

**FISH AND WILDLIFE SERVICE  
ENGINEERING AND CONSTRUCTION**

**2.1 What is the purpose of this chapter?** This chapter describes the standards and requirements of our Dam Safety Program.

**2.2 What terms do you need to know to understand this chapter?**

**A. Cross-dike or interior dike.** A cross-dike or interior dike:

(1) Is an artificial embankment constructed to subdivide a reservoir or provide vehicular access across a reservoir,

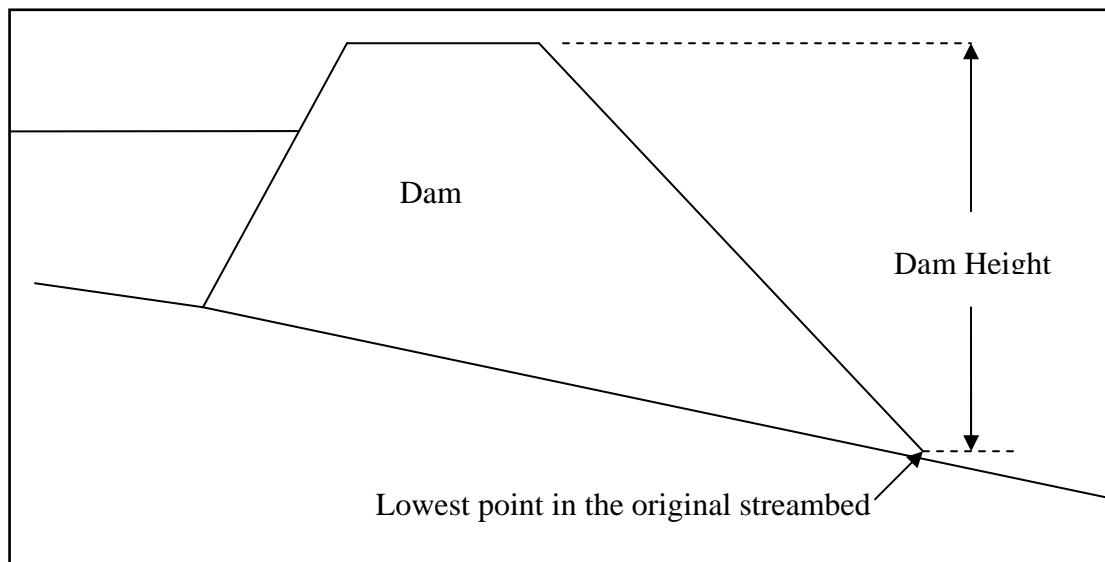
(2) Does not provide any additional water storage above the maximum storage of the dam that creates the reservoir, and

(3) May be considered a dam if the difference in the water surface elevation from upstream to downstream of the dike can be more than 3 feet.

**B. Dam.** A dam is an artificial barrier, including appurtenant works, constructed to impound water for permanent storage or flood control storage.

**C. Dam Height.** A dam's height is the vertical distance between the lowest point on the dam crest and the lowest point in the original streambed measured at the toe of the dam (see Figure 1).

**Figure 1: Dam Height**



**D. Hazard Classification.** Hazard classification is a rating based on the potential loss of life or property damage downstream of a dam if the dam were to fail or be misoperated. We do not determine hazard classification based on the existing condition of a dam and its appurtenant structures.

**E. Hydraulic Height.** A dam's hydraulic height is the vertical distance between the maximum design water level and the lowest point in the original streambed measured at the toe of the dam.

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**F. Inflow Design Flood.** The Inflow Design Flood is the rate of water coming into the reservoir over time that the dam must be able to safely pass through a combination of spillway and outlet works and attendant surcharge storage.

**G. Inventory Dam.** We include a dam in the Service Inventory of Dams and the National Inventory of Dams if it meets the following criteria:

- (1) It has a storage capacity at maximum water storage elevation in excess of 15 acre-feet, and:
  - (a) It exceeds 25 feet in height from the natural bed of the stream (or a watercourse) to the maximum water storage elevation measured at the downstream toe of the dam, or
  - (b) If it is not across a stream channel or watercourse, it exceeds 25 feet in height measured from the lowest elevation of the outside limit of the dam, to the maximum water storage elevation; or
- (2) It exceeds an impounding capacity at maximum water storage elevation of 50 acre-feet **and** a height measured as section 2.2 G(1) above describes in excess of 6 feet; and
- (3) It has a high or significant hazard classification.

**H. Maximum Water Storage Elevation.** The maximum water storage elevation is the highest elevation of water that the dam can impound, including temporary storage of flood water.

**I. Maximum Design Water Level.** The maximum design water level is the highest elevation of water determined as a result of safely passing the Inflow Design Flood (see section 2.15A).

**J. Noninventory Dam.** Noninventory dams are:

- (1) Low hazard dams that do not meet the criteria in section 2.2G, and
- (2) Interior dikes or cross dikes located within an impoundment.

**K. Probable Maximum Flood (PMF).** The Probable Maximum Flood is the runoff flow of water that we expect from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a drainage area under study.

**L. Structural Height.** The structural height of a dam is the vertical distance between the lowest point on the crest of the dam and the lowest point of the excavated foundation.

**2.3 How does the Service classify dams?** We classify dams based on hazard potential and a dam's size.

**A. Hazard Classification.** The hazard classification for a dam gives us the minimum requirements for security, investigation, design, and construction.

- (1) The Regional Dam Safety Officer (RDSO) or a member of the Service's Dam Safety inspection team provides a preliminary hazard classification recommendation.
- (2) The Division of Engineering analyzes the hazard classification, when appropriate, in accordance with the latest version of the Federal Emergency Management Agency (FEMA) 333, Department of the Interior (753 DM), and the Bureau of Reclamation (BOR) guidelines, (i.e., Downstream Hazard Classification

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Guidelines, Assistant Commissioner Engineering and Research (ACER) Technical Memorandum (TM) #11).

**(3)** A hazard classification panel assigns a formal hazard classification to all Service dams by using the RDSO's preliminary hazard classification recommendation, the Division of Engineering's hazard classification analysis, and other data.

**(a)** The panel consists of a Service Dam Safety Officer (SDSO) designee(s), the affected RDSO and an RDSO from another Region. The panel provides a written determination to the SDSO.

**(i)** A majority vote of the panel is required to classify new dams, and

**(ii)** A unanimous vote of the panel is required to change the hazard classification of existing dams.

**(b)** The hazard classification panel determines the formal classification of a dam in accordance with the guidelines in section 2.3A(2).

**(4)** The RDSO reviews the hazard classification of low hazard inventory dams and noninventory dams at least every 6 years.

**(5)** The RDSO or the SDSO may request the reclassification of a dam.

**B. Size Classification.** The RDSO or a member of the Service's Dam Safety inspection team determines the size classification of a dam. They use the dam height or the water storage capacity at maximum water storage elevation, whichever yields the larger size classification, to determine the size of a dam.

**(1) Small dams** are structures that are less than 40 feet high or that impound less than 1,000 acre-feet of water.

**(2) Intermediate dams** are structures that are 40 to 100 feet high or that impound 1,000 to 50,000 acre-feet of water.

**(3) Large dams** are structures that are more than 100 feet high or that impound more than 50,000 acre-feet of water.

**2.4 What is the Service's Safety Evaluation of Existing Dams (SEED) inspection program?**

**A. The SEED Inspection program.**

**(1) Purpose.** The purpose of the SEED Program is to ensure protection of life and property and to assure the integrity of our inventory dams and appurtenant structures (also see The Federal Guidelines for Dam Safety FEMA 93, 2004). Periodic inspections disclose conditions that might disrupt operation or threaten dam safety.

**(2) Correction of Deficiencies.** We must correct any deficiencies noted as a result of inspections. The Division of Engineering will set priorities and completion dates to correct deficiencies in accordance with the relative level of failure potential and downstream consequences. To determine priorities for maintenance, repair, or removal, the Division of Engineering looks at the adequacy of structures and facilities to continue serving the purpose for which they were constructed and identifies the extent of deterioration.

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**B. Types of Inspections.** There are four types of inspections:

**(1) Informal inspections** are visual examinations carried out during day-to-day operations. They provide frequent surveillance of the general appearance and functioning of the dam and its appurtenances to identify, as soon as possible, any readily observable changes. For each high and significant hazard dam, Project Leaders and staff perform these inspections in accordance with the dam's Standing Operating Procedures (see section 2.5).

**(2) Formal SEED inspections** assess the safety and integrity of all aspects of a dam. Formal inspections are comprehensive searches for evidence of deterioration of materials, developing weaknesses, and unsafe hydraulic or structural conditions. Engineers perform these inspections which include:

**(a)** Field examinations,

**(b)** Photographic or video recording of all physical features,

**(c)** Examination of any adjacent endangering conditions,

**(d)** Review and evaluation of all recorded performance data, including engineering loadings, analytical methods, instrumentation and spillway discharge measurements,

**(e)** Evaluation of the performance of the dam and a comparison of the long-term examination record with current conditions,

**(f)** An overall condition rating, and

**(g)** Recommendations to maintain or improve the integrity of the dam.

**(3) Intermediate SEED inspections** are visual site investigations conducted to identify deterioration of materials, developing weaknesses, and unsafe hydraulic or structural conditions.

**(a)** Engineers perform these inspections which consist of:

**(i)** Field examinations,

**(ii)** Photographic or video recording of all physical features, and

**(iii)** Examination of any adjacent endangering conditions.

**(b)** Intermediate inspections do not include a comprehensive evaluation of the engineering loadings and analytical methods to predict dam performance.

**(4) Special inspections** are made following (or during, if possible) unusual floods, significant earthquakes, mishaps, or the appearance of unexpected dam performance. These inspections determine the extent of any damage and the need for emergency repair or other action.

**C. Frequency of Inspections.**

**(1)** Project Leaders and dam operators perform informal inspections routinely during day-to-day operations in accordance with SOPs.

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(2) The frequency of formal and intermediate inspections is based on the hazard classification of the dam.

(a) High and significant hazard dams are inspected every 3 years, alternating between a formal SEED inspection and an Intermediate SEED inspection.

(b) Low hazard dams are inspected every 6 years, alternating between a formal SEED inspection and an Intermediate SEED inspection. (The SDSO may change the frequency based on size and condition of the dam.)

(3) The frequency of special inspections depends on the occurrence of an unusual event (e.g., seepage through the dam has become turbid). Those responsible for the dam must be alert to identify situations or events that may require special inspections.

**D. Reporting Dangerous or Unusual Conditions.**

(1) The SEED Inspector must immediately report dangerous or unusual conditions to the Project Leader and the RDSO.

(2) In response to a dangerous or unusual condition, the RDSO must immediately:

(a) Initiate appropriate response in accordance with the dam's Emergency Action Plan (see section 2.6 and 361 FW 3), and

(b) Contact the SDSO and the Regional Safety Manager if an inspection indicates imminent danger or threat of serious injury or significant property damage.

**E. Inspection Reports.**

(1) Use written checklists for informal inspection reports. They contain enough information to determine whether or not further action is necessary and may be obtained from the SDSO or the RDSO.

(2) Formal and intermediate inspection reports are written reports prepared in a format consistent with established Service guidelines.

**F. Inspectors.**

(1) **Inspectors for Informal Inspections:** These inspectors:

(a) May be Project Leaders, dam operators, and other Service personnel who are in the vicinity of the dam in the course of their regular activities. The RDSO may request an individual to conduct informal inspections of a dam.

(b) Should have a basic knowledge of dams so they can recognize unusual conditions, abrupt changes from previous conditions, and obvious new defects such as seepage, cracks, and displacements.

(2) **Inspectors for Formal, Intermediate, and Special Inspections:**

(a) **High and Significant Hazard Dams:** Staff from the Division of Engineering, RDSOs, or consultants perform SEED inspections for high and significant hazard dams. Members of the inspection team must include a Registered Professional Engineer trained in the safety inspection of dams.

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**(b) Low Hazard Dams:** Staff from the Division of Engineering, RDSOs, or consultants perform SEED inspections for low hazard dams. Dam safety professionals must perform the inspections under the direct supervision of a Registered Professional Engineer trained in the safety inspection of dams.

**2.5 What are the requirements for writing Standing Operating Procedures (SOPs)?**

**A.** The SDSO must:

- (1)** Prepare SOPs for all high and significant hazard dams using the Service format.
- (2)** Update SOPs associated with major repair or rehabilitation to high and significant hazard dams.

**B.** The RDSO must annually review and update, as appropriate, the SOPs for each high and significant hazard dam within the Region.

**2.6 What are the requirements for writing and implementing Emergency Action Plans?** The SDSO must prepare Emergency Action Plans for all high and significant hazard dams (see 361 FW 3 for more information about Emergency Action Plans).

**A.** The RDSO:

**(1)** Must annually review the Emergency Action Plan for each high and significant hazard dam within the Region in accordance with procedures outlined in the Emergency Action Plans.

**(2)** Is responsible for:

- (a)** Annual testing, verification, and certification of Emergency Action Plans by November 1<sup>st</sup>.
- (b)** Submitting a verification statement, in accordance with the SOPs, along with any revisions to the Emergency Action Plans, to the SDSO annually on or before November 30<sup>th</sup>.
- (c)** Distributing revisions of the Emergency Action Plan to the plan holders.

**B.** The SDSO is responsible for:

- (1)** Performing Emergency Action Plan periodic tests every 6 years concurrent with Formal SEED inspections and tabletop exercises concurrent with Intermediate SEED inspections, and
- (2)** Updating Emergency Action Plans associated with major repair or rehabilitation to high and significant hazard dams.

**2.7 What is the approval process and procedure for building new dams?**

**A. Review and Approval.** Table 2-1 shows who must review and approve or decline to approve all plans, designs, drawings, and construction specifications for Service dams by performing a Qualified Engineering Review and Approval:

<b>Table 2-1: Who Must Review and Approve Plans, Designs, Drawings, and Specifications</b>	
<b>Type of Dam</b>	<b>Approving Official(s)</b>
Noninventory dams	The RDSO

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<b>Table 2-1: Who Must Review and Approve Plans, Designs, Drawings, and Specifications</b>	
<b>Type of Dam</b>	<b>Approving Official(s)</b>
Low hazard inventory dams	The RDSO and SDSO
High and significant hazard dams	The SDSO (The SDSO must also obtain an independent review by an outside organization, such as the Bureau of Reclamation, the Army Corps of Engineers, or a consultant.)

**B. Project Planning, Design, and Construction.**

(1) The SDSO or a designee serves as the project manager for planning (including environmental impacts), design, permitting and construction of high and significant hazard dams.

(2) The Regional Engineer designates the RDSO or another qualified engineering staff person to be the project manager for planning (including environmental impacts), design, permitting and construction of all low hazard, inventory dams, and noninventory dams.

(3) The RDSO classifies all new dams as either inventory or noninventory dams. The RDSO sends this determination, along with the vital statistics of the dam, to the SDSO. The SDSO adds the dam to the Service inventory, if appropriate.

**2.8 How does the Service address newly acquired dams?** Before acquiring new lands, we must identify any dams being conveyed with the property. We must inspect and classify the dams and clearly identify any needed rehabilitation or repair costs before we acquire the land.

**A.** The RDSO must ensure that a SEED inspection is performed as part of the Engineering Assessment we conduct for all proposed land acquisitions (see 341 FW 2). See section 2.4 for more information about the SEED inspection program

(1) The SEED inspection should describe:

(a) The condition of the dam,

(b) The cost of any work required to bring the dam up to Service safety standards, and

(c) Future costs and liabilities associated with the dam.

(2) The RDSO must review the SEED report and approve it before it can be included with the Engineering Assessment. The Engineering Assessment must clearly state any significant deficiencies and costs associated with the dam(s) and must be included in the Decision Document the Region's Engineering Division gives to the Regional Director for approval (see 341 FW 1).

**B.** The RDSO must ensure that SEED II studies are performed on all newly acquired dams. The SEED II study is a detailed assessment of the design and condition of the dam and normally includes hydrologic and hydraulic, structural, and geotechnical analyses (stability, seepage, liquefaction, etc).

**C.** The acquisition contract or other legally enforceable agreement should include the cost associated with work required to bring the dam up to Service safety standards, including modifications, repairs, and development of Emergency Action Plans and SOPs. Land acquisition budget requests should include the costs for SEED inspections and SEED II studies (see 341 FW 3).

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**2.9 What is the process for rehabilitating, modifying, or repairing an inventory dam?**

**A.** We must follow the same approval process and procedures for major rehabilitation, modification, or emergency repair of inventory dams as for new dams (see section 2.7).

**B.** Major rehabilitation or modification may include:

- (1) Raising a dam crest,
- (2) Enlarging or replacing spillways and outlets, and
- (3) Constructing auxiliary or emergency spillways.

**C.** Major rehabilitation, modification, or emergency repair does not include annual operation and maintenance work such as repairs to gates, repair of erosion on embankments, simple concrete repair, etc.

**2.10 How do Project Leaders request funding for safety modifications, operations and monitoring, and rehabilitation of dams?** Table 2-2 shows who should request funding for modifying and operating dams.

<b>Table 2-2 Requesting Funding</b>		
<b>Type of Project</b>	<b>Responsible Official(s)</b>	<b>How Requested</b>
<b>A.</b> Routine maintenance, operations and monitoring and minor repairs of high and significant and low hazard dams	Project Leaders and Regional Service Asset Maintenance Management System (SAMMS) Coordinators	Resource Management funds through SAMMS
<b>B.</b> Priority 1 and 2* recommendations except recommendations for engineering studies or major repair or rehabilitation	Project Leaders and Regional SAMMS Coordinators	Resource Management funds through SAMMS the year they are identified in SEED inspections
<b>C.</b> Planning, design, and construction of major rehabilitation or modification to low hazard dams and appurtenances and noninventory dams	Project Leader, in consultation with the RDSO and the Regional Engineer	Resource Management or Construction funds through SAMMS or the Construction 5-year Plan
<b>D.</b> Planning, design, and construction of major rehabilitation or modification to high and significant hazard dams and appurtenances	SDSO, through the Chief, Division of Engineering	Construction funds through the Construction 5-year Plan

\*P1 Recommendations indicate that the normal condition of the structure is impaired and the safety of the structure is in jeopardy.

P2 Recommendations are mainly maintenance deficiencies.



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**2.11 How does the Service coordinate with State Dam Safety Programs?** We consult on the design and safety of dams with the Dam Safety Program officials in the States in which we own, operate, or propose to construct a dam. We also invite State officials to participate in safety inspections and Emergency Action Plan exercises.

**2.12 What are the requirements for privately funded dams on Service property?**

**A.** To allow construction of a privately funded dam on Service property the proposed dam must satisfy the requirements in section 2.7, and the SDSO must review and approve a Professional Engineer's certification of the dam. The Professional Engineer must be licensed by the State in which the dam will be located.

**B.** The certification must at least attest to the following:

**(1)** The hazard and size classification of the dam;

**(2)** The proposed project has been designed by a Professional Engineer, qualified in dam design and construction, to meet Federal standards for dam design, construction, and rehabilitation including, but not limited to, the Federal Guidelines for Dam Safety (FEMA 93, 2004) and Service design standards;

**(3)** The project design and specifications have been reviewed and approved by the State dam safety program staff;

**(4)** There is a dedicated funding source for future operation, inspection, maintenance, and repairs of the dam;

**(5)** If the dam is a high or significant hazard dam, there is an Emergency Action Plan in effect for the dam that meets the requirements of Emergency Action Planning for Dam Owners (FEMA 64, 2004); and

**(6)** Federal and State permits will be obtained prior to construction.

**2.13 How are privately owned dams on Service property inspected?**

**A.** The non-Federal entity who owns the dam or lessee is responsible for ensuring the dam complies with State regulations and the Federal Guidelines for Dam Safety (FEMA 93 April, 2004). Although Service inspection teams do not inspect private dams, the SDSO maintains a list of the dams.

**B.** Responsibilities for dam safety must be identified in the Memorandum of Understanding or lease agreement that authorizes use of Service lands. Responsibilities should include ensuring the owner/lessee contacts the Project Leader and the RDSO if significant dam safety deficiencies or unusual circumstances are identified on a private dam on Service property.

**2.14 What are the requirements for State dam projects to which the Service provides funding?**

**A.** We may provide funds to supplement approved State dam safety projects on a cost-sharing basis through the Federal Aid Program.

**B.** For all inventory dams for which we provide funds (see section 2.2G), we must obtain:

**(1)** Reasonable assurances that the State has a dedicated funding source to safely operate and maintain the dam and that there is an Emergency Action Plan for any high and significant hazard dams, and

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**(2)** Certification from the State Dam Safety Official, signed by a Registered Professional Engineer licensed in the requesting State, that proposed projects involving the construction, enlargement, or rehabilitation of any dam (including appurtenant works) satisfies the criteria for our inventory and meets Federal requirements. The certification must attest to the following:

- (a)** The hazard and size classification of the dam are correct and its present condition and deficiencies have been accurately identified;
- (b)** The proposed project has been designed by a Professional Engineer, qualified in dam design and construction, to meet Federal standards for dam design, construction, and rehabilitation including, but not limited to, the Federal Guidelines for Dam Safety (FEMA 93, 2004), and any other technical requirements identified in the Federal Aid project agreement documents;
- (c)** A Registered Professional Engineer qualified in the design and construction of dams completed the State's technical review of the project design and specifications;
- (d)** There is a dedicated funding source that will provide for future operation, inspection, maintenance, and repairs of the dam;
- (e)** If the dam is a high and significant hazard dam, there is an Emergency Action Plan in effect for the dam that meets the requirements of Emergency Action Planning for Dam Owners (FEMA 64, 2004); and
- (f)** Federal and State permits will be obtained prior to construction.

**C.** The requirements in section 2.14B do not apply to noninventory Federal Aid dams.

**2.15 What are the technical standards for the Dam Safety Program?** The planning, design, construction, and rehabilitation of all inventory dams must follow the technical standards below and in 361 FW 1 and 3.

**A. Inflow Design Flood.** The Inflow Design Flood is the rate of inflow discharge into the reservoir over time that the dam must be able to safely pass through a combination of spillway and outlet works and attendant surcharge storage.

- (1)** Service inventory dams must meet the Inflow Design Flood standards in Exhibit 1.
- (2)** The Project Leader must obtain a waiver from the Inflow Design Flood standards in Exhibit 1:
  - (a)** For high or significant hazard dams from the Chief, Division of Engineering and the SDSO.
  - (b)** For low hazard inventory dams from the SDSO and the RDSO.
- (3)** Approval of Inflow Design Floods other than those in Exhibit 1 may be granted only after performing an incremental damage assessment or risk-based analysis to determine if a waiver is appropriate.
  - (a)** Studies and mapping must clearly demonstrate that consequences of dam failure at flood flows larger than the selected Inflow Design Flood will not increase projected loss of life and will have no significant incremental increase on property damage. All Inflow Design Floods must follow FEMA 97, Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams or a more conservative approach. Analysis must include existing structures and inhabitants and projected inhabitants and structures based on approved planning documents and over at least the next 20 years. The incremental

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increase in property damage versus the potential frequency of floods must be clearly identified in a management decision chart.

(b) The RDSO or the SDSO must provide the proposed Inflow Design Flood using an incremental damage assessment or risk-based analysis to the affected State dam safety office for review and discussion.

(c) The minimum Inflow Design Flood for high and significant hazard dams must at least meet the 100-year flood frequency.

**B. Freeboard Requirements.** Freeboard is the vertical distance from the water surface to the top of the dam. Freeboard should meet the requirements of ACER TM No. 2, Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams, BOR 1992 or the latest revision.

**C. Low-Level Outlets.** All inventory dams must have a low-level outlet that can evacuate the major portion of the reservoir storage volume by gravity flow.

(1) Only the SDSO may approve waivers to this requirement.

(2) Criteria for reservoir draining should recognize site-specific conditions, economic aspects, and project needs to provide an acceptable balance between costs and rates of draining and filling. Draining times established for a dam reflect downstream channel capacity, level of risk to the dam, and hazard potential to the downstream areas. A low-level outlet works, in conjunction with other release facilities, should meet the requirements in Criteria and Guidelines for Evacuating Storage Reservoirs and Sizing Low-level Outlet Works, ACER TM No. 3, the Department of the Interior, BOR 1990 or the latest revision.

(3) For small low-hazard inventory dams, the low-level outlet works, in conjunction with other release facilities, should be located and sized to draw down the reservoir within 1 to 4 months, at a minimum, to the lower of the following levels:

(a) The reservoir level commensurate with a storage capacity that is 10 percent of that at the normal reservoir level, or

(b) The reservoir level with less than 50 percent of the hydraulic height.

**D. Risk Analyses:** The Division of Engineering may use risk assessments to identify appropriate repair criteria. The assessments predict the annual probability of loss of life and failure probabilities of the structure over a projected 50-year period.

(1) The average annual loss of life probability must be less than or equal to 1 in 1,000.

(2) The annual failure probability of the structure must be less than or equal to 1 in 10,000.

Acting   
DIRECTOR

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