Corps was one of the first agencies to initiate a periodic inspection and evaluation program, and the COE program was used as input to the development of the "Federal Guidelines for Dam Safety" due to its early, comprehensive and effective program.

C-1.2. *Federal Dam Safety Action*: As a result of several dam failures in the mid 1970's, none of which were Corps' owned or operated, a Presidential Memorandum was issued on 23 April 1977 that required each Federal agency having responsibility for dams to review their practices and activities related to dam safety. This memorandum also directed the Federal Coordinating Council for Science, Engineering and Technology to prepare guidelines for management practices and procedures to ensure dam safety. "Federal Guidelines for Dam Safety" was published in June 1979, and with a memorandum dated 4 October 1979, President Carter asked each Federal agency having responsibility for dams to adopt and implement these guidelines and report their progress to the Federal Emergency Management Agency (FEMA) on a biennial basis. Executive Order 12148 gives FEMA the responsibility to coordinate dam safety in the nation. The purpose of these guidelines is to enhance national dam safety and to encourage high safety standards in the management procedures and technical activities of Federal agencies. The guidelines require the head of each Federal agency having responsibility for design, construction, operation and regulation of dams to establish a dam safety office (officer), which reports directly to the head of the agency. The Interagency Committee on Dam Safety (ICODS) was established in 1980 to promote and monitor Federal and State dam safety programs. The Corps of Engineers is the Department of Defense representative on ICODS.

C-1.3. *Corps Dam Safety Officer:* On 7 February 1980, the Chief of Engineers appointed the Chief of the Engineering Division, Directorate of Civil Works, as the HQUSACE Dam Safety Officer. This appointment also required that the Dam Safety Officer chair a standing committee composed of individuals having assigned responsibilities for dam safety to include programming and policy functions. The purpose of this committee is to provide surveillance, evaluation, and guidance for the administrative, technical, and regulatory practices within the Corps of Engineers. The Dam Safety Officer is advisory to the Chief of Engineers, through the Director

of Civil Works. The HQUSACE Dam Safety Officer is now Chief, Engineering and Construction.

C-2. Introduction. It is difficult to quantify the overall safety of a dam, however the way to achieve maximum dam safety is to apply the utmost care and competence to every aspect of design, construction, operation, and maintenance. The most important prerequisite for dam safety is the professional competence of persons associated with the dam over its life span. A dam with a record of safe performance may still experience failure from undetected deficiencies within the dam structure or in the foundation. Dam safety must take precedence over all other considerations (references 55, 56, 57, and 58).

C-3. History of Dam Safety.

C-3.1. *Early Development of Dams:* History indicates that dams have been vital to civilization for more than 5,000 years. The early United States settlers constructed dams in the 1600's for water supply and to power gristmills and sawmills. The oldest Corps of Engineers' dams are six locks and dams on the Green and Kentucky Rivers built between 1836 and 1844.

C-3.2. *Dam Safety:* Although construction of dams dates back many years, the history of dam safety covers a much shorter time span. Only a limited number of states had any laws regulating dam safety prior to 1900. The failure of the South Fork Dam in 1889 at Johnstown, Pennsylvania, resulting in 2,209 deaths, had limited influence on dam safety programs. California initiated a dam safety program following failure of the St. Francis Dam in 1928. Failure of the Buffalo Creek Dam in West Virginia and the Canyon Lake Dam in South Dakota in 1972 contributed to Congress passing "The National Dam Inspection Act" in 1972. "The Reclamation Safety of Dams Act" in 1977 followed failure of Teton Dam in Idaho in 1976. Failure of the Laurel Run Dam in Pennsylvania and the Kelly Barnes Dam in Georgia in 1977 set in motion the development of the "Federal Guidelines for Dam Safety" issued in 1979 by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) (reference 47).

C-3.3. *Interagency Committee on Dam Safety:* Although the Interagency Committee on Dam Safety (ICODS) was created in 1980, the Water Resources Development Act (WRDA) of 1996 codified it as a permanent forum for the various government agencies to advise FEMA on institutional, managerial, technical, legislative, and policy issues affecting national dam safety. The following Federal agencies serve on ICODS:

Department of Agriculture
Department of Defense
Department of Energy
Department of Interior
Department of Labor
Federal Emergency Management Agency
Federal Energy Regulatory Commission
International Boundary and Water Commission (U.S. Section)
Nuclear Regulatory Commission

Tennessee Valley Authority

ICODS encourages the establishment and maintenance of effective Federal programs, policies, and guidelines intended to enhance dam safety for the protection of human life and property. This is accomplished through (1) coordination and information exchange among Federal agencies and State dam safety agencies; (2) coordination and information exchange among Federal agencies concerning implementation of the "Federal Guidelines for Dam Safety"; (3) Federal activities that foster State efforts to develop and implement effective programs for the safety of dams; (4) improved techniques, historical experience, and equipment for rapid and effective dam construction, rehabilitation, and inspection; and (5) devices for the continued monitoring of the safety of dams. ICODS has an Operations Subcommittee, which focuses on activities essential to carrying out the operating activities of ICODS.

The Director of the Federal Emergency Management Agency was designated coordinator of the National Dam Safety Program in WRDA96, and is the Chair of the ICODS and the National Dam Safety Review Board.

C-3.4. *National Dam Safety Review Board:* The Water Resources Development Act of 1996 established the National Dam Safety Review Board (NDSRB). The NDSRB monitors state implementation of dam safety programs, and advise the Director of FEMA in national dam safety policy. The Director of FEMA based on their dam safety expertise selects nominees to the NDSRB. The USACE Dam Safety Officer recommends a qualified individual to serve on the NDSRB. Five subcommittees serve under NDSRB and focus on activities essential to carrying out the goals of the Program. These subcommittees are:

Dam Safety Research Work Group
Dam Safety Training Work Group
National Inventory of Dams Work Group
Guidelines Development Work Group
Dam Security Work Group

APPENDIX D

Corps of Engineers Dam Safety Program Management Team (CEDSPMT)

D-1. Authority and Responsibilities. The Team is empowered to develop and implement a strategic plan and a long-range plan for the USACE Dam Safety Program, including a mission statement, goals, objectives, and performance measures. The Team shall establish USACE Dam Safety Standards and monitor district compliance with these standards. The Team shall function in accordance with requirements of the Project Management Business Process (PMBP).

D-2. Objectives and Goals. The objective of the Team is to provide a formal USACE structure to develop policies, practices, and relationships to effectively facilitate dam safety practices and accomplishments. The Team maintains a consistent and accountable nationwide dam safety program. The Team works with other agencies to improve the USACE Dam Safety Program. The Team affirms accountability for dam safety to all elements within the command chain, monitors performance, and inculcates dam safety as a fundamental USACE mission. The goals of the Team are:

Participating in development of USACE-wide guidance when requested by the HQUSACE Dam Safety Officer (DSO),

Making recommendations to HQUSACE Dam Safety Officer for studies, investigations, and research designed to improve the safety of dams,

Rendering consulting service and advice on specific safety of dams issues and problems as requested by various elements of USACE or other agencies,

Maintaining a continuing evaluation of the state-of-the-art for the safety of dams,

Serving as a liaison for the dam safety process between HQUSACE and MSC/districts and disseminate pertinent information throughout USACE, and

Promoting dam safety engineering career development.

D-4. Scope of Team Activities. The Team will provide recommendations to the HQUSACE DSO on all topics in the areas of safety of dams such as roles and responsibilities, training, career development, automated systems and software, guide specifications, uniformity of project specifications, uniformity of process, research and development, and interface with other elements within USACE, other agencies, and professional organizations.

D-5. Composition. The team members are full-time civilian employees of USACE. The Team shall seek to maintain a diversity of civil works dam safety experience as well as a diversity of the engineering disciplines. A current list of members will be posted on the Corps of Engineers Technical Excellence Network (TEN). The team officers shall be team leader, alternate team leader, and recording secretary. The Special Assistant for Dam Safety shall serve as the team leader. The HQUSACE Dam Safety Program Manager shall serve as recording secretary. The

Team shall elect an alternate team leader. The Team shall be composed of seventeen (17) members as listed below.

D-5.1. *HQUSACE Members:* Four (4) HQUSACE individuals, who will be the Special Assistant for Dam Safety (CECW-CE), the Dam Safety Program Manager (CECW-CE), one member from Operations (CECW-CO), and one member from Program Integration Division (CECW-IP).

D-5.2. *Major Subordinate Command (MSC) Members:* Eight (8) individuals comprised of the Dam Safety Program Manager from each MSC.

D-5.3. *Engineering Research and Development Center (ERDC) Member:* One (1) ERDC individual appointed by the ERDC Director.

D-5.4. *District Members:* Four (4) district representatives with experience in the safety of dams who shall be elected by the Team as at-large members. At least one of the district representatives shall be from an operating element.

D-5.5. *Alternate Members:* In the event that a member of the Team cannot attend a Team meeting, the member may designate an alternate to serve in his capacity. The member shall provide the name of the alternate to the team leader prior to the meeting.

D-6. General. The Team will carry out its objective in accordance with the following:

D-6.1. *Oversight:* The Team functions under the general direction of the Corps DSO.

D-6.2. *Meetings:* The team leader will call meetings as required to carry out the Team's objective; normally meetings will be held semi-annually. Advance notice, agenda, and minutes of each meeting will be furnished to team members and pertinent USACE commands.

D-6.3. *Funding:* HQUSACE, MSC, and ERDC members will be funded by their respective organizations for team activities. District members' salary, travel and per diem expenses may be funded by HQUSACE for team activities based on the availability of funds.

APPENDIX E

Dam Safety Program Management Tools

E-1. Purpose. The purpose for the Dam Safety Program Management Tools (DSPMT) is to facilitate agency wide data collection and monitoring of the USACE dam safety program and to track compliance against the "Federal Guidelines for Dam Safety" and USACE criteria.

E-2. Introduction. The DSPMT consist of a set of interactive software programs that provide a resource to the Dam Safety Data owners, managers, and data providers. The software is under continual development and is evolving as needs are expressed by users. The DSPMT currently includes three distinct functional software programs:

Dam Safety Program Performance Measures (DSPPM),

National Inventory of Dams (NID) Electronic Submittal Workflow, and

Palm or Pocket PC-based Inspection Checklists.

Each of these programs is applicable to all levels of a dam safety organization. Output from the DSPPM at each level can be used individually and/or collectively as input at the next higher level to evaluate program performance on broader and broader scales (e.g., district, division, agency, State). By utilizing the tools provided by the DSPMT, data managers and providers can achieve the one-time-only data entry objective while maintaining an up-to-date, error-checked, consistent format database of dam inventory and program performance information.

E-3. Background. The software was originally named Dam Safety Program Performance Measures (DSPPM) since it started as an effort to develop a few simple, unbiased, generic performance measures (or indicators). The goal of the performance indicators was to help dam safety program managers answer questions such as:

How well are our dam safety programs being implemented?

Are we doing too much in some areas and not enough in others?

Are we spending our scarce resources in the right places?

Are we improving?

Since the inventory of dams is a natural extension of the DSPPM, the NID Electronic Submittal Workflow software easily became an integral part of the DSPMT to help users provide a consistent, error-checked electronic submittal of inventory information. The software name was then changed to Dam Safety Program Management Tools (DSPMT). Subsequently, the Palm and Pocket PC-based Inspection Checklist software was incorporated. It consists of a standardized application for the collection and updating of performance measure information,

NID information, and a number of flexible and configurable "plug-in" applications for dam safety inspection checklists.

E-4. Discussion. The overall objective of the DSPMT is to enable each user to have a stand-alone computer program that interacts with the NID, local databases, and other external cooperative databases in a one-time-only data entry environment. The vision is to eventually achieve:

One-time data entry for programs targeted at the different aspects of dam safety;

Efficient data extraction from local state and federal databases into a consistent user-friendly and user-managed inventory and performance measure database;

Automated error checking and identification of conflicting data;

Simple online exports of local inventory and performance measure (or indicator) data and import of national level data to/from a centralized server; and

Updating and reporting of inventory, performance measure, and incident information as frequently as desired.

The objectives of the DSPPM are also to provide simple, unbiased, quantitative data that are useful separately and/or collectively as metrics to help users:

Evaluate how well their dam safety programs are being implemented;

Determine whether they accomplished what they set out to accomplish;

Proactively “tell” their dam safety stories to others, both internal and external to their organizations; and

Encourage uniform and consistent application of laws, policies, and regulations.

E-5. DSPMT Overview.

E-5.1. *DSPPM:* The DSPPM is currently divided into seven subject areas:

Dam Safety Program Management Authorities and Practices,

Dam Safety Staff Size and Relevant Experience,

Inspections and Evaluations,

Identification and Remediation of Deficient Dams,

Project Response Preparedness,

Agency and Public Response Preparedness, and

Unscheduled Dam Safety Program Actions.

E-5.2. *NID Submittal Workflow:* The NID electronic submittal software provides tools for data owners to efficiently collect, access and manage NID data. The workflow starts by importing a State or Federal agency's local inventory of dams, which can be in a variety of database formats. Interactive graphical tools provided by the DSPMT are then utilized to check for data errors in numeric values and spelling errors or inconsistencies in text values. The NID inclusion rules are then applied. The data submittal is checked for differences between the candidate and the current NID, and is then electronically sent to the Corps for review and incorporation into the NID.

E-5.3. *Palm or Pocket PC-Based DSPMT Inspection Checklists:* Utilization of Palm or Pocket PC-based computing technology is optional. Its usage would further allow the one-time-only data entry objective to become a reality. Field Inspectors can download NID and DSPPM information from their desktop DSPMT program to the handheld computer, which can then be utilized in the field for collecting data. The software consists of a single standardized application for the review, collection, and update of DSPPM and NID information, and a number of flexible and configurable "plug-in" applications for dam safety inspection checklists. These plug-in applications are currently available for some organization-specific checklists such as FERC, BOR, and a few individual State's safe dams programs. Inspection checklists are also available that are targeted at particular aspects of dams such as the checklist for Earth-fill Dams, Concrete Dams, Spillways, Powerhouses, Water Conveyance Structures, or Instrumentation. User's can easily configure the application to only present the inspection checklists utilized by the user's organization. This software configuration provides for standardized, consistent, one-time-only data entry of DSPPM and NID information while providing maximum flexibility for utilizing/ configuring the inspection checklists pertinent to the dams in a users local inventory.

E-6. USACE DSPMT Implementation Specifics. This section provides specific guidance to USACE regarding implementation of the dam inventory data, database maintenance, data collection, and submittal workflows currently provided by the DSPMT software.

E-6.1. *Getting Started:* This section describes how to obtain the DSPMT software, what to do the first time the program is run to identify the District/Division, how to load the initial inventory of dams, and how to initialize 'starting' values for selected performance measure for all dams in the District.

E-6.1.1. The DSPMT software may be obtained/downloaded from the DSPMT web site, which is currently located at www.safedams.org. The website provides descriptions of the various aspects of the DSPMT, what the specific performance measures are, various configurations for using the program, and provides download areas for program installation files and User's Manual. Installation files are available for either Windows 2000 Professional or Windows 9x operating systems. Windows 2000 Professional operating systems include Windows NT and Windows 2000 Professional. Windows 9x operating systems include Windows 95, 98, Me, and

XP. After downloading the installation files to any directory on the User's hard drive, run setup.exe to install the program.

E-6.1.2. When the program is run for the first time, users are asked to identify themselves by manually entering their 5-letter organization code. Even though there is a default list of organizations provided on a pull down list on the form interface that contains all of the States and Federal agency names, they should not be used by USACE. For USACE, use of the District or Division organization name is required and must be manually entered/typed into the list-box blank field. It is very important that the name be the five-letter district, MSC, or HQ designation only. Values such as "CESAD" or "CESWT" are expected. Do not elaborate on the organization code by using values such as "CEMVM-ED-DS". The program only expects the 5-letter organization code value.

E-6.1.3. To load the local (district) inventory of dams, the DSPMT is used to connect to the centralized network server, which contains pre-loaded initial inventory data for all of the USACE districts. Use the DSPMT User's Manual for detailed specifics on how to accomplish the following. From the DSPMT main form, go to Executive Review, then DSPPM Review Functions, then Organizational level download. From this interface, press the "Download Submittal Data from TEC FTP Site". This will bring up an interface, which connects, to the centralized network server. A password is required to access the files on this site. Each USACE district and division has been assigned a unique password. The USACE division dam safety program managers are aware of what the current passwords are for each district, and they should be contacted for this information. Passwords must be guarded and not disclosed. After entering the password, a list of files shows the inventory data available from the site. There are files for each State, several Federal Agencies, and each USACE district. The USACE district filenames are constructed using the 5-letter district or division name followed by an ".mdb" extension. "CENWK.mdb" and "CESAM.mdb" would be included in this list, for example. The initial inventory file may then be highlighted, downloaded, and then imported into the local DSPMT program using the detailed procedures described in the DSPMT User's Manual.

E-6.1.4. For first-time users only, after downloading and importing the initial district inventory information into the DSPMT, each district shall initialize standard default performance measure values for all, or selected, dams in the local inventory. These starting (default) performance measure values are for items such as inspection frequency, whether a seismic evaluation is required, whether an EAP is required, etc., and are selected based on hazard potential classifications. The DSPMT User's Manual provides specific detailed procedures for initializing these items using the performance measures spreadsheet capabilities of the expert user interface.

E-6.2. *Maintaining the Database:* Since the Dam Safety Program Managers at the district level should be most familiar with the details of the individual projects in their inventory, they shall have the primary burden of maintaining up-to-date information on the dams in the database. As inspections are completed, the DSPMT shall be updated to include any modifications to NID information on the dam, and to include the results of the inspection and any impacts on the performance measures such as inspection date, identified deficiencies, estimated costs of remediation, priority ratings, etc. The updates should then be uploaded to the central server. The MSC shall be responsible for providing quality assurance and review functions on district

submittal information on a periodic basis. This is accomplished at the MSC level by first deleting all dams from their local inventory of dams and then downloading and importing the latest district submittal data files from the centralized network server. A 'live update' capability has been incorporated for both data and software version so that users at all levels can download the most current information and software versions. Instructions for accomplishing these updates are described in the DSPMT User's Manual. If questions, data conflicts, or errors are noticed in district inventory information, they shall not be corrected or modified at the division level or HQ level. It shall be the district responsibility to resolve the question or implement the correction in the district database and the district shall then provide a new data upload.

E-6.3. *Providing Submittal/Inventory Information:* Data submittal and inventory information shall be provided on an as available, as-requested, and periodic basis. Data submittals can be in the form of very standardized NID electronic submittals or in the form of very specific non-standard data requests by the MSC, HQ, other agencies or organizations. The DSPMT provides workflows for easily generating both types of submittal information. Inventory and other data may also be exported at any time using the Excel output capability of the DSPMT. For example, capability has been provided for creating a customized Excel spreadsheet of selected NID and performance measure fields to be generated for all dams or only for dams, which meet specified query criteria. This Excel spreadsheet may then be provided to the requesting organization. Detailed procedures for generating this customized Excel spreadsheet are included in the DSPMT User's Manual.

APPENDIX F

Periodic Inspection Program - Inspection and Evaluation Procedures

F-1. Project Documentation.

All engineering data relating to project structures inspected shall be collected and permanently retained in appropriate files at the project site for availability to the inspection team and readily accessible for emergencies response. Formal Inspection Reports shall indicate which items are not available, and describe attempts to locate such records or documents. Project engineering data shall also be retained at the district office. In the absence of on-site administrative headquarters, the data shall be retained at the nearest field office. These documents and drawings shall be considered as permanent engineering data, subject to retirement or disposal only upon termination of operation of the project. These data shall consist of, but not be limited to, the items listed below.

F-1.1. All previous Periodic Inspection Reports.

F-1.2. Records of inspections by project personnel and interim inspections by district personnel.

F-1.3. Design Memoranda or Design Documentation Reports to include principle design assumptions, stability and stress analyses, slope stability, seepage and settlement analyses, consolidation, shear, permeability, compaction, classification tests or summaries thereof, and contract plans and specifications.

F-1.4. As-built plans, elevation, and sections.

F-1.5. As-built drawings of important project features, to include details such as instrumentation, internal drainage, transition zones, or relief wells, and reports of any special investigations.

F-1.6. Foundation data and geological features, including boring profiles, foundation mapping, and final logs of subsurface exploration.

F-1.7. Location of borrow areas and identification of embankment, filter, riprap, large stone sources.

F-1.8. Laboratory Reports including:

F-1.8.1. As-built properties of foundation and embankment materials, such as shear strength, unit weight, and water content and classification. The number of control tests and undisturbed record sample tests shall be included.

F-1.8.2. Physical, chemical, and thermal properties of concrete and concrete-making materials.

F-1.8.3. Summary of concrete mixture proportions and control procedures.

F-1.9. Project Geotechnical and Concrete Materials Completion Report.

F-1.10. Construction history records, including diversion schemes and construction sequences shown on appropriate drawings.

F-1.11. Details of the overall instrumentation program to include predicted performance and record of actual observations, and annual updated evaluations.

F-1.12. Operations and Maintenance Manual.

F-1.13. Water Control Manual.

F-1.14. Copy of PCA.

F-1.15. Dam Safety Information:

F-1.15.1. Project copy of "Federal Guidelines for Dam Safety".

F-1.15.2. Emergency Action Plans - complete with the emergency identification subplan (Federal), emergency operations and repair subplan (Federal), full-scale inundation maps (Federal), notification subplan (Federal and non-Federal) and evacuation subplan (non-Federal), if available.

F-1.15.3. Records of dam safety training for project personnel.

F-1.15.4. Surveillance plan of the project that includes events and threshold reservoir levels that initiate observations and/or inspections and reporting procedures.

F-1.15.5. List of local contractors and construction materials available for use in emergency situations.

F-1.15.6. Physical security plan for the project.

F-1.16. Manufacturers data for purchased items.

F-2. Inspection Program.

F-2.1. *Initial Pre-inspection Brochure:* A technical brochure shall be prepared in advance of the first project inspection to familiarize inspection team members with general project features. This brochure shall include a technical summary of the structural, material, and foundation conditions, instrumentation data, including settlement monuments, location of instrumentation and description of reservoir operations procedures, if pertinent. The brochure shall also include appropriate pertinent project data, project layout and typical section drawings, Federal and non-Federal responsibilities for OMRR&R, summaries of sub-surface soil profiles and boring logs, and the checklist developed for conducting the inspection. Pre-inspection brochures shall be completed and distributed to inspection team members at least 30 days prior to the inspection date.

F-2.2. *Pre-inspection Packets:* A technical pre-inspection packet shall be prepared in advance of all subsequent project inspections to familiarize inspection team members with general project features

and history. This packet shall include a project access map, history of project deficiencies and remedial measures, technical summaries of the structural, material, and foundation conditions, and description of reservoir operations procedures, if pertinent. Also include evaluation and plots of most recent instrumentation data, including settlement monuments, and location of instrumentation. Also, as appropriate, the packet shall include project data, layout and typical section drawings, Federal and non-Federal responsibilities for OMRR&R, summaries of sub-surface soil profiles and boring logs, and the checklist developed for conducting the inspection. Packets may be tailored to each discipline to avoid excessive reproduction. Pre-inspection packets shall be completed and distributed to inspection team members at least 15 days prior to the inspection date.

F-2.3. *Inspection Procedures:* A systematic plan will be established for the inspection and operation of those features related to the safety and stability of the structure and to the operational adequacy of the project. Operational adequacy means the inspecting, testing, operating, and evaluation of those components of the project whose failure or failure to operate properly could impair the operational capability and/or usability of the structure. Where the operation of these components is vital to the safe operation of the project under emergency conditions, these components will be operated by emergency power at least annually and these operations recorded in a project log. Emergency generators shall be tested under load on more frequent intervals to maintain their integrity. In addition, standby emergency generating systems shall be reviewed and tested during the scheduled inspection to assure the inspection team that all critical project features can be operated under emergency conditions or in the absence of the normal source of power. The testing of emergency power shall include the maximum power demand that could be expected in emergency situations. As much as possible the operation and or inspection of all the features shall be conducted during the scheduled inspection. The inspection of the remaining features may be conducted any time prior to completion of the inspection report, but, no earlier than occurrence of the last major flood event for the project. However, if possible, the inspection of features such as stilling basin dewatering, tainter gate inspections, operability inspections, etc. shall be completed before the periodic inspection so that the team can review the inspection reports during the periodic inspection. If appropriate, a video of the event could document pertinent results of the pre-inspection for showing at the regularly scheduled inspection.

F-2.4. *Inspection Plan:* The systematic inspection plan shall also provide, as appropriate, the examination and the operation of, but not be limited to, the following features and conditions:

F-2.4.1. Hydraulic Steel Structures (HSS), as defined in ER 1110-2-8157 (reference 41) which include flood and outlet control gates (including flood gates in levees or flood walls), navigation lock gates and valves, emergency closure gates, spillway tainter gates, stoplogs and bulkheads, and associated lifting beams; hoists and operating machinery (including safety devices such as limit switches and fail-safe interlocks)**;** flood control pumps and related equipment**;** and cathodic protection systems.

F-2.4.2. Structures including piers, overflow and non-overflow monoliths, roadways, parapets, training walls, spray walls, dam outlet conduits, intake towers, bridges to gate towers, and steel sheet pile features.

F-2.4.2.1. Structural features

F-2.4.2.2. Concrete surfaces.

F-2.4.2.3. Structural cracking and deterioration of material.

F-2.4.2.4. Joints and joint materials, including relative movement at joints between structures or portions of structures.

F-2.4.3. Water passages.

F-2.4.4. Embankments including foundation drains, joint drains, face drains.

F-2.4.4.1. Embankment cracks, bulging, and sliding; condition of abutment and embankment junctions; and vertical and horizontal alignment of the embankment or structure crest, slope, or toe area.

F-2.4.4.2. Unusual movement or cracking at or beyond the embankment or slope toe.

F-2.4.4.3. Seepage through or under embankment or abutment slopes.

F-2.4.4.4. Sloughing or erosion of embankment or abutment slopes.

F-2.4.4.5. Condition of riprap, armor or other slope protection.

F-2.4.4.6. Scour protection stone and below water surface erosion control features.

F-2.4.4.7. Conditions of relief wells, collector pipes, inspection manholes, or other features of seepage control systems (EM 1110-2-1914 (reference 13) and ER 1110-2-1942 (reference 39)).

F-2.4.4.8. Condition and location of any known embedded utilities, including gas, water, and sewer lines in the embankment, abutments, or toe of the dam.

F-2.4.4.9. Seepage, depressions, sinkholes, and soft, marshy areas downstream of the dam.

F-2.4.4.10. Tailrace area, for muddy flows.

F-2.4.5. Spillways, spillway buckets and stilling basins and outlet channels including submerged features as necessary.

F-2.4.6. Conditions of instrumentation, and most recent measurements prior to the inspection (Chapter 7 of this regulation).

F-2.4.7. Reservoir rim conditions. (Can be limited to areas impacting the operation or stability of the dam).

F-2.5. *Checklist:* A detailed checklist of elements relative to the structural stability and operational adequacy of the project shall be developed for each structure in order to ensure an adequate examination coverage for each feature. The facility's instrumentation shall be included in the checklist to ensure that data are regularly collected and analyzed and to ascertain whether the instruments are in proper operating condition.

F-2.6. *Photographs:* In order to more accurately portray conditions and changes in conditions of surfaces and structural details, color photographs are encouraged. In addition to photographs, video is encouraged for use in monitoring areas of concern. This is especially useful for comparing movement, water leakages, wave action, etc.

F-2.7. *Examination of Deteriorated Concrete Structures:* If the inspection reveals the need for any type of in-depth evaluation to determine the cause of deterioration or malfunction and to make sound recommendations for remediation, the need for the investigation shall be stated in the periodic inspection report. Guidance on repair of concrete is given in EM 1110-2-2002 (Reference 14).

F-2.8. *Structures:* Steel structures shall be visually inspected for structural and operational adequacy. The inspection shall be sufficient to identify major defects such as visible cracks. Those structures involved directly in the safety of the project shall receive special consideration. Fracture critical members, where failure would result in probable loss of life, shall initially be inspected by additional means, such as ultrasonic or other nondestructive testing. HSS inspection reports shall be prepared in accordance with ER 1110-2-8157 (reference 41) and shall be included in the Periodic Inspection Report. Reference EM 1110-2-6054 (reference 20) for additional information on these structures.

F-2.9. *Riprap:* The quantity, size, and location of riprap, sand, gravel, clay, sand bags, geotextiles, and other related materials and available equipment required to place these materials under any weather conditions shall be stated. Material sources that have unsatisfactory performance records shall be identified, reported and eliminated from further use.

F-3. Composition and Qualifications of the Inspection and Independent Technical Review Teams. Inspection team and Independent Technical Review team personnel shall consist of individuals qualified by experience in the design, construction, inspection, and operation of the project, and of individuals with appropriate specialized knowledge in structural, mechanical, electrical, hydraulic, geotechnical (embankment design), geology, concrete materials, and construction procedures, as required. A representative(s) of the sponsor shall be invited to be part of this team. In every case, the inspection team qualifications may vary with the complexity of the facility and with the level of inspection. All team members shall receive training in the inspection procedures and personal safety during the inspection, including the use of personal protective equipment. Training Aids for Dam Safety (TADS) modules are recommended as a minimum for each team member, as well as a thorough understanding of this regulation. Where appropriate, inspection personnel shall be trained for confined space entry. The Dam Safety Officer of each district is responsible for scheduling this training.

F-4. Inspection Report Content. The periodic inspection report shall present the results of each project inspection. The title of this report shall indicate the name of the project, watercourse, state, project features, and inspection number and date, in that order. An example of an appropriate title is:

"Beech Fork Lake Project; Twelvepole Creek, West Virginia; Dam, Outlet Works and Spillway; Periodic Inspection Report No. 1, September 1992". Report No. 1 (report of initial inspection) shall provide a general project description and present the results of the initial inspection. Reports of subsequent inspections shall be supplementary to the initial report and will be numbered sequentially with the initial report; i.e., Report No. 2 would describe inspection number 2, etc.

F-4.1. *Initial Report:* To the extent possible, major elements of this report are:

F-4.1.1. An executive summary of the major items found in the inspection, including a statement regarding the project's ability to continue acceptable and safe operation.

F-4.1.2. A general project description including layouts and typical section for the purpose of familiarization with general features of the project.

F-4.1.3. List of project documents, and engineering data that identifies the status and location of the project documents.

F-4.1.4. Results of examination for each feature, including a statement as to its ability to function as designed and copy of the completed inspection checklist.

F-4.1.5. Evaluation and summaries of the observations and inspection of instrumentation (Chapter 7 of this regulation) and relief wells with comparison to design predictions and actual conditions that signal changes in the structure's performance.

F-4.1.6. Where appropriate, statements, or exhibits summarizing the duration and frequency of spillway and control gate operations, including heads or velocities, and number of lock filling and emptying operations.

F-4.1.7. Technical assessment of the causes of distress, of abnormal conditions, and evaluation of the behavior, movement, deformation, and loading of the structure and its individual components. If such assessment cannot be accomplished within the time allotted to complete the inspection report, a preliminary assessment shall be discussed with a plan scheduled to complete the assessment.

F-4.1.8. Color photographs with an appropriate caption, including the date taken.

F-4.1.9. A discussion of the deficiencies, the proposed remedial measures, with sketches if appropriate, related maintenance operations and both the cost estimates and a proposed completion schedule.

F-4.1.10. A discussion of the overall structural and individual project components stability, safety, and operational adequacy compared to its intended purpose(s) for the conditions with and without the recommended remedial measures. The DSMPT priority code 1 thru 6 assigned to each recommendation should be updated in the deficiency spreadsheet module screen 4.5 of the Dam Safety Program Management Tool software so the assigned priority can be tracked over time.

F-4.1.11. Recommendations, except for the routine maintenance type that can be performed by project personnel, should include the priority level for the recommended action in accordance with the following table:

Dam Safety Work Item Funding Priority Levels and Description		
Priority Funding Level	DSPMT Code	Descriptions
CY	1	Serious dam safety deficiency exists that needs remediation immediately. If not corrected, item has an unacceptable dam safety risk. May require operational restrictions placed on the project. Reprogramming funds is appropriate.
BY	2	Remediation should be initiated within 12 months. May require operational restrictions placed on the project. Reprogramming funds is appropriate.
BY+1	3	Study and remediation (as applicable) should be initiated within 24 months.
BY+ 2	4	Study and remediation (as applicable) should be initiated within next budget cycle or 36 months.
BY+ 3	5	Study and remediation (as applicable) should be initiated within next budget cycle or 48 months.
BY+4	6	Needs to be resolved within 5 years. This work will probably not get funded unless the deficiency worsens. Monitoring is appropriate.

Definitions: CY = Current Fiscal Year
BY = Budget Year, usually CY +2 for O&M,
BY+1 = Budget Year plus one year.
DSPMT = Dam Safety Program Management Tools

F-4.1.12. Views of the non-Federal sponsor on any of the above shall be included (if applicable).

F-4.1.13. Exhibits shall include, as appropriate: trip reports; plots of instrumentation data; inspection checklist; summaries of crack surveys; correspondence that documents the performance of the project; the results of special investigations; and the status and location of the project documents required by this document and ER 1130-2-530 (reference 44).

F-4.1.14. A discussion of the need for updating the project design parameters (hydraulic, seismic, HSS, etc.), if applicable.

F-4.1.15. Copies of selected drawings and boring logs.

F-4.2. *Subsequent Reports:* Subsequent reports shall generally include the items stated in paragraph F-4.1. above and shall follow the requirements of paragraph F-5 below, however they shall also include:

F-4.2.1. A general description of the facility.

F-4.2.2. Brief summary of past performance and problems and concentrate on the new and continuing conditions that affect or may affect the overall safety and operational capability of the structure. This summary shall not be merely a reference to a previous report.

F-4.2.3. A discussion on maintenance and remedial activities to include materials used, application techniques, and performance.

F-4.2.4. A discussion on recommended remedial measures not completed since the previous inspection report, as well as a proposed schedule to accomplish the remedial measures.

F-4.2.5. Copies of selected drawings; however, extensive reproduction of previously published drawings shall be avoided. As a minimum, a location and vicinity map which also show project access shall be included, as well as a general plan that shows each feature discussed in the report. The names and stationing shall be consistent on the drawings, narrative, and photograph captions.

F-4.2.6. A summary of the project's bridge inspections that may impact project safety or access during emergency conditions shall be included. ER 1110-2-111 (reference 31) provides guidance on bridge inspections.

F-5. Inspection Report Format. The following paragraphs describe the requirements for hard-copy reports. Reports may be submitted electronically, as approved by the respective MSC, and shall be prepared in the same format as stated herein; however, at least two hard copies shall be retained at the district and at least two hard copies submitted to the MSC.

F-5.1. *Organization:* Reports shall generally be organized as follows:

Table of Contents

1. Executive Summary, including a statement regarding the status of project safety for continued operation, and Certification of Independent Technical Review.

2. Independent Technical Review Comments and Resolutions.

3. General Statement of Inspection Program (include statement on hazard potential classification and report approval authority).

4. Description of the Project.

5. Brief Project Summary.

5.1. Construction conditions.
5.2. Project characteristics.
5.3. History of remedial measures.
5.4. Deficiencies corrected since last inspection.

5.5. Past deficiencies not yet corrected, and explanation for not correcting.
5.6. Non-Federal sponsor OMRR&R responsibilities (if applicable).

6. Inspection Results. (Reference to trip reports or appendices is not acceptable). A summary table (in addition to text) is recommended for documenting deficiencies, repair/evaluation recommendations, estimated costs, schedules, responsible office, and current status.

7. Recommendations, including date of next inspection.

Exhibits

I. Figures.

II. History of Remedial Measures.

III. Photographs.

IV. Inspection Checklist.

V. Summary of Inspection Notes.

VI. Summary of Intermediate Inspection Reports (documentation only, not to replace the narrative in the body of the report).

VII. Instrumentation Data and/or Plots. Data shall contain all figures since the last inspection and have sufficient background data to support the report discussion, conclusions and recommendations. Reproduce the plan of instrument locations in each report. Where appropriate, cross-sections showing piezometric data shall show design uplift assumptions along with the current pressure line. Plots of piezometric elevation versus pool elevation and plots of relief well or drain flow versus pool elevation shall be included. In each case, upper limit correlation lines should be drawn (to help eliminate time lag effects) and when possible, extrapolations should be made to maximum possible pool elevations. A summary of analyses of all instrumentation should be set forth. Where possible, threshold values for key instruments should be established. Threshold values should also be entered into the project emergency operations plans.

VIII. Summary of Crack Surveys.

IX. Documents. A listing of the status of engineering and operation design data, manuals, reports and correspondence as required by this document, ER 1130-2-530 (reference 44), and others as deemed necessary to provide comprehensive project documentation.

X. Emergency Response Status. Status of Dam Safety training (ER 1130-2-530 (reference 44)). Status of Emergency Action Plans and their updates

F-5.2. *Text:* All sections and paragraphs shall be numbered and shall be on 8 1/2 by 11-inch paper with sufficient margin on the left side for binding. Reproduction shall be any available process with printing done head-to-head, if possible.

F-5.3. *Drawings:* Drawings or plates shall normally be 8 1/2 by 11-inch with sufficient margin on the left for binding. Foldouts normally shall not exceed 11 inches by 17 inches. Drawings and photos may be included in the text or placed entirely in the Appendix. However, any figure or drawing in the text shall support the written material.

F-5.4. *Binding and Cover:* Reports shall have flexible paper or card stock, hidden-hinge covers with fasteners that facilitate removal and insertion of pages and drawings. Information to be on the cover will be as described in paragraph F-4 above. Also, the name of the preparing agency and the date of inspection shall be shown on the cover.

F-6. Distribution of Approved Inspection Reports.

F-6.1. *Library Copy:* Upon approval of the inspection report, one copy together with a copy of all correspondence bound under the front cover, will be sent by the originating district directly to:

Commander U.S. Army Engineer Research & Development Center
ATTN: CEERD-II-K
3909 Halls Ferry Road
Vicksburg MS. 39180-6199

(A copy of the transmittal letter to ERDC is to be provided to the MSC.)

F-6.2. *Executive Summary:* The district shall submit an electronic Executive Summary of each Periodic Inspection Report to HQ-DamSafety@hq02.usace.army.mil within 90 days of the completion of the formal inspection. The Executive Summary shall also be entered into the Dam Safety Program Management Tools (DSPMT) database. The electronic executive summary should be limited in length to two to four pages and shall contain the following information.

F-6.2.1. A brief description of the project that was inspected.

F-6.2.2. A statement concerning the current inspection and major findings.

F-6.2.3. A statement regarding the project's safety status for continued operation.

F-6.2.4. A general periodic inspection schedule including the dates of the previous, current, and next scheduled inspections of the project.

F-6.2.5. A statement concerning any uncorrected deficiencies from the previous inspection.

F-6.2.6. A list of major deficiencies found during the inspection and recommendations to correct the deficiencies.

F-6.2.7. A summary of conclusions from the formal inspection report.

F-6.3. *MSC and District Distribution:* The MSC's and the districts shall determine the distribution of completed reports within their respective offices, to include the project site, local sponsor, military installation, and other federal agency and/or state agency, as deemed appropriate.

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APPENDIX G

Dam Safety Assurance Program Studies and Reports

PART I - FORMAT AND CONTENT OF DAM SAFETY ASSURANCE PROGRAM REPORTS

G-1. Format of Dam Safety Assurance Program Evaluation Report. Each report will include the requirements contained in the following paragraphs and the report format shall follow the order as presented below.

G-1.1. *Project Authorization:* Provide pertinent information on the project authorization, including any modifications, and quote verbatim the requirements of local cooperation.

G-1.2. *Project Description:* Briefly describe the project, including type of dam or major structure and seismic zone and enclose a map to indicate its location.

G-1.3. *Current Condition:* Describe the current condition of the project features. Give the reason(s) that justify the need for modification for dam safety purposes, reference paragraph 8.1.1. of this regulation, and describe the scope of the problem in quantifiable terms.

G-1.4. *History of Maintenance and Rehabilitation or Modification:* Provide a chronology of the expenditures for maintenance on the project since its completion, and a brief description of all previous major rehabilitations or dam safety modifications and their associated costs.

G-1.5. *Project Use:* Provide a narrative description of the use currently being made of the project and the use projected during an appropriate period in the future (e.g., life without and, new life with, recommended modifications for dam safety). Indicate whether the project currently satisfies the authorized project purposes and what impact the proposed modifications for dam safety will have on the project's capability to do so. Provide supporting data, as available from Corps or non-Corps sources.

G-1.6. *Consequences of No Dam Safety Modifications:* Explain what may occur if the problem described in paragraph 8.2.3. is not corrected. Describe the degree of hazard potential, the mode and magnitude of expected failure, to include the resultant damage to the dam and related structures, and the downstream impact. Under the description of the downstream impact include the potential for loss of life among the threatened population; the extent and types of economic losses; the area inundated and non-inundated areas which would be isolated due to loss of highways, bridges or services; and the impact, if any, on other retention structures. Describe the effectiveness of existing flood warning system and evacuation plans in reducing the potential for loss of life.

G-1.7. *Evaluation Process:* The evaluation process will result in the development and presentation of economic data so that economic considerations may be understood in a context with other important considerations, and have appropriate influence in determining justification for project modifications required to correct problems related to dam safety. Include an economic analysis if the estimated cost of the recommended work is greater than $10 million, or is greater

than 25% of the replacement cost of the total project. The economic analysis is to be conducted on a sunk cost basis, i.e., all annual costs associated with the modification would be compared with the total project annual benefits. The results of this analysis will provide some perspective on the economics of providing the proposed work; however, where there is a significant question of safety, a benefit-to-cost ratio will not be calculated.

G-2. Content of Dam Safety Assurance Program Evaluation Reports. Dam Safety Assurance Program Evaluation Reports shall contain information on the following:

G-2.1. *Type of Problem:* Nature of the dam safety problem.

G-2.1.1. Hydraulic or Hydrologic Deficiency - Ability or inability to safely pass the probable maximum flood.

G-2.1.2. Seismic Deficiency - Ability or inability to safely withstand current earthquake design criteria.

G-2.1.3. Other unsafe conditions not meeting current design or construction criteria or seriously affecting project performance.

G-2.2. *Extent of Deviation:* Extent of deviation from current design and construction criteria.

G-2.3. *Loss/Damage Potential:* Nature of potential damages and potential for loss of life associated with dam failure. Damages in excess of that expected from the most extreme event, that the project could survive, are pertinent. Also include damages that would be expected if the proposed design criteria are not to current standards and are exceeded after project improvement.

G-2.4. *Average Annual Benefits:* Current average annual benefits being provided by the project.

G-2.5. *Alternatives:* Alternatives to be considered and presented:

G-2.5.1. Do nothing. Indicate potential future costs to the Federal Government in the event of failure (claims and construction costs).

G-2.5.2. Partial correction. Indicate average annual cost of improvement, remaining deficiencies and potential damages, continuing potential for loss of life, and potential future costs to the Federal Government. Present benefits achieved.

G-2.5.3. Complete correction. Provide an appropriate discussion of feasible alternatives for the dam safety modification. Indicate what impact these alternatives would have on the project's capability to satisfy authorized project purposes. Show the estimated cost of modification for each item or group of items. Indicate average annual cost of improvement and all benefits achieved.

G-2.5.4. Remove structure.

G-2.5.5. Replace structure.

G-3. Recommended Plan.

G-3.1. *Rationale for Recommended Plan:* Provide rationale for the alternative recommended, to include non-economic considerations such as potential loss of life, public confidence and other non-tangible aspects. When available information is insufficient to justify the need for modification, recommendations will be made on special engineering investigation(s), which would support a decision. In this case, the most probable plan will be presented, pending the outcome of the proposed investigations.

G-3.2. *Schedule of Funding:* Provide a schedule of funding requirements by fiscal year to accomplish recommended modifications to the project. Indicate which requirements are recommended for funding under Construction, General, and which are recommended for funding under Operation and Maintenance, General. If both authorized and unauthorized work are recommended and the work can stand on its own from an engineering and economic standpoint, a two-stage design and construction procedure may be required. The first stage would consist of work that is authorized. The second stage could involve those items of work that require additional authorization.

G-3.3. *Environmental Impacts:* Provide an assessment/description (for each alternative evaluated) of the impacts on the existing environment. Highlight any significant resources that are likely to be affected as well as any that are covered by a specific law (e.g., endangered species, clean air, clean water, cultural and historical, etc.). Consider potential hazardous, toxic waste and radioactive concerns and conduct appropriate surveys. Identify the location of impacts and explain their significance, the likelihood of being able to mitigate such impacts, and associated cost. Indicate the concurrence or non-concurrence given by resource agencies that mitigation is possible and appropriate. Identify any environmental constraints that would render an alternative infeasible. For the recommended alternative, provide the pertinent correspondence, a summarization of the studies conducted to evaluate the environmental effects of the plan, and the necessary National Environmental Protection Act (NEPA) documentation required in ER 200-2-2 (reference 23) (e.g., EA, FONSI, EIS, or Supplement) and/or Section 404(1)(b) evaluation.

G-3.4. *Cost Sharing Requirements:* Include a general explanation of the cost sharing requirements of WRDA 86 followed by a discussion of the circumstances of the particular project. Show the amount to be cost shared. Explain the determination of cost allocation and cost sharing for the specific project. This will require documentation of pertinent agreements or contracts. The discussion shall include a tabulation of the costs to be paid by the Federal Government and the sponsor(s). Identify the sponsor(s) for the project and their contributions to initial project development, and sponsor(s) subsequently added to the project. Include the sponsor(s) views concerning cost sharing. Include copies of the existing contracts or agreements.

G-3.5. *Local Cooperation:* When the project includes requirements of local cooperation, indicate the views or concurrence of local interests in the general plan of the proposed work, state whether these views were obtained by conference or public meeting, and provide a letter

from local interests, which sets forth their views. Give the best available estimate of required local cooperation cost, a statement of the prospects for fulfillment of the required conditions, and the names, titles, and addresses of the principal officers and representatives responsible for fulfillment. Identify any differences in local cooperation requirements under existing agreements that should be changed and the basis therefore. Also indicate what will be done to obtain the desirable local cooperation.

G-4. Appendices. The report shall contain appendices, which contain the following documents.

G-4.1. *Authorizing Legislation:* Applicable legislation for the initial construction and subsequent addition of project purposes. Specifically include documentation on cost sharing of added authorized purposes.

G-4.2. *Existing Contracts:* Copies of existing contracts, agreements or letters of intent from project sponsor(s), cost sharing partners, and users.

G-4.3. *Special Investigations:* Special investigations, i.e., seismic, hydrologic/hydraulic, structural, etc. completed in support of the recommended plan.

G-4.4. *Project Management Plan:* Include a schedule of any additional engineering investigations needed in the design phase and all DDR's that will be prepared.

G-4.5. *Cost Estimate:* A Micro Computer Aided Cost Engineering System (MCACES) baseline feasibility estimate (ER 1110-2-1302 (reference 35)) in the Civil Works/HTRW Work Breakdown Structure will be prepared for the recommended plan. The level of the cost detail will vary with the design information available to support the project scope, but shall be at least to the sub-feature level of detail. However, a higher level of detail approaching that of a feasibility report should be the goal in order to more accurately identify the baseline cost estimate. Although this baseline estimate is not subject to reauthorization if the Section 902 limit (WRDA 86) is exceeded, the goal is to make every effort to adhere to the criteria of the 20% growth limitation. Provide a Total Project Cost Summary (TPCS) and separate the costs to the sub-feature level. The TPCS shall be prepared following the current cost engineering policy.

G-4.6. *Real Estate:* A Real Estate Plan shall be prepared at a level of detail commensurate with the scope of the project and the real estate requirements, if any, included in the evaluation report. If no land acquisition or relocation requirements are identified, the appendix shall so state.

G-4.7. *Hazardous, Toxic, and Radioactive Waste (HTRW):* Unless the project will result in additional real estate acquisitions, HTRW should not be a consideration. However, if HTRW is encountered, follow the guidance of ER 1165-2-132, (reference 45).

G-5. Design Documentation Report for Dam Safety Assurance Program Projects.

G-5.1. *Content:* The content of the DDR shall be as outlined below, in accordance with ER 1110-2-1150 (reference 34).

G-5.1.1. General.

G-5.1.2. Syllabus.

G-5.1.3. Table of Contents.

G-5.1.4. Project Description. Cite the authority for the preparation of the DDR, referring to the approved evaluation report prepared in accordance with Part I of this appendix. Provide a description of the design as originally constructed, and the present condition of the dam and related facilities. Include a discussion on the suitability of the feature or structure as constructed, and whether the design and/or construction have proven sufficient in serving the authorized project purposes. Also discuss the necessity for the proposed modification for dam safety and summarize any information in the evaluation report on the potential risk, damage and economics of the proposed work. Explain required real estate acquisitions. If the cost estimate of the work has increased since the evaluation report to the point that it now exceeds $10 million or is greater than 25% of the replacement cost of the total project, and there is no detailed economic analysis in the evaluation report, present such an analysis here. An Acquisition Plan is also required when a project cost exceeds $10,000,000 and shall be accomplished in accordance with applicable Federal Acquisition Regulations.

G-5.1.5. Pertinent Data. Include a brief description of the feature(s) to be rehabilitated or modified for dam safety, why the modification is required, and a summary of the estimated cost.

G-5.1.6. References.

G-5.1.7. Project Cooperation Agreement. If there will be no non-Federal sponsor for the project, this section can be omitted.

G-5.1.8. Engineering Studies, Investigations, and Design. The results of special investigations completed following the preparation of the evaluation report shall be summarized in this section. Any additional studies of investigations accomplished as part of the design process shall be described to the level of detail set forth in ER 1110-2-1150 (reference 34).

G-5.1.9. Environmental Engineering.

G-5.1.10. Plates.

G-5.1.11. Project Cost Estimate and Associated Sponsorship. Include a brief summary of the cost sharing information contained in the evaluation report, and a revised estimate of costs. Provide the sponsor(s) views and willingness to provide the required cooperation.

G-5.1.12. Economic Analysis. Projects accomplished under the authority of this Dam Safety Assurance Program do not need a benefit-cost ratio calculated. However, the cost and benefits from the proposed modifications need to be set forth.

G-5.1.13. Post-Authorization Changes. Modifications requiring new authorization may be recommended in the evaluation report. However, preparation of the DDR will not commence until such authorization is obtained.

G-5.1.14. Recommendations.

G-5.1.15. Real Estate Plan. If additional real estate is required, then a real estate plan will be developed in accordance with ER 405-1-12, Chapter 12 (reference 24). If the project is cost shared, the non-Federal sponsor would be provided credit in accordance with said Chapter 12.

G-5.2. *Applicability of Guidance:* Guidance included above is supplemental and shall be complied with, as appropriate to the project.

PART II - SEISMIC SAFETY EVALUATION PROCESS FOR EMBANKMENT DAMS AND FOUNDATIONS

G-6. Introduction.

G-6.1. *Purpose:* This portion of the appendix provides detailed guidance for evaluating the seismic safety of existing USACE embankment dams and foundations. The process ensures: (a) that seismic evaluations/re-evaluations for embankment dams and foundations accurately identify site conditions and are conducted with minimum expenditure of project funds, manpower or delay and (b) that embankment dams and/or foundations not requiring modifications are accurately identified and removed from further study at the earliest possible point in the evaluation process.

G-6.2. *Scope:* This guidance is to be used in evaluating the seismic safety of existing USACE Civil Works embankment dams in accordance with provisions of the Dam Safety Assurance Program as defined in Chapter 8 of this regulation.

G-6.3. *Background:* The seismic safety of many existing embankment dams must be evaluated or re-evaluated in accordance with requirements in ER 1110-2-1806 (reference 38). Seismic safety evaluation of major civil works projects, particularly embankment dams, is typically a complex, multi-stage process. It generally requires progressively more detailed definition of certain project characteristics and analysis of project response to the design earthquake ground motions at each subsequent stage. This process can be expensive and manpower intensive, and may take many months to several years to complete; however, the question of seismic deficiency should be completed and not allowed to linger if a deficiency is found to exist.

G-7. Seismic Safety Evaluation Process.

G-7.1. *Evaluation Process:* Stages of the seismic safety evaluation process are designated as (a) Seismic Safety Review, (b) Phase I Special Studies, and (c) Phase II Special Studies. The stages are described in the following paragraphs. A multi-page flow chart illustrating the process is located at the end of this part of this appendix (Figure G-1). The evaluation process is structured to validate technical conclusions and policy compliance as an integral part of each stage of the process. This is accomplished during appropriately timed Policy Compliance & Criteria Reviews

(PCCR). The PCCR's eliminate the need for several report submission and approval cycles preceding the development of an official decision document. The evaluation process leads either to negative findings (i.e., that critical project features are likely to perform in an acceptable manner during and following the design earthquake) resulting in removal of the dam from further evaluation, or to the conclusion that modifications are required to the embankment dam and/or its foundation to ensure acceptable performance when subjected to the design earthquake. Negative conclusions at any stage beyond the initial screening at the Seismic Safety Review stage require validation during a PCCR. Negative conclusions at any stage of evaluation should be documented enough to verify that the project is able to properly accommodate the design seismic loads and to guide future re-evaluations. Conclusions that indicate additional studies are required or that the project requires some form of remediation or modification must be validated during a PCCR. Additionally, the evaluation process and resultant conclusions must be documented for record prior to proceeding into the next phase. An information copy of the memorandum for record must be provided to both the MSC and HQUSACE (CECW-CE). If studies through the Phase II level lead to the conclusion that some form of remediation is required, the results of the evaluation process, recommended remediation or modifications and justification are presented in an official decision document designated the Dam Safety Assurance Program (DSAP) Evaluation Report.

G-7.2. *DSAP Evaluation Report:* The DSAP Evaluation Report documents the entire evaluation process and recommendation for remediation or modification. It is the only formal report required prior to proceeding into detailed design and subsequent development of plans and specifications for seismic modifications. It has a specific format for documenting and presenting the evaluation, analyses, conclusions, economic justification and recommendations for modifying the dam and/or other project features. A detailed description of the required content and format is contained in paragraph 8.7.1. and in Part I of this appendix. The DSAP Evaluation Report is the formal decision document, which must be approved by HQUSACE before proceeding into detailed design and subsequent development of plans and specifications.

G-7.3. *Phase III/Detailed Design:* Following official approval of the DSAP Evaluation Report, Phase III work should proceed in accordance with the approved schedule. This includes detailed design for the seismic modifications approved in the DSAP Evaluation Report as well as preparation of the plans and specifications for those measures. In accordance with current guidance, Phase III work may be carried out using Operations and Maintenance, General appropriations or the maintenance portion of the FC, MR&T account, as described in paragraph 8-11.

G-7.4. *Funding:* Consistent with current guidance, all work for the Seismic Safety Review, the Phase I Special Studies, the Phase II Special Studies and the DSAP Evaluation Report are to be carried out using project O&M funds or the maintenance portion of the Flood Control, Mississippi Rivers and Tributaries (FC, MR&T) account, in accordance with paragraph 8.11. Budgeting for this work should normally be covered in the annual budget EC for Civil Works activities. The DSAP Evaluation Report is the formal decision document that must be approved by HQUSACE before budgeting for Construction General funds.

G-8. Seismic Safety Review.

G-8.1. *Basis for Review:* A Seismic Safety Review (SSR) is required when certain conditions exist as described in ER 1110-2-1806 (reference 38).

G-8.2. *Purpose and Scope:* The purpose of the SSR is to review and document conclusions about the seismic safety of embankment dams and foundations for civil works projects in accordance with ER 1110-2-1806 (reference 38). This review will conclude whether or not a Phase I Special Study is required. The SSR is normally limited to office examination and screening of available data and the results of the most recent periodic inspection. In this review, available information, such as geologic maps, boring logs, seismic zone maps, acceleration contour maps, existing field investigation reports, as-built project records, and previous seismic evaluation reports, shall be used. If the initial screening indicates that the embankment dam and/or its foundation may require remediation/modification for seismic adequacy, then limited, simple preliminary analyses using existing available data shall be performed as part of the SSR. If these analyses indicate that there is potential for sudden, uncontrolled loss of reservoir pool or other form of unacceptable performance that causes loss of life as a result of the project being subjected to the design earthquake, then a Phase I Special Study shall be recommended. Where specialized expertise is needed, subject matter experts, either USACE or external, shall participate in the examination and analysis as early as practical in the evaluation process. The level of effort to accomplish the SSR shall be the minimum required to resolve whether or not seismic safety issues exist which require a Phase I Special Study. (The level of effort and associated cost are estimated to be on the order of a few man-weeks of office effort.)

G-8.3. *Seismic Safety Issues:* Issues that are relevant to the determination of seismic safety and the need for further investigations may include some or all of the following:

G-8.3.1. Project Hazard Potential Classification, as described in Part IV of this appendix, which reflects the criticality of the project in terms of threat to public safety in the event of failure. It is USACE policy that seismic safety of USACE embankment dams, where failure would result in loss of life, must be assured. For embankment dams and other features for which the consequences of failure are economic and no loss of life is expected, the decisions about further investigations or other actions shall be justified on an economic basis.

G-8.3.2. Adequacy of past seismic evaluations, if any; including the adequacy of procedures used in selection of design ground motions and the appropriateness and adequacy of methods of analysis used, in light of the present state-of-the-practice.

G-8.3.3. Proximity to seismic source zones.

G-8.3.4. Changes in the state of knowledge of regional or local seismicity since the last review.

G-8.3.5. Existence of soils that are potentially unstable due to buildup of excess residual pore pressures or degradation of strength from cyclic loading in either the embankment or foundation.

G-8.3.6. Existence of slopes that may be seismically unstable, including embankment slopes, the abutments or the reservoir rims.

G-8.3.7. Existence of project features that may become critical to safety after small deformations of the embankment dam (i.e., outlet works becoming non-operational, thin filter zones within the embankment being disrupted, relief wells becoming non-operational, etc).

G-8.4. *Policy Compliance and Criteria Review:* A Policy Compliance & Criteria Review (PCCR) shall be held after 95% completion of the technical examination and analysis for the SSR, but prior to forwarding a recommendation to the district Dam Safety Committee. The PCCR shall include geotechnical representatives from HQUSACE and the MSC as well as district representatives including representatives from Engineering and Operations. The Dam Safety Officer or a designated representative shall also attend. A PCCR is not needed if the results of the SSR indicate that the dam is seismically adequate. The PCCR shall summarize the examination and screening and shall provide a recommendation with justification for the initiation of Phase I studies. Supporting documentation shall be presented. If a Phase I study is recommended, then a scope of work, cost estimate and schedule for the Phase I study shall be presented. If the SSR is done in conjunction with a periodic inspection, the results of the SSR shall be incorporated into the Periodic Inspection Report. As a minimum, the district shall document the SSR as well as the results and conclusions of the PCCR in a memorandum for record to project files. No formal report or documentation is required to be submitted to the MSC or HQUSACE for review and approval; the PCCR replaces the MSC and HQUSACE review and approval process for the SSR. An information copy of the memorandum for record must be provided to both the MSC and HQUSACE (CECW-CE).

G-9. Phase I Special Study.

G-9.1. *General:* A Phase I Special Study is necessary when the PCCR for the SSR concludes that potential deficiencies exist in an embankment dam or foundation which could lead to sudden, uncontrolled loss of reservoir pool or other form of unacceptable performance likely to cause loss of life if the project were subjected to the Maximum Credible Earthquake (MCE), as defined in ER 1110-2-1806 (reference 38), or a lesser event.

G-9.2. *Purpose:* The purpose of Phase I study is as follows:

G-9.2.1. Develop site-specific ground motions appropriate for seismic evaluation of all project features to be evaluated,

G-9.2.2. Perform limited field investigations and laboratory studies, and,

G-9.2.3. Perform preliminary analyses, based on the ground motions, field data and laboratory testing results, to determine the response of the dam to seismic loading and to identify potential problem areas, which may need more detailed analyses.

G-9.3. *Content:* The type and level of study required in the Phase I study will be project dependent; however, the content of a Phase I study normally includes the following:

G-9.3.1. Project Description: Provide a brief description of the project, including type of dam, major structures or other critical feature. Provide tabulated pertinent project data. Describe design and current project operations. Identify key operational pool levels such as conservation pool, power pool, seasonal pool levels, spillway crest, flood pool and maximum pool. Other relevant pool information shall include reservoir pool history elevation versus time, average yearly maximum pool, and the reservoir pool elevation versus frequency relationship based on historical data supplemented with flood routing analyses for less frequent flood events as required.

G-9.3.2. Purpose and Scope: Describe the purpose and scope of the study and the deficiency(s) identified in the SSR. (Estimating the level of effort and cost to perform a Phase I study is difficult to address on other than a project specific basis but are likely to range from many man-months to a few man-years of effort. Phase I duration shall be limited to the shortest possible time period consistent with project complexity, manpower, funding and quality considerations.)

G-9.3.3. Site Characterization: Perform limited field and laboratory investigations to define the soil and rock stratigraphy and to further clarify location and extent of potential problem areas. These investigations shall be sufficient to develop preliminary soil and rock cross sections of the dam and foundation in areas, which have potentially unstable soils. These investigations may include Standard Penetration Tests (SPT), Cone Penetration Tests (CPT), shear wave velocity, permeability, Becker Penetration Tests (BPT), conventional undisturbed sampling, and trenching in areas of much lateral heterogeneity or anisotropy.

G-9.3.4. Seismotectonic Evaluation: Develop a detailed evaluation of the geology, tectonics and seismic history of the area, and the proximity of the dam to active seismic zones. Provide fault study and related field investigations and laboratory testing where necessary.

G-9.3.5. Seismicity and Ground Motions: Select the final design earthquake ground motions and develop the ground motion parameters to which the project could be subjected. For all critical projects or features, these input ground motions will be obtained from a deterministic analysis of historic seismicity and active fault systems or seismic source zones and their activity. Develop several accelerograms for site response computations. The accelerograms should contain energy, frequency and duration components appropriate for the source, the region and the feature being evaluated. Caution is advised to avoid undue conservatism in selection of ground motions for use in analyses. Selection of specific accelerograms or the manipulation of accelerograms to generate records with specific time histories not representative of the characteristic ground motion records within the region of the project should be strongly justified and well documented. Of particular concern is that accelerograms be developed with energy content and occurrence of the peak energy representative of the seismological setting of the feature(s) being evaluated. For effective stress analyses, where site permeability profiles and boundaries are accurately known and seismic generated residual excess pore water pressures will be simultaneously dissipated, input motion time histories should not be manipulated to shift the energy content to the end of shaking to minimize pore pressure dissipation and thereby maximize excess residual pore pressures during modeling of post earthquake response unless justified from

seismological investigations and by expert seismologists. Selection of ground motions should be made with input from qualified seismologists, geologists and geotechnical engineers.

G-9.3.6. Seismic Evaluations and Analyses:

G-9.3.6.1. Liquefaction Potential: Evaluate the potential for liquefaction or development of excess pore pressure in soils of the embankment and foundation using standard methods. This shall consist of using an appropriate empirical method linking documented field performance with site characteristics using field investigations. Use a 1-D analysis, such as SHAKE, to model propagation of earthquake induced rock motions through the foundation and the embankment.

G-9.3.6.2. Post Earthquake Stability: Evaluate post-earthquake limit equilibrium slope stability for the reach(es) of the embankment where liquefaction of the embankment and/or foundation is indicated. Post-earthquake shear strengths for zones not indicated to liquefy shall be estimated taking into account residual excess pore pressures. Post-earthquake shear strengths for zones, which are indicated, to liquefy shall be selected based on residual strengths back calculated for well-documented liquefaction induced failures. The further reduction in shear resistance below the residual level is not justified.

G-9.3.7. Post Earthquake Deformation Evaluation: Assess the shape and amount of deformation in the embankment after sliding or slumping for the cross section where inadequate factors of safety are indicated by limit equilibrium slope stability analyses. Similar cautions noted for selection of strength and pore pressure values in evaluating limit equilibrium stability are to be observed in evaluating the post earthquake deformed shape of an embankment or other slope.

G-9.3.8. Conclusions and Recommendations: Develop conclusions and recommendations on the need for a Phase II seismic evaluation or departure from requirements of ER 1110-2-1806 (reference 38).

G-9.3.9. Cost Estimate and Schedule: If Phase II studies are recommended, develop a detailed scope, cost estimate and schedule for the proposed Phase II studies.

G-9.3.10. Phase I PCCR: Conduct a PCCR for the Phase I study.

G-10. Phase II Special Study.

G-10.1. *General:* A Phase II Special Study is necessary when the PCCR for the Phase I concludes that potential deficiencies exist in an embankment dam or foundation which could lead to sudden, uncontrolled loss of reservoir pool or other form of unacceptable performance likely to cause loss of life if the project were subjected to the design earthquake. The Phase II study shall be detailed and sufficiently comprehensive such that conclusions reached concerning the seismic adequacy of the dam in question are definitive and constitute the basis for selection, detailed design and construction of modifications or other form of remediation required to ensure seismic safety of the project.

G-10.2. *Purpose and Scope:* The purpose and scope of Phase II study are as follows:

G-10.2.1. Perform comprehensive detailed analyses to evaluate performance of the critical project features when subjected to the ground motions identified in Phase I.

G-10.2.2. Determine if the dam is seismically adequate or if remediation/modifications are required to ensure acceptable seismic performance.

G-10.2.3. Establish remediation requirements.

G-10.2.4. Evaluate various alternative remedial techniques and select the most appropriate alternative.

G-10.2.5. Prepare cost estimates, scope, and schedule for design documentation, plans and specifications, and construction.

G-10.3. *Methods of Analysis:* The recommended engineering approach to analysis of an embankment dam and foundation for seismic stability generally consists of assessing both post earthquake static limit equilibrium slope stability and deformation response of the dam using, as appropriate, detailed 2D and 3D numerical analyses. The steps involved in a Phase II seismic analysis for earth dams normally include:

G-10.3.1. Use the recommended design earthquake ground motions and accelerograms developed in the Phase I study for site response computations. For all critical projects or features, these input ground motions will be obtained from a deterministic analysis. The selected accelerograms shall be used in the application of an appropriate, validated dynamic finite element program used for modeling the deformation process in response to an imposed earthquake ground motion time history.

G-10.3.2. Perform detailed field investigations which may include SPT, BPT, CPT, field vane shear tests, field permeability, ground water observation wells, conventional undisturbed sampling, geophysical evaluations, and laboratory testing, to develop a detailed understanding of site conditions, including stratigraphy, geometry, hydrology, material properties and their variability, and the aerial extent of potential problem zones.

G-10.3.3. Determine the pre-earthquake vertical effective shear stresses, and the initial static shear stresses on horizontal planes throughout the dam and its foundation.

G-10.3.4. Determine the dynamic shear moduli of the soils in the dam and foundation.

G-10.3.5. Using an appropriate dynamic finite element analysis procedure, determine the stresses induced in the embankment and foundation when subjected to the accelerograms selected for the design earthquake. Pore water pressure dissipation shall be properly accounted for in determining pore pressure behavior during shaking and residual excess pore pressure level after shaking stops. Consider relevant soil properties and stratigraphy including permeabilities in soil layers adjacent to the liquefiable soil layer, which restricts pore pressure dissipation.

G-10.3.6. Determine the liquefaction resistance of the embankment and foundation soils and the maximum potential residual excess pore water pressure that can be generated by the earthquake using corrected penetration data from in-situ tests such as SPT, CPT, BPT, and laboratory index tests.

G-10.3.7. Map the area extent of all suspect materials. Determine post earthquake shear strength of relevant soils. Prepare several generalized cross sections of the dam and foundation for final analysis to determine seismic response.

G-10.3.8. Perform static limit equilibrium slope stability analyses of the generalized cross sections to assess post earthquake stability and to identify potential zones of the dam and foundation, which may require remediation.

G-10.3.9. Estimate the deformation response of the embankment dam and the post earthquake shape of the embankment by using an appropriate 2D and/or 3D finite element or other appropriate deformation analysis program.

G-10.3.10. Remediation shall be recommended when the embankment dam is (a) found to have inadequate limit equilibrium slope stability factors of safety and/or (b) projected to experience unacceptable deformations when subjected to the design earthquake and it is concluded that either situation would result in sudden, uncontrolled loss of the reservoir pool and loss of life. If remedial measures are recommended, establish the remediation requirements, evaluate various remediation alternatives, and select the most appropriate alternative.

G-10.3.11. Perform additional post earthquake limit equilibrium slope stability and finite element analysis to determine preliminary remediation needs such as extent and location of remediation required, strength/resistance required and to determine the level of protection to be obtained by remediation.

G-10.3.12. Evaluate various preliminary remediation alternatives and select the most appropriate alternatives for cost estimating purposes.

G-10.3.13. Perform additional finite element deformation analyses to determine expected deformations in both remediated and non-remediated sections of the dam. Determine overall dam response and differential deformation.

G-10.3.14. Develop detailed scope, cost, and schedule for PED phase (Preconstruction Engineering and Design), which includes preparation of design documentation and plans and specifications (P&S).

G-10.3.15. Conduct a PCCR for the Phase II study.

G-10.3.16. Prepare the Phase II study summary. This is the basis for a technical appendix to the DSAP Evaluation Report. The suggested format and content for the Phase II summary is described in paragraph G-10.4. below.

G-10.4. *Phase II Study Documentation:* There is no specific requirement for documenting the Phase II Special Study prior to development of the DSAP Evaluation Report, however, a detailed summary of the entire evaluation process including the Phase II study must be included as a Technical Appendix to the DSAP Evaluation Report. To facilitate the Phase II PCCR, a summary should be developed and presented at the PCCR in the general format and scope indicated as follows:

G-10.4.1. Introduction, including Authorization, Purpose, Project Description, and Method of Analysis

G-10.4.2. Static Stress Analyses including General Description, Development of Static Properties of the Dam, and Results of Static Stress Analyses

G-10.4.3. Design Earthquake Motions including General Discussion, Design Earthquake and Ground Motions with Response Spectra and Time Histories

G-10.4.4. Dynamic Response Analyses including General Discussion, Field and Laboratory Tests and Results, Development of Dynamic Properties, Dynamic Analyses, and Dynamic Response

G-10.4.5. Seismic Stability Assessment including Evaluation of Dynamic Strengths with Laboratory Data and Field Data, Dynamic Response and Stability, and Earthquake Induced Deformation Analyses

G-10.4.6. Post Earthquake Stability Analyses including General Discussion, Post Earthquake Strength Properties, Slope Stability, and Post Earthquake Deformed Condition

G-10.4.7. Deformation Response Analyses including General Discussion, Deformation analyses of Remediated Sections, and Deformation Analyses of Unremediated Sections

G-10.4.8. Remediation Alternatives including General Description, Potential Remediation Alternatives, Cost Estimates for Potential Remediation Alternatives, and Estimated Construction Sequence, Schedule, Duration for Alternatives

G-10.4.9. Summary

G-10.4.10. Conclusions and Recommendations

G-10.4.11. References

G-10.4.12. Attachments

FIGURE G-1
SEISMIC ANALYSIS PROCESS

Liquefaction/Deformation Evaluation

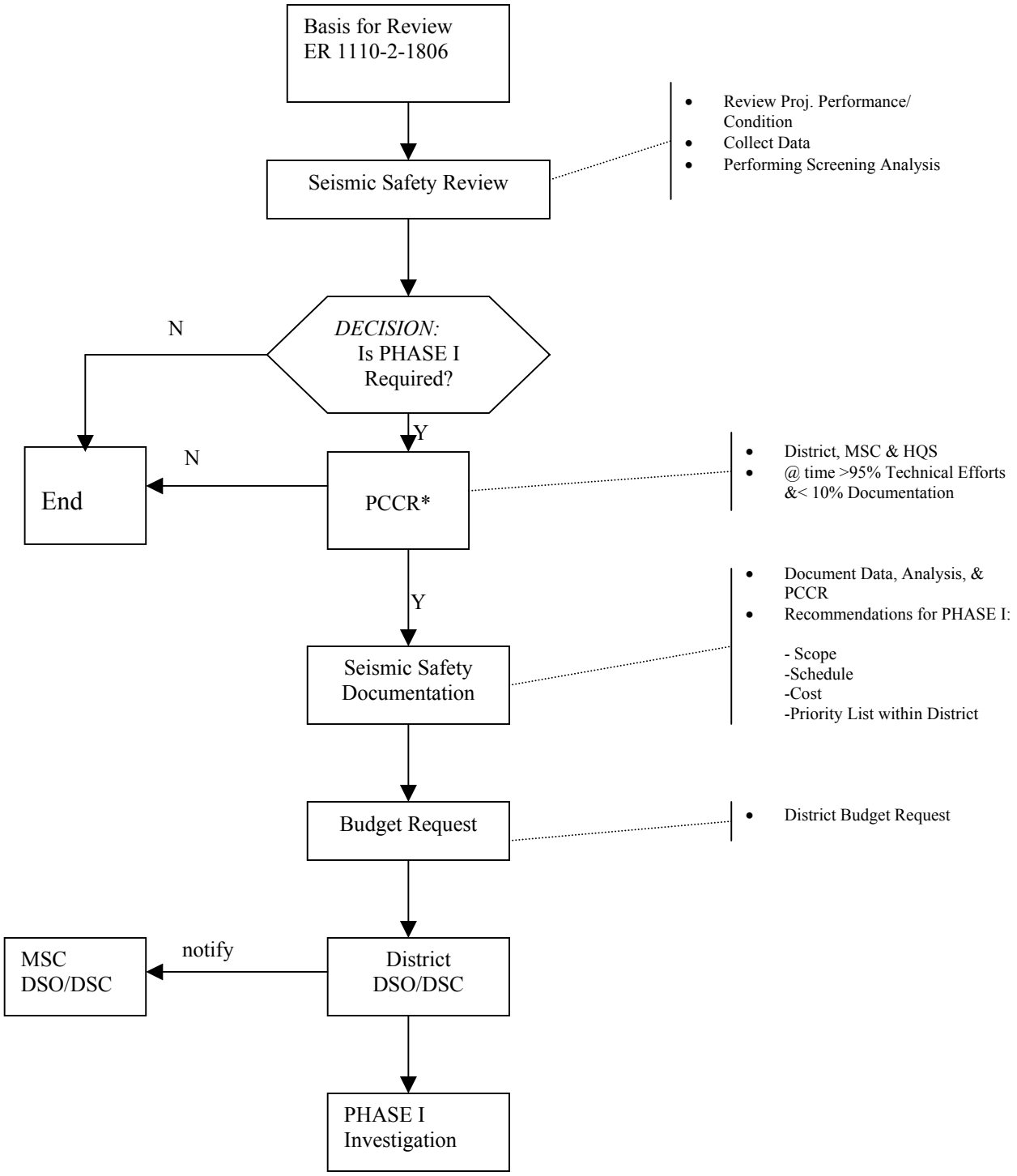


FIGURE G-1 (CONT)
SEISMIC ANALYSIS PROCESS

Liquefaction/Deformation Evaluation (Continued)

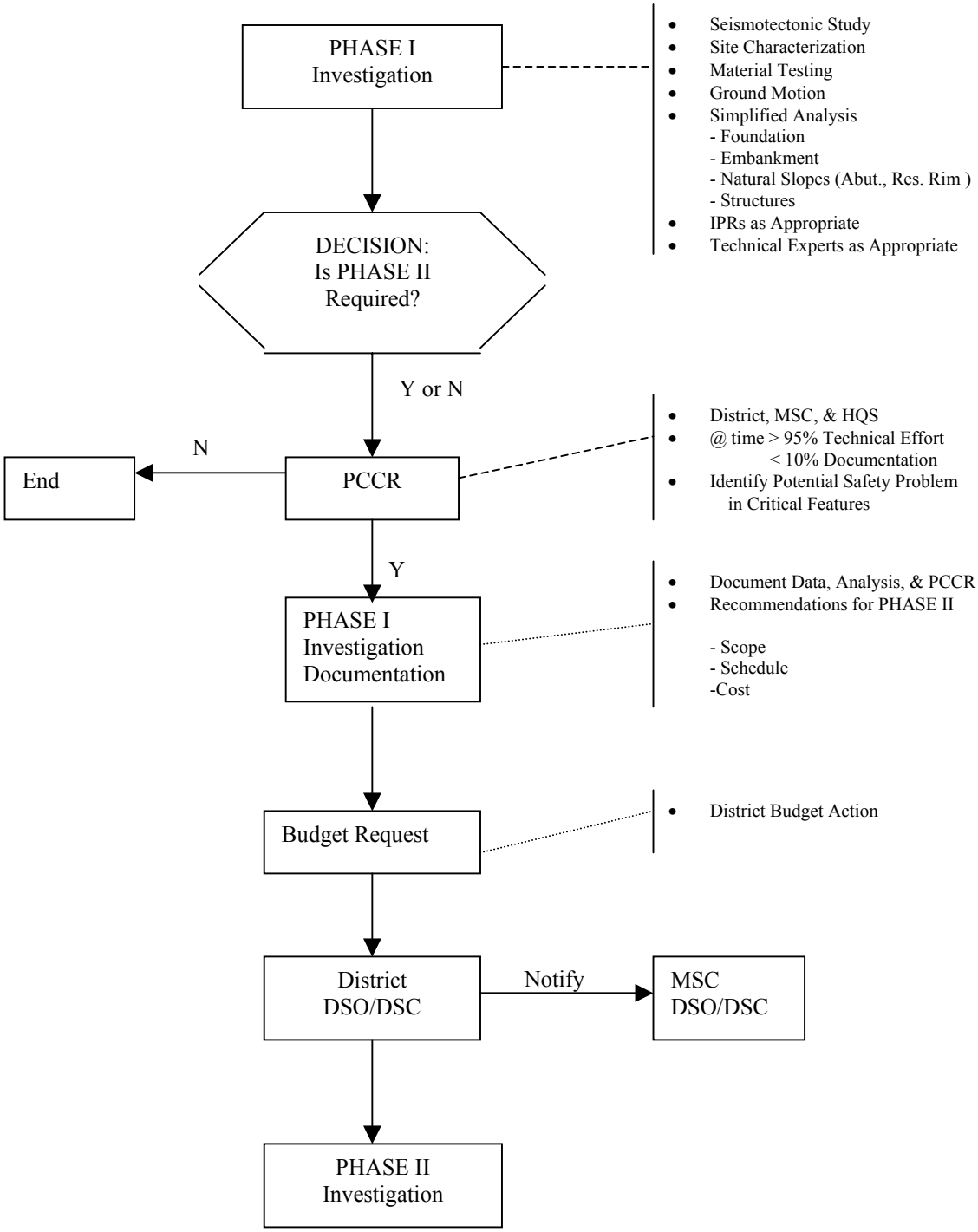
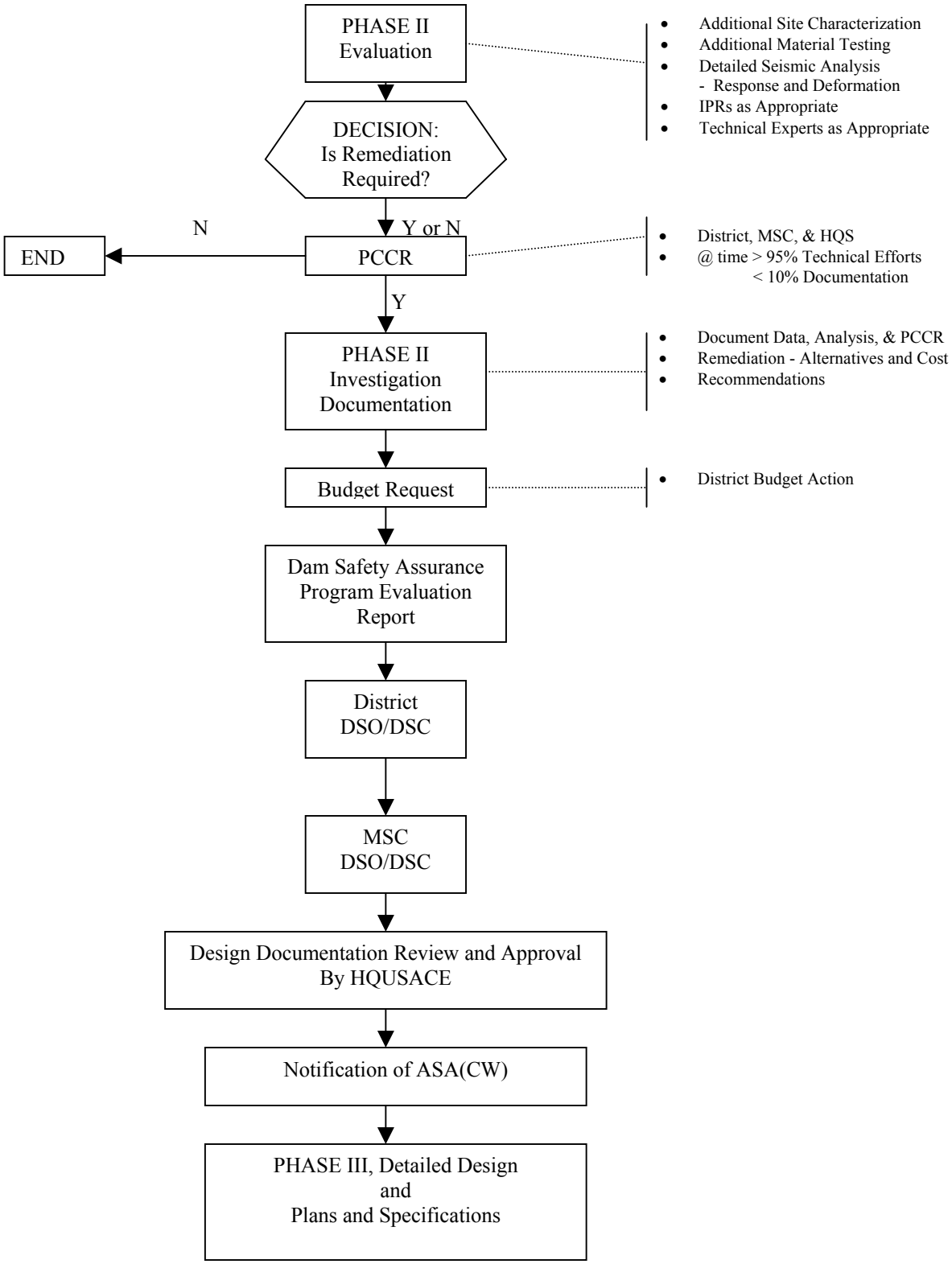


FIGURE G-1 (CONT)
SEISMIC ANALYSIS EVALUATION

Liquefaction/Deformation Evaluation (Continued)



PART III - SEISMIC SAFETY EVALUATION PROCESS FOR CONCRETE STRUCTURES AND FOUNDATIONS

G-11. Seismic Safety Review.

G-11.1. *General:*

G-11.1.1. Types and levels of programs for seismic evaluation of concrete dams needed at various times and for various purposes start with a Seismic Safety Review (SSR) and may be followed by special studies consisting of preliminary seismologic investigations coupled with simplified seismic evaluations (Phase I), full seismologic investigations and dynamic analysis of the project (Phase II), Dam Safety Evaluation Report, preparation of design documents, plans and specifications, and then construction. Flexible guidelines, consistent with the policy in paragraph 5b of ER 1110-2-1806 (reference 38) are needed to permit experienced investigators to do the best practical and economical job for each specific situation. The district Dam Safety Officer is responsible for making the final determination of critical structures for water control projects within his area of responsibility.

G-11.1.2. A review is required to identify specific problem areas and establish priorities for further study. Generally, Seismic Safety Reviews are based on evaluations of available pertinent data and surface inspections. Seldom do SSR level investigations include extensive exploratory or testing provisions.

G-11.2. *Project Description:* Briefly describe the project, including type of dam or major structure and seismic zone. Enclose a location map and the tabulated pertinent project data. Describe design and current project operations.

G-11.3. *Geology/Seismicity:* Describe site-specific geology and provide current detailed seismicity of the site including faulting, seismic evaluation parameters used in the design and changes or experienced shaking at site based on a search of existing project files and current professional literature. Describe site-specific ground motion data. No fieldwork or new research is needed for the SSR; existing data should be used.

G-11.4. *Structural Investigations:* Summarize structural design and results of recent analyses, if available. Describe those analyses used to conduct the evaluation.

G-11.5. *Evaluation:* Provide diagnostic seismic evaluation of the structure and foundation based on the data presented. Evaluate post-seismic stability. Develop a basis for decision on the need for and justification of additional studies or departure from further studies of risk assessment based on probabilities of occurrence of earthquakes, operating pool elevations and structural failure.

G-11.6. *E&D Cost Estimate and Schedule:* Provide scope of recommended studies and associated study costs and schedule.

G-11.7. *Conclusions and Recommendations:* Provide conclusions and specific recommendations based on existing data evaluations. Schedule and conduct the PCCR.

G-12. Phase I Special Study Content.

G-12.1. *Project Authorization:* Reference the Project Guidance Memo (PGM) from the Policy Compliance & Criteria Review (PCCR) of the SSR for the project.

G-12.2. *Project Description:* Briefly describe the project, including type of structures. Provide tabulated pertinent project data. Describe design and current project operations.

G-12.3. *Purpose and Scope:* Describe the purpose of the study, scope, and deficiency identified in the SSR.

G-12.4. *Seismologic Investigations:* Provide detailed seismologic study results, including fault study investigations, related field investigations.

G-12.5. *Seismicity:* Develop design earthquakes in relation to active fault systems and their activity.

G-12.6. *Seismic Evaluation:* Provide seismic evaluation of features subjected to design earthquakes. Provide basis for selection of parameters, method of analysis, and rationale for the decision on seismic assessment of the project.

G-12.7. *Conclusions and Recommendations:* Develop conclusions and recommendations for terminating the study or proceeding to a Phase II seismic evaluation in accordance with the requirements of ER 1110-2-1806 (reference 38).

G-12.8. *Cost Estimate and Schedule:* Provide scope, cost estimate, and schedule of recommended Phase II studies. Conduct the PCCR.

G-13. Phase II Special Studies - Guidelines for Dynamic Analysis of Concrete Structures.

G-13.1. *Design Earthquakes and Ground Motions:* Design earthquakes and ground motions for the seismic evaluations of concrete dams and appurtenant structures shall be determined in accordance with ER 1110-2-1806 (reference 38). The study scope shall be consistent with the PGM for the Phase I PCCR.

G-13.2. *Dynamic Analyses of Existing Structures and Proposed Remedial Alternatives:*

G-13.2.1. Review the candidate earthquake, location, and ground motions for most severe conditions to concrete structures.

G-13.2.2. Select design response spectra.

G-13.2.3. Select appropriate acceleration-time history records compatible with the design response spectra.

G-13.2.4. Select dynamic properties for the concrete and foundation.

G-13.2.5. Analyze and evaluate any cracking.

G-13.2.6. Follow guidance in the current technical guidance and EM appropriate for that concrete structure.

G-13.3. *Remediation Alternatives:* Discuss and analyze the remedial alternatives in the DSAP Evaluation Report.

G-13.4. *Conclusions and Recommendations:* Discuss the selection of a remediation plan to be developed in Phase III Plans and Specifications. Provide a summary of the Phase II studies in the DSAP.

G-14. Phase II Special Study Content.

G-14.1. *Introduction:* Introduction including Authorization, Purpose, Project Description, and Method of Analysis.

G-14.2. *Static Finite Element Analysis:* Static Finite Element Analysis including General Discussion, Development of Static Properties, and Results of Static FEM Analyses.

G-14.3. *Design Earthquake Motions:* Design Earthquake Motions including General Description, Design Earthquake and Ground Motions, Response Spectra, and Time Histories.

G-14.4. *Dynamic Finite Element Analyses:* Dynamic Finite Element Analyses including General Discussion, Field and Laboratory Tests & Results, Development of Dynamic Properties, Dynamic Analyses, Dynamic Response, Evaluate Cracking in Concrete Structures, Fracture Mechanics Analysis, and Non-Linear Analyses of Concrete Structures.

G-14.5. *Seismic Stability Assessment*: Seismic Stability Assessment including Evaluation of Dynamic Strengths with Laboratory Data and Field Data, Dynamic Structural Response, Soil Structure, Interaction of backfill, structure and piles, and Earthquake Induced Cracking Analyses.

G-14.6. *Post Earthquake Stability Analyses:* Post Earthquake Stability Analyses including General Discussion, Evaluate Cracking in Concrete Structures, Evaluate Structural Stability, and Post Earthquake Stability

G-14.7. *Remediation:* Remediation including General Description, Alternatives, and Cost.

G-14.8. *Summary*

G-14.9. *Conclusions and Recommendations*

G-14.10. *References*

G-14.11.*Attachments*

PART IV - HAZARD POTENTIAL CLASSIFICATION

G-15. Discussion. The current classification system used to evaluate the hydrologic hazard potential of dams was established in response to several dam failures in the early 1970's which resulted in significant loss of life and property damage. This classification system while useful for the evaluation of hazard to life and property is deficient in that it does not consider the indirect losses of critical lifelines due to a dam failure. These losses, such as the loss of water supply, loss of key transportation or medical facilities, loss of power generation capability, or loss of navigation and environmental damage can have a significant impact on the public after a major hydrologic or seismic event. Some attempt has been made in the past to consider lifeline and environmental losses as economic losses; however, a standard classification system has not been established. An additional deficiency in the existing classification system is in the potential loss of life posed by the significant and high classifications. The terms "few" under the significant category, and "high potential" under the high category are too vague and subject to interpretation. The following is an attempt to quantify the loss of life associated with each level of hazard potential.

G-16. Classification System. Table I-1 establishes a classification system, which groups losses into four general categories: loss of life, property, lifeline and environmental losses. This hazard potential classification is related to the functional integrity of the project, not the structural integrity of project features or components. Direct loss of life is quantified as either none, certain (one or more) or uncertain. Economic indirect losses are classified as either direct property, environmental or lifelines losses. Hazard potential ratings are based entirely upon the proximity of the project to population, which would be at risk due to project failure or operation, and the impact upon life, and property of the loss of essential services. A more detailed discussion on each of the four categories follows:

G-16.1. *Loss of Life:* If there is certainty that one or more lives will be lost due to failure or incorrect operation of the project, the project shall be classified as high hazard potential. This certainty shall be due to extensive residential or industrial development in the flood plain downstream of the project, and shall be confirmed by inundation mapping which considers population at risk, time of flood wave travel and warning time. If the loss of life potential is uncertain because the downstream flood plain development is predominately rural or agricultural, or is managed so that the land usage is for transient activities such as with day-use facilities, then a significant hazard potential rating shall be appropriate. Only those projects with no permanent downstream development located in rural or agricultural areas with no expected loss of life can be considered to have a low hazard potential.

G-16.2. *Property Losses:* Property losses are classified as either: direct economic losses due to flood damaged homes, businesses, and infrastructure; or indirect economic losses due to the interruption of services provided by either the failed facility or by damaged property or infrastructure downstream. Examples of indirect losses include:

G-16.2.1. Loss of power generation capability at the failed dam (or at an inundated powerhouse downstream).

G-16.2.2. Loss of navigation due to evacuation of the navigation pool at a failed reservoir (or due to direct damage to a lock).

G-16.2.3. Loss of water supply due to a reservoir emptied by a failed dam.

G-16.3. *Lifelines Losses:* Disruption of essential lifeline services or access to these services during or following a catastrophic event can result in indirect threats to life. The loss of key transportation links such as bridges or highways would prevent access to medical facilities at a time critically injured people need access the most. Another example would be the loss or damage to medical facilities.

G-16.4. *Environmental Losses:* Damage to the environment caused by project failure or operation can result in the need for mitigative measures, or can cause irreparable damage to the environment. Environmental damage estimates shall consider the damage, which would normally be caused by the flood event under which the project failure occurs. Only the incremental damage caused by the project failure shall be attributed to project failure or operation. Some other examples of environmental impacts are:

G-16.3.1. Environmental damage caused by the release of a reservoir contaminated by toxic or hazardous mine waste.

G-16.3.2. Environmental damage caused by sediment released by a reservoir.

G-17. Classification Table.

See Table G-1 for guidance in classifying Civil Works projects as low, significant, or high hazard potential.

TABLE G-1: HAZARD POTENTIAL CLASSIFICATION FOR CIVIL WORKS PROJECTS

CATEGORY[1]	LOW	SIGNIFICANT	HIGH
Direct Loss of Life[2]	None expected (due to rural location with no permanent structures for human habitation)	Uncertain (rural location with few residences and only transient or industrial development)	Certain (one or more extensive residential, commercial or industrial development)
Lifeline Losses[3]	No disruption of services - repairs are cosmetic or rapidly repairable damage	Disruption of essential facilities and access	Disruption of critical facilities and access
Property Losses[4]	Private agricultural lands, equipment and isolated buildings	Major public and private facilities	Extensive public and private facilities
Environmental Losses[5]	Minimal incremental damage	Major mitigation required	Extensive mitigation cost or impossible to mitigate

Notes:

1. Categories are based upon project performance and do not apply to individual structures within a project.

2. Loss of life potential based upon inundation mapping of area downstream of the project. Analyses of loss of life potential shall take into account the extent of development and associated population at risk, time of flood wave travel and warning time.

3. Indirect threats to life caused by the interruption of lifeline services due to project failure, or operation, i.e., direct loss of (or access to) critical medical facilities or loss of water or power supply, communications, power supply, etc.

4. Direct economic impact of value of property damages to project facilities and down stream property and indirect economic impact due to loss of project services, i.e., impact on navigation industry of the loss of a dam and navigation pool, or impact upon a community of the loss of water or power supply.

5. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond which would normally be expected for the magnitude flood event under a without project conditions.

APPENDIX H

PROJECT STUDY ISSUE CHECKLIST

A. Sensitive Policy Areas. Areas which require vertical team coordination with MSC/HQUSACE to Washington: (Issues not previously accounted for in an Administration approved Feasibility/Chiefs Report) _____

_____

B. General Project Information.

Project Name: (State, County, River Basin/Waterbody under Study)

Project Description: (Need project description with general details, such as a fact sheet attached--if project is the same as authorization attach a summary, if different provide a description of what differs from original authorization, the authorizing language, and dimensions to give perspective of the change in scope and scale. If there was an authorizing report, what level approved it—i.e., OMB, ASA(CW), HQUSACE (include date of approval). If no prior reports, give a more detailed description.)

Cost Sharing: (Describe the cost sharing for the project to be constructed. Describe whether the cost sharing follows general law or if there is other special cost sharing for the project)

C. General Questions.

1. Has a NEPA document been completed?
Response: YES _____ NO__*
Remarks:

2. Will the NEPA Documentation be more than 5 years old at the time of PCA signing or construction initiation?

Response: YES *____ NO_____
Remarks:

3. Will the ESA Findings be more than 3 years old at the time of PCA signing or construction initiation? [Note: Findings refers to Corps documentation and/or US Fish and Wildlife Service's opinions and recommendations]

Response: YES__*__ NO_____
Remarks:

* Response where a "*" requires coordination through vertical team and complete description of issues under "Remarks", before decision to approve project/report can be delegated.

4. Is ESA coordination complete?

Response: YES___ NO__*___
Remarks**:**

5. If an EIS/EA was completed for the project, has the Record of Decision/Finding of No Significant Impact been signed?

Response: YES _____ NO __*
Remarks:

6. Is the proposed project consistent with the ROD/FONSI?

Response: YES _____ NO __*
Remarks:

7. Has there been any changes in Federal environmental laws or Administration or Corps policy since original project authorization that make updating necessary? [e.g., change to the Clean Air Act status for the project area…going from attainment to non-attainment]

Response: YES *_____NO_____
Remarks:

8. Is there a mitigation plan?

Response:
a. Fish and Wildlife: YES__*___ NO_____
b. Flood Damage: YES__*___ NO_____
c. Cultural and Historic Preservation: YES__*___ NO_____
d. Recreation: YES__*___ NO_____

Remarks: [If yes, identify and describe what is being mitigated and cost shared. Describe the authority for the cost sharing.]

9. Are the mitigation plan(s) that are now being proposed the same as the authorized plan?

Response:
a. Fish and Wildlife YES_____ NO___*____
d. Flood Damage YES_____ NO___*____
e. Cultural and Historic Preservation YES_____ NO___*____
f. Recreation YES_____ NO___*____

Remarks:

*** Response where a "*" requires coordination through vertical team and complete description of issues under "Remarks", before decision to approve project/report can be delegated.**

10. Is there an incremental analysis/cost effectiveness analysis of the fish and wildlife mitigation features based on an approved method and using an accepted model?

Response: YES_____ NO___*___
Remarks:

11. Is it expected that the project's fully funded cost would exceed the cost limit of Section 902 of WRDA 1986? [Note: for hurricane and storm damage reduction projects there are two separate 902 limits, one for initial project construction and one for periodic renourishment]

Response: YES *_____ NO_____
Remarks: [In this section provide the authorized project cost, price level, and current and fully funded project cost estimates and price levels]

12. Does the project involve HTRW clean-up?

Response: YES *_____NO_____
Remarks:

13. Does the work involve CERCLA covered materials?

Response: YES *_____NO_____
Remarks:

14. Are the project purposes now being proposed different than the authorized project? [Note: different than specifically noted in authorization or noted in Chief's report and is it measured by project outputs]

Response: **YES *_____ NO**_____
Remarks:

15. Are there any proposed scope changes to the authorized project? [Reference: ER 1105-2-100]

Response: **YES *_____ NO**_____
Remarks: [Describe the authority that would enable the project to proceed without additional Congressional modification]

*** Response where a "*" requires coordination through vertical team and complete description of issues under "Remarks", before decision to approve project/report can be delegated.**

16. Is Non-Federal work-in-kind included in the project? [Note: Credit to a non-Federal sponsor for work-in-kind must be based upon having an existing authority. Need to identify the authority and if not a general authority such as Sec 215, provide a copy of the authority.]

Response: YES *_____ NO_____
Remarks:

17. Does project have work-in-kind authority? [Note: If there is no existing authority, as determined in conjunction with District Counsel, the only other vehicle is to propose work-in-kind and rationale in the decision document and submit to HQUSACE for specific Congressional authorization.]

Response: YES_____ NO___*___
Remarks:

18. Are there multiple credit authorities (e.g., Sec. 104 & 215) including LERRDS, Work-In-Kind and Ability to Pay? [Note: See App. B of ER 1165-2-131. Describe the authority for work-in-kind and if authority exists, the PM should submit a completed App. B through the vertical team.]

Response: YES *_____ NO_____
Remarks:

19. Is an Ability to Pay cost sharing reduction included in the proposed project? [If yes, fully describe the proposal, citing how this authority is applicable. Include a table showing the cost sharing by project purpose and expected Ability to Pay reductions.]

Response: YES *_____ NO_____
Remarks:

20. Is the recommended plan different from the NED plan? [Note: if this answer is yes, then a series of questions arise that will need to be addressed in the Remarks section…is plan less costly than NED plan, is the plan more costly with the same cost sharing the same as NED plan (exception), is plan more costly with all costs exceeding the cost of the NED plan at 100% non-Federal cost, or has ASA(CW) already granted an exception]

Response: YES*_____ NO_____
Remarks:

*** Response where a "*" requires coordination through vertical team and complete description of issues under "Remarks", before decision to approve project/report can be delegated.**

21. Was a standard accepted Corps methodology/model used to calculate NED benefits?

Response: YES_____ NO __*
Remarks:

22. Are there non-standard benefit categories? [Reference ER 1105-2-100].

Response: YES_____ NO __*
Remarks:

FLOOD DAMAGE REDUCTION COMPONENT

23. Is there a flood damage reduction component in the project?

Response: YES_____ NO_____
(If Yes, answer each of the following questions)

24. Is the project for protection of a single property or beneficiary?

Response: YES *_____ NO_____
Remarks:

25. Is the project producing land development opportunities/benefits? [If land creation benefits are expected to occur, describe whether special cost sharing should apply.]

Response: YES *_____ NO_____
Remarks:

26. Is there any recommendation to cost share any interior drainage facilities?

Response: YES *_____ NO_____
Remarks:

*** Response where a "*" requires coordination through vertical team and complete description of issues under "Remarks", before decision to approve project/report can be delegated.**

27. Are there any windfall benefits that would accrue to the project sponsor or other parties? [If windfall benefits are expected to occur, describe whether special cost sharing should apply.]

Response: YES *_____ NO_____
Remarks:

28. Are there non-structural buyout or relocation recommendations?

Response: YES *_____ NO_____
Remarks: [If yes list the authority and describe what is proposed]

29. Are the reallocation studies likely to change the existing allocated storage in lake projects ?

Response: YES *_____ NO_____
Remarks:

CONCURRENCE

_____ Date:_____
Project Manager

_____ Date: _____
Chief, Planning Division

_____ Date:_____
District Counsel

_____ Date:_____
District Dam Safety Officer

_____ Date:_____
Engineering and Construction CoP (MSC)

_____ Date:_____
MSC Counsel

APPENDIX I

POST-AUTHORIZATION DECISION DOCUMENT CHECKLIST

I-1. Basic Information:

I-1.1. Name of Authorized Project: _____

I-1.2. Name of Separable Element: _____

I-1.3. PWI Number: _____

I-1.4. Authorizing Document: _____

I-1.5. Law/Section/Date of Project Authorization: _____
(Note: attach copy to checklist)

I-1.6. Laws/Sections/Dates of Any Post-Authorization Modification: _____

I-1.7. Non-Federal Sponsor(s): _____

I-1.8. Project/Separable Element Purpose(s): _____

I-1.9. Congressional Interests (Senator(s), Representative(s) and District(s)): _____
_____

I-2. Project Documents:

I-2.1. Type of Decision Document: _____

I-2.2. Approval Authority of Decision Document: _____

I-2.3. Project Management Plan Approval Date: _____

I-2.4. Independent Technical Review (ITR) Approval Date: _____

I-2.5. Mitigation Authorized: ___ Yes ___ No Cost of Mitigation _____
Describe Type of Mitigation and Whether Included in Project Report: _____
_____
(Note: Project report is the one that supports the authorization for the mitigation. Need to make sure that mitigation is authorized as part of the project cost)

I-2.6. Current M-CACES Estimate: $ _____ Date Prepared and Price Level: _____

I-2.7. Section 902 Cost Limit: $ _____ Fully Funded as of 1 Oct FY_____

I-2.8. Date of Latest Economic Analysis: _____

I-2.9. Current Economics: BCR _____ @ _____ % FY_____
RBRCR ____ @ _____ % FY_____
(Note: list period of analysis)

I-3. Cost Sharing Summary:

Purpose (s)	Non- Fed Cash	Non-Fed LERRD	Non-Fed Const. Credit	Total Non-Fed Share	Federal Share (%)	Total Project Cost
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
Totals	_____	_____	_____	_____	_____	_____

I-3.1. Projected Credit for Section 215 Work and Date 215 Agreement Signed: _____

I-3.2. Projected Credit for Section 104 or Other Authorized Creditable Work and Date Work Approved by ASA(CW) or Agreement Addressing Work Signed: _____

I-3.3. Annual Non-Fed OMRR&R Costs (1 Oct FY_____ Price Levels): _____

I-4. Funding History -- Appropriations History for Project/Separable Element:

Fiscal Year	Budget Amount	Appropriated Amount
_____	_____	_____
_____	_____	_____

I-5. Certification For Delegated Decision Documents: You must answer "Yes" to all of the following questions to approve the decision document under delegated authority.

I-5.1. Project Plan

Has the project study issue checklist been completed and all issues resolved? ___Yes ___No
(Note: Is the project the same as contained in the project report supporting authorization; if not, is it within the 902 limit, who has the authority to allow the change by regulation…district, division, Chief, Congress)

Does the non-Federal sponsor concur in the project plan as submitted? ___Yes ___No

Has project plan as submitted been reviewed and concurred in by the non-Federal sponsor's counsel? ___ Yes ___ No

I-5.2. Authority

Has authority been delegated to the MSC for approval of the project report? ___Yes ___No

Is authority adequate to complete the project as proposed? ___ Yes ___ No

I-5.3. Policy/Legal/Technical Compliance

Has the District Counsel reviewed and approved the decision document for legal sufficiency?
_____Yes (Certification included in decision document package submittal)
_____ No

Have all aspects of ITR been completed with no unresolved issues remaining? ___Yes __No

Has the District Dam Safety Officer documented policy/legal/technical compliance of the decision document? ___ Yes ___ No

Has the MSC Dam Safety Officer certified the policy/legal/technical compliance of the decision document? ___ Yes ___ No

I-6. Authentication:

_____Date: _____
Project Manager

_____Date: _____
Chief, Planning Div

_____Date: _____
District Counsel

_____Date: _____
District Dam Safety Officer

_____Date: _____
District Support Team Leader

_____Date: _____
MSC Counsel

_____Date: _____
MSC Dam Safety Officer

APPENDIX J

Procedures for Preparation of Emergency Action Plans and Emergency Exercises

J-1. Basic Considerations for Preparing Emergency Action Plans (EAP's)

J-1.1. *Purpose:* There are many types of emergency events that could affect dams. Whenever people live in areas that could be flooded as a result of failure of or operation at a dam, there is a potential for loss of life and damage to property. The general purpose of these guidelines is to encourage thorough and consistent emergency action planning to help save lives and reduce property damage in areas that would be affected by dam failure or operation.

An Emergency Action Plan (EAP) is a formal document that identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The EAP specifies actions the dam owner 1/ should take to moderate or alleviate the problems at the dam. It contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities of the emergency situation. It also contains inundation maps to show the emergency management authorities of the critical areas for action in case of an emergency. Emergency Potential. Whenever people live in an area that could be flooded by the operation or failure of a dam, an emergency potential is assumed to exist. An emergency in terms of dam operation is defined as an impending or actual sudden release of water caused by an accident to, or failure of, a dam or other water retaining structure, or the result of an impending flood condition when the dam is not in danger of failure. The release of water may endanger human life or downstream property.

J-1.2. *Responsibility of the Federal Emergency Management Agency:* The Federal Emergency Management Agency (FEMA) is responsible for coordinating federal response to disasters and providing federal guidance to state and local emergency management authorities for all foreseeable emergencies in the United States. A recent survey indicates there are over 22,000 high or significant hazard potential dams in the United States, of which approximately 18,300, or 83 percent, do not have an EAP. The absence of an EAP at most state-regulated dams is recognized by FEMA as a deficiency in national emergency preparedness. To improve the Nation's emergency preparedness posture to respond to emergencies affecting dams, FEMA believes formal guidelines are needed to help dam owners effectively develop and exercise EAP's for dams. This process includes coordination, planning, and joint exercises involving both the EAP's of the dam owner and warning and evacuation plans of local emergency management authorities.

J-1.3. *Uniformity of Plans:* The effectiveness of EAP's can be enhanced by promoting a uniform format which ensures that all aspects of emergency planning are covered in each plan. Uniform EAP's and advance coordination with local and state emergency management officials and organizations should facilitate a timely response to a developing or actual emergency situation.

Organizations and individuals who own or are responsible for the operation and maintenance of

dams are encouraged to use these guidelines to develop, update, and/or revise their EAP's. These guidelines supersede the Emergency Action Planning Guidelines for Dams, FEMA 64/February 1985 and incorporate many technologically advanced emergency action planning concepts available from a wide variety of sources.

J-2. Scope. This document contains guidelines for preparing or revising EAP's for all high and significant hazard potential dams, i.e., those dams which, if they were to fail, would be likely to cause loss of life or significant property damage. Ownership and development of the floodplain downstream from dams varies; therefore, the potential for loss of life as a result of failure or operation of a dam will also vary. Every EAP must be tailored to site-specific conditions. EAP's generally contain six basic elements. All of the elements should be included in a complete EAP. The dam owner is responsible for the development of the EAP. However, the development or revision of an EAP must be done in coordination with those having emergency management responsibilities at the state and local levels. Emergency management agencies will use the information in a dam owner's EAP to facilitate the implementation of their responsibilities. State and local emergency management authorities will generally have some type of plan in place, either a Local Emergency Operations Plan or a Warning and Evacuation Plan. The six elements are as listed below.

J-2.1. *Notification Flowchart*

J-2.2. *Emergency Detection, Evaluation, and Classification*

J-2.3. *Responsibilities*

J-2.4. *Preparedness*

J-2.5. *Inundation Maps*

J-2.6. *Appendices*

J-3. The Six Basic Elements of an EAP. This section lists and briefly examines why there is a need for the six basic elements of an EAP. The requirements of these elements are discussed in detail in Chapter II of these guidelines, which presents a recommended format for uniformity among EAP's.

J-3.1. *Notification Flowchart:* A notification flowchart shows who is to be notified, by whom, and in what priority. The information on the notification flowchart is necessary for the timely notification of persons responsible for taking emergency actions.

J-3.2. *Emergency Detection, Evaluation, and Classification:* Early detection and evaluation of the situation(s) or triggering event(s) that initiate or require an emergency action are crucial. The establishment of procedures for reliable and timely classification of an emergency situation is imperative to ensure that the appropriate course of action is taken based on the urgency of the situation. It is better to activate the EAP while confirming the extent of the emergency than to wait for the emergency to occur.

J-3.3. *Responsibilities:* A determination of responsibility for EAP-related tasks must be made during the development of the plan. Dam owners are responsible for developing, maintaining, and implementing the EAP. State and local emergency management officials having statutory obligation are responsible for warning and evacuation within affected areas. The EAP must clearly specify the dam owner's responsibilities to ensure effective, timely action is taken should an emergency occur at the dam. The EAP must be site-specific because conditions at the dam and downstream of all dams are different.

J-3.4. *Preparedness:* Preparedness actions are taken to moderate or alleviate the effects of a dam failure or operational spillway release and to facilitate response to emergencies. This section identifies actions to be taken before any emergency.

J-3.5. *Inundation Maps:* An inundation map should delineate the areas that would be flooded as a result of a dam failure. Inundation maps are used both by the dam owner and emergency management officials to facilitate timely notification and evacuation of areas affected by a dam failure or flood condition. These maps greatly facilitate notification by graphically displaying flooded areas and showing travel times for wave front and flood peaks at critical locations.

J-3.6. *Appendices:* The appendices contain information that supports and supplements the material used in the development and maintenance of the EAP.

J-4. Coordination. It is vital that development of the EAP be coordinated with all entities, jurisdictions, and agencies that would be affected by a dam failure and/or flooding as a result of large operational releases, or that have statutory responsibilities for warning, evacuation, and post-flood actions. The finished product should be user friendly as it realistically takes into account each organization's capabilities and responsibilities.

J-4.1. *State and Local Emergency Management Officials:* Coordination with state and local emergency management officials at appropriate levels of management responsible for warning and evacuation of the public is essential to ensure that there is agreement on their individual and group responsibilities. Participation in the preparation of the EAP will enhance their confidence in the EAP and in the accuracy of its components. Coordination will provide opportunities for discussion and determination of the order in which public officials would be notified, backup personnel, alternate means of communication, and special procedures for nighttime, holidays, and weekends.

J-4.2. *Compatibility:* The tasks and responsibilities of the dam owner and the emergency management officials that would be implemented during a dam emergency incident need to be as compatible as possible. To facilitate compatibility, the dam owner should coordinate emergency response actions with the local emergency management officials who have the responsibility to provide a timely warning and evacuation notice to populations at risk. This should help prevent over, or under, reaction to the incident by various organizations.

J-5. Evacuation. Evacuation planning and implementation are the responsibility of the state and local officials who are responsible for the safety of the public who live in areas that would be inundated by failure of a dam or flood releases. The dam owner should not usurp the

responsibility of the local authorities responsible for evacuation. However, there may be situations where recreational facilities, campgrounds, or residences may be located below a dam where local authorities would not be able to issue a timely warning. In such cases, the dam owner should coordinate with local emergency management officials to determine who will warn these people and in what priority.

J-6. Emergency Duration, Security, Termination, and Follow-up. An EAP needs to address who in the dam owner's organization will issue status reports during the emergency, when and how a declared emergency will be terminated, what security provisions shall be maintained at the dam, and plans for a follow-up evaluation and report.

J-6.1. *Emergency Duration:* Emergency situations that occur at a dam will require that status reports and situation assessments be provided by the dam owner to appropriate organizations throughout the duration of the incident.

J-6.2. *Security Provisions:* An EAP should consider security provisions at and surrounding the dam during emergency conditions to protect the public and permit effective performance of emergency response actions.

J-6.3. *Emergency Termination:* There are two conditions requiring a termination of the emergency. One has to do with emergency conditions at the dam and the other is related to the evacuation and disaster response. The dam owner is usually responsible for making the decision that an emergency condition no longer exists at the dam. The EAP should clearly designate the responsible party. The applicable state or local emergency management officials are responsible for termination of the evacuation or disaster response activities. The dam owner and state and local officials should agree on when it is appropriate to terminate an emergency. The dam owner should cooperate with state and local officials to determine if a news release which can be used by the media for broadcast to the general public notifying them of termination of the emergency condition is appropriate. Such news releases are expected to be a supplement to other methods of notifying the public that the emergency has been terminated.

J-6.4. *Follow-up Evaluation:* Following an emergency, an evaluation and review should be conducted that includes all participants. The following should be discussed and evaluated in the after-action review:

J-6.4.1. Events before, during, and following the emergency

J-6.4.2. Significant actions taken by each participant, and improvements practicable for future emergencies

J-6.4.3. All strengths and deficiencies found in procedures, materials, equipment, staffing levels, and leadership

J-6.5. *After Action Report:* The results of the after-action review should be documented in an evaluation report chaired by the dam owner and used as a basis for revising the EAP.

J-7. Maintaining an EAP. After the EAP has been developed, approved, and distributed, the job is not done. Without periodic maintenance, the EAP will become out-dated, lose its effectiveness, and no longer be workable. If the plan is not exercised (verified), those involved in its implementation may become unfamiliar with their roles and responsibilities, particularly if emergency response personnel change. If the plan is not updated, the information contained in it may become outdated and useless.

J-7.1. *Exercising:* Emergency incidents at dams and/or dam failures are not common events. Therefore, training and exercises are necessary to maintain operational readiness, timeliness, and responsiveness. The status of training and levels of readiness should be evaluated in non-threatening simulated periodic emergency exercises for key personnel of the dam owner.

J-7.2. *Key Personnel:* Key personnel from state and local emergency management agencies should be encouraged to participate in any training and exercises of the EAP whenever possible and as appropriate.

J-7.3. *Dam Owner Exercises:* The dam owner should exercise the EAP because it promotes emergency preparedness, mitigation, and response, and demonstrates how effective the EAP will be in an actual emergency situation. Periodic exercises will result in an improved EAP as lessons learned during the exercise can be incorporated into an updated EAP document.

J-7.4. *Types of Exercises:* There are five types of exercises in an exercise program. It is not a requirement that every exercise program include all five exercises. However, it is advisable to build an exercise program upon competencies developed from simpler exercises to achieve greater success with the more complex exercises. This means that emergency exercises should be developed and conducted in an ascending order of complexity. It is important that sufficient time be provided between each exercise to learn and improve from the experiences of the previous exercise before conducting a more complex exercise. The five exercise types, listed from simplest to most complex, are described below.

J-7.4.1. Orientation Seminar - This exercise is a seminar that involves bringing together those with a role or interest in an EAP, i.e., dam owner and state and local emergency management agencies, to discuss the EAP and initial plans for an annual drill or more in-depth comprehensive exercise. The seminar does not involve an actual exercise of the EAP. Instead, it is a meeting that enables each participant to become familiar with the EAP and the roles, responsibilities, and procedures of those involved. An orientation seminar can also be used to discuss and describe technical matters with involved, non-technical personnel.

J-7.4.2. Drill - A drill is the lowest level exercise that involves an actual exercise. It tests, develops, or maintains skills in a single emergency response procedure. An example of a drill is an in-house exercise performed to verify the validity of telephone numbers and other means of communication along with the dam owner's response. A drill is considered a necessary part of ongoing training.

J-7.4.3. Tabletop Exercise - The tabletop exercise is a higher level exercise than the drill. The tabletop exercise involves a meeting of the dam owner and the state and local emergency

management officials in a conference room environment. The format is usually informal with minimum stress involved. The exercise begins with the description of a simulated event and proceeds with discussions by the participants to evaluate the EAP and response procedures and to resolve concerns regarding coordination and responsibilities.

J-7.4.4. Functional Exercise - The functional exercise is the highest level exercise that does not involve the full activation of the dam owner and state and local emergency management agency field personnel and facilities or test evacuation of residents downstream of the dam. It involves the various levels of the dam owner and state and local emergency management personnel that would be involved in an actual emergency. The functional exercise takes place in a stress-induced environment with time constraints and involves the simulation of a dam failure and other specified events. The participants "act out" their actual roles. The exercise is designed to evaluate both the internal capabilities and responses of the dam owner and the workability of the information in the EAP used by the emergency management officials to carry out their responsibilities. The functional exercise also is designed to evaluate the coordination activities between the dam owner and emergency management personnel.

J-7.4.5. Full Scale Exercise - The full scale exercise is the most complex level of exercise. It evaluates the operational capability of all facets of the emergency management system (both dam owner and state and local emergency management agencies) interactively in a stressful environment with the actual mobilization of personnel and resources. It includes field movement and deployment to demonstrate coordination and response capability. The participants actively "play out" their roles in a dynamic environment that provides the highest degree of realism possible for the simulated event. Actual evacuation of critical residents may be exercised if previously announced to the public.

J-7.5. *Comprehensive EAP Exercise:* A comprehensive EAP exercise is an in-depth EAP exercise that simulates a dam failure and involves the active interaction and participation of the dam owner with state and local emergency management personnel in a stressful environment with time constraints. Functional and full scale exercises are considered comprehensive exercises. The basic difference between these two exercise types is that a full scale exercise involves actual field movement and mobilization, whereas field activity is simulated in a functional exercise. A comprehensive exercise provides the necessary verification, training, and practice to improve the EAP and the operational readiness and coordination efforts of all parties responsible for responding to emergencies at a dam, such as failure, misoperation, and sabotage.

J-7.6. *Frequency:* For most dam owners, the orientation seminar, drill, tabletop exercise, and functional exercise should receive the most emphasis in their EAP exercise programs. It is recommended that dam owners conduct a functional exercises at least once every 5 years. Tabletop exercises are usually conducted on a more frequent basis. Full scale exercises should be considered as optional emergency exercise activities, and should be conducted primarily when there is a specific need to evaluate actual field movement and deployment. When a full scale exercise is conducted, safety becomes a major concern because of the extensive field activity. If a dam owner has the capability to conduct a full scale exercise, a commitment should be made to schedule and conduct the entire series of exercises listed above before conducting any full scale exercise. This will also require that at least one functional exercise be conducted before

conducting a full scale exercise. Functional and full scale exercises can be coordinated with other scheduled exercises to share emergency management agency resources and reduce costs.

J-7.7. *Objectives of Comprehensive Exercise:* The primary objectives of a comprehensive exercise are as listed below.

J-7.7.1. Reveal the strengths and weaknesses of the EAP, including specified internal actions, external notification procedures, and adequacy of other information, such as inundation maps.

J-7.7.2. Reveal deficiencies in resources and information available to the dam owner and the state and local agencies.

J-7.7.3. Improve coordination efforts between the dam owner and the state and local agencies.

J-7.7.4. Close coordination and cooperation among all responsible parties is vital for a successful response to an actual emergency.

J-7.7.5. Clarify the roles and responsibilities of the dam owner and the state and local emergency management officials.

J-7.7.6. Improve individual performance of the people who respond to the dam failure or other emergency conditions.

J-7.7.7. Gain public recognition of the EAP.

J-7.7.8. Testing of monitoring, sensing, and warning equipment at remote/unattended dams should be included in emergency exercise activities.

J-7.8. *Exercise Evaluation:* Emergency exercises and equipment tests should be evaluated orally and in writing, and the EAP should be revised and corrected, as necessary. Immediately following an exercise or actual emergency, an evaluation of the EAP should be conducted with all involved parties. The evaluation should focus on the procedures and other information in the EAP, not on the performance of the individuals who carried out the established procedures. It should address both the procedures that worked well and the procedures that did not work so well. The responses from all participants involved in the exercise should be considered. The exercise evaluation should discuss and evaluate the events before, during, and following the exercise or actual emergency; actions taken by each participant; the time required to become aware of an emergency and to implement the EAP; and the improvements practicable for future emergencies. The purpose of the evaluation is to identify strengths and deficiencies in the EAP, such as outdated telephone numbers on the notification chart, inundation maps with inaccurate information, and problems with procedures, priorities, assigned responsibilities, materials, equipment, and staff levels. After the evaluation has been completed, the EAP should be revised, as appropriate, and the revisions disseminated to all involved parties.

J-7.9. *Updating:* In addition to regular exercises, a periodic (at least annual) review of the overall EAP should be conducted to assess its workability and efficiency, i.e., timeliness of

implementation, and to improve weak areas. Changes that may frequently require revision and update of an EAP include changes in personnel of various organizations and changes in communications systems. Therefore, a periodic review of telephone numbers and appropriate personnel included in the notification flowchart should be conducted. A review should be made of any changes to the dam and/or floodplain as this may affect the information on the inundation maps. Changes to the maps should be made as soon as practical and noted in the EAP. Once the plan has been revised, the updated version--or simply the affected pages--should be distributed to all involved parties. The distribution of copies of the EAP and the notification flowchart (if issued separately) must be controlled and documented to ensure simultaneous updating of all copies. Updates should be made promptly. In addition, it is recommended that the entire EAP be reprinted and distributed to all parties at least every 5 years.

J-8. EAP Format.

J-8.1. *Suggested Format:* A suggested format is provided in these guidelines to ensure all six basic elements are included in an EAP, to provide uniformity, and to encourage thorough and consistent emergency action planning for levels of preparedness that may save lives and reduce property damage in areas affected by dam operation or failure. It is important that dam owner and regulatory requirements be satisfied when selecting a format for an EAP. Although it is not necessary to follow exactly the format outlined below, it is necessary that all EAP's within a given jurisdiction be similar and consistent to eliminate confusion when activating any EAP. To the extent possible, an EAP should be organized in the format that is most useful for those involved in the plan. The EAP must be user friendly so that it will actually be used during EAP exercises and actual emergency events. Regardless of the format used, development of an EAP should consider the elements described on the following pages to ensure all aspects of emergency action planning are covered. It is helpful to place the EAP in a loose-leaf binder so that outdated pages (or the entire EAP) can be easily removed and replaced with updated information, and to ensure a complete, current, and workable plan. It is also beneficial to place the date of the EAP or current revisions on each page. The suggested format for an EAP appears below.

Title Page/Cover Sheet
Table of Contents
- I. Notification Flowchart
- II. Statement of Purpose
- III. Project Description
- IV. Emergency Detection, Evaluation, and Classification
- V. General Responsibilities Under the EAP
  - A. Dam Owner Responsibilities
  - B. Responsibility for Notification
  - C. Responsibility for Evacuation
  - D. Responsibility for Termination and Follow-Up
- VI. Preparedness
- VII. Inundation Maps

VIII. Appendices
- A. Investigation and Analyses of Dambreak Floods
- B. Plans for Training, Exercising, Updating and Posting the EAP
- C. Site-Specific Concerns
- D. Approval of the EAP

J-8.2. *Purpose of Suggested Format:* Suggested format was purposefully devised to separate an EAP into two distinct sections: the basic EAP and the Appendices which, when combined together, constitute a complete EAP.

J-8.2.1. The Basic EAP: Sections I through VII of the format constitute the basic EAP, i.e., they contain information that will likely be used by all parties (both the dam owner and emergency management officials) during an actual emergency. For example, the dam owner will use the notification flowchart to issue its emergency warning to the appropriate officials in a prioritized order. Similarly, the emergency management officials will use the flowchart to contact other officials or the dam owner, as needed, throughout the emergency. As a second example, both the dam owner and the emergency management officials will use the inundation maps extensively in fulfilling their responsibilities. It must be remembered that the responsibilities of the state and local emergency management authorities and other organizations in the jurisdictions affected by a dam failure or flooding as a result of operation of a dam are not included in an EAP. Information unique to state and local emergency management authorities, and any other organizations that would have responsibilities for the warning and evacuation of populations at risk, would be included in the portion(s) of the appropriate jurisdiction's Emergency Operations Plan dedicated specifically to warning and evacuation of populations placed at risk as a result of dam failure or flooding due to large operational releases. However, the information in the EAP must be coordinated with the appropriate authorities because they will depend on and use the information in the dam owner's EAP to help them carry out their responsibilities.

J-8.2.2. The Appendices: The Appendices are an important element which completes the EAP. However, the information contained in the Appendices is not necessarily needed by all parties during an actual emergency. They typically contain support materials used in the development of the basic EAP. More specifically, the Appendices focus on important issues such as those that specifically address maintenance requirements for the EAP and dambreak investigations and analyses, among others. This information may be directly applicable to the actions of the dam owner and possibly some of the emergency management parties, but may not be critical to the actions and activities of other parties during an actual emergency. All emergency management officials should be offered the complete EAP. However, it may be left to their discretion to decide whether they want to receive a copy of the complete EAP (basic EAP + Appendices) or the basic EAP. Those who elect to receive the basic EAP should understand that if it does not provide sufficient information for them to perform their functions, they should obtain the complete EAP.

NOTE: Every EAP must be tailored to site-specific conditions and to the requirements of the organization that owns, operates, or regulates the use of the dam. This can be accomplished under the suggested format. Uniformity of EAP’s is important because any one state or local emergency management agency may be affected by a river system that has a series of dams, the

independent failure or operation of which may impact the jurisdiction. Uniformity provides for clarity and better understanding of the information in the EAP for each individual dam.