Session XVIII

EVALUATION OF FACILITY EMERGENCY PREPAREDNESS

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INTRODUCTION

The emergency preparedness of a facility reflects its relative ability to respond effectively to emergencies. Emergency preparedness is assessed in order to define the hazards that a dam represents and to reduce loss of life and property damage that may be caused by flooding due to dam failure or unusually high flow through the spillway system.

COMPONENTS OF FACILITY EMERGENCY PREPAREDNESS

The components of facility emergency preparedness may be grouped into the following categories:

- Site conditions and procedures
- Emergency preparedness equipment

Site Conditions And Procedures

Site conditions include:

- Downstream Hazard Classification. A downstream hazard classification is a rating (e.g, low, moderate/significant, or high hazard) that is a representation of the probable loss of life and property damage downstream from a dam, based on the results of breaching studies of the dam and an identification of the area downstream that would be inundated. Generally, worst-case scenarios (such as failure of the dam at night with little or no warning) are used in assigning hazard classifications.
- Access. Access to the site of the dam includes not only the capability of dam personnel to reach the site under adverse conditions to operate electrical and mechanical equipment, but also the transportation of construction equipment and material to the site, if the nature of the emergency makes averting or alleviating dam failure possible.
- Security. At a minimum, a dam's security system should effectively prevent vandals or saboteurs from gaining access to and operating or damaging dam electrical and mechanical operating equipment. Additional security should be considered against other damage or destruction to the facility by vandals or saboteurs.

Site procedures include:

- Standing Operating Procedures. The document containing instructions for normal operation, including the passage of floods often is referred to as the Standing Operating Procedures (SOP).

- Emergency Action Plan. The Emergency Action Plan (EAP) contains procedures to be followed if structural problems, equipment malfunctions, or a natural event such as a flood or earthquake causes the design limits of a dam to be approached or exceeded.

  For some dams, the SOP includes both normal operating procedures and the EAP. At other dams two separate documents are maintained. The dam owner or operator is responsible for preparing and maintaining the SOP and the EAP.

- Operating Logbook. An operating logbook should be maintained at a dam in which all operations and maintenance performed is recorded, as well as inspections, the occurrence of unusual incidents or observations, and site visitation.

- Operator Training. Recurring training for the dam operator and backup(s) is important to ensuring that they understand their responsibilities with regard to operating and maintaining the dam and responding to emergencies.

Emergency Preparedness Equipment

The adequacy of emergency preparedness equipment is fundamental to the successful execution of an EAP. An inspection of a dam must include an assessment of the various features or equipment that would be utilized during an emergency. The EAP prepared by the dam owner/operator must contain descriptions or assessments of such equipment, which includes:

- Communications Systems. The available communications systems must be adequate during adverse situations to serve the needs of persons or organizations responsible for emergency operations.

- Warning Systems. Dams may have electrical/mechanical devices to alert onsite or remote personnel of adverse conditions. However, dam attendance is the major means of warning for most sites.

- Auxiliary Power Systems. In the event of failure of the primary power system, auxiliary power, which could be manual operation, must be available to operate mechanical equipment and lighting and communications equipment, if necessary.

- Remote Operation. Remote operation is the ability to operate equipment, such as spillway gates, from a location other than the dam site.

- Reservoir Drawdown Capability. During an emergency at a dam, the time required to lower the reservoir to a safe level often becomes extremely important. Reservoir drawdown is generally accomplished with the low-level outlet works.

THE NEED FOR REGULAR INSPECTION AND EVALUATION

Site conditions at a dam, including the area downstream, and the condition of emergency preparedness equipment may change. Facility emergency preparedness may be affected by:

- Changes in access, security, or downstream development
- Deterioration or failure of electrical and mechanical equipment

Thorough and regular inspection and evaluation of these elements is the best way to identify problems or deficiencies with emergency preparedness, which if left uncorrected, could cause an emergency or reduce the effectiveness of response to an emergency.

IMPORTANCE OF EVALUATING DOWNSTREAM HAZARD CLASSIFICATION

A dams's hazard classification is an expression of the potential for death and destruction to downstream population and property if a dam were to fail. The dam's condition, or potential for failure, has no bearing on hazard classification. Greater emergency preparedness measures can be expected for dams with higher hazard classifications. Compared to dams with lower hazard classifications, higher hazard dams may:

- Be inspected more frequently, depending on owner or regulating agency policy.
- Receive a greater share of maintenance funds.
- Be given a higher priority for any necessary corrective actions.

PREPARING TO EVALUATE DOWNSTREAM HAZARD CLASSIFICATION

Hazard classification schemes vary from agency to agency, but usually consist of three or more categories, defined by the consequences of failure of a dam and uncontrolled release of the reservoir. The extent of anticipated loss of life and economic, lifeline and/or environmental losses determine the categories. Specific numbers of lives and the dollar value of economic, etc. losses may not be defined. Normally, economic losses do not include loss of the dam itself nor loss of the economic benefits of the dam.

The hazard potential classification system in the Federal Emergency Management Agency's publication FEMA 333, Hazard Potential Classification Systems for Dams is:

- High-hazard dams are those whose failure or mis-operation would probably cause loss

of life and high economic, environmental, and lifeline losses (although the latter is not necessary for this classification).

- Significant-hazard dams are those whose failure or mis-operation would not be expected to result in loss of life, but economic, environmental, and lifeline losses would be anticipated.

- Low-hazard dams are those whose failure or misoperation would not be expected to result in loss of life, and economic, environmental, and lifeline losses would be low and generally limited to the owner.

Inundation maps are usually developed during dam-break inundation studies. These maps show areas that would be inundated by the uncontrolled release of reservoir water, and also may show the areas inundated by the passage of the design flood and sometimes other floods as well.

If a dam has been given a hazard classification previously, the basis for this classification should be reviewed. If the dam has not been classified, a preliminary classification should be made, if possible, along with a recommendation that a formal evaluation be performed. Prior to an inspection in which a hazard classification will be made, aerial photographs and all available maps should be reviewed.

The amount of downstream channel data required to classify a high-hazard structure may be less than information required for moderate-hazard or low-hazard dams. This seeming contradiction results from the fact high hazard classifications may be obvious because towns and other development are clearly within the inundated area. A more sophisticated evaluation may be required, however, for smaller dam-break flood releases and rural dam sites.

EVALUATING DOWNSTREAM HAZARD CLASSIFICATION

If a classification has not been made, or if reevaluation of a dam's downstream hazard classification is deemed necessary after initial research, then an inspection of the downstream floodplain should be made during inspection of the dam.

The actual conditions at the site should be compared with the information presented on any maps or other materials reviewed during preparation to verify that the existing studies accurately depict field conditions. Additional development in the floodplain might result in a higher hazard classification. Therefore, the floodplain of low-hazard and moderate-hazard dam should be reinspected periodically.

The data review may identify some structures that would be peripherally affected by flooding. Such structures should be viewed during the inspection, if possible, to better determine their potential for damage from flooding. Prior to the inspection, the predicted flood depths at the location of these structures should be determined by dam-break analyses.
Methods used to initially classify downstream hazard potential for a dam include:

- Use of existing dam-break/inundation studies.

- Engineering judgment based on field reconnaissance.

- Performing a dam-break/inundation study.

The methods generally used are not complex, and they conservatively estimate the peak discharges at downstream locations. In most cases, such methods will identify the inundated area with enough accuracy to establish hazard. However, in some borderline cases, recommending a more sophisticated analysis to determine potentially inundated areas may be warranted.

Remember, if a hazard classification is incorrect, limited dam safety resources may be earmarked for lower hazard structures, while dams actually representing a higher hazard may not receive deserved resources or priority to correct any dam safety deficiencies. Furthermore, proper emergency action planning may not be done and lives may thus be endangered.

Hazard classifications based on anticipated loss of life and economic loss, as determined by locating and describing potentially inundated areas may vary. A degree of judgment is always involved in assigning a hazard classification, particularly in assessing potential loss of life under adverse conditions in temporary-use areas such as parks and campsites.

Hazard classifications should be based on the values of property and the number of persons estimated to in the potentially inundated area and exposed to risk, regardless of the potential for dam failure detection, warning, and evacuation of people in the floodplain under advantageous conditions. In other words, classification is based on a worst-case scenario.

REPORTING ON DOWNSTREAM HAZARD CLASSIFICATION

The following information on downstream hazard classification should be included in the report documenting the classification:

- The guidelines on which the classification is based.

- Changes to population and property that might affect the current hazard classification.

- Conclusions about the suitability of the hazard classification, and reasons why reclassification might be necessary.

- Recommendation for a formal classification or a reevaluation of the existing classification, if needed.

IMPORTANCE OF EVALUATING ACCESS

In an emergency, successful execution of an Emergency Action Plan (EAP) may depend upon:

- Personnel arriving at the site to operate equipment or evaluate conditions and issue warnings as appropriate.

- Transportation to the project site of construction materials and equipment needed for repairs and damage control.

Any access problems caused by weather or flood conditions should be anticipated, and measures to overcome those problems should be planned.

PREPARING TO EVALUATE ACCESS

If an initial inspection report exists for a dam, access should have been discussed in that report. The EAP for the dam may include a narrative description of access to the site from project headquarters or from the owner's office. The written description and available highway and topographic maps should be reviewed. If a description has not been prepared, one should be prepared for the inspection report.

EVALUATING ACCESS

Site personnel are the best source of information on access. The following issues should be discussed them:

- Potential hindrances to access that have been identified in previous inspection reports, or that were identified in pre-inspection research.

- Seasonal access conditions.

- Alternative access routes. (Such routes often are not discussed in operating documents, and may not have been used for access during the current inspection).

- Any problems with access that operating personnel are aware of, or have experienced.

During the onsite inspection, the inspector should also verify that there is a clear delineation of who is responsible for day-to-day operation of the dam, the locations of the residences and offices of these people, and distance and travel time for them to reach the site.

Occasions requiring access might include:

- Normal operation and inspection

- Inspection after or during an event that may affect the dam
- Operation for flood releases
- Operation for reservoir drawdowns or emergency repairs to the structure

A realistic estimate of time required for various essential personnel to reach the dam site should be established. Access during non-business hours and/or darkness should be considered.

Evaluation of ground access should begin with a review of normal access conditions. If dam access is marginal under normal conditions (for example, only on foot or with a four-wheel-drive vehicle), it is likely that access under adverse conditions is inadequate.

Evaluation of accessibility under adverse conditions should include a minimum consideration of normal winter access and access during potential flooding of rivers near the site. Total coverage of potential problems that may arise due to large-scale earthquakes and flooding remote from the site is not normally possible within the scope of an inspection.

The ability to transport construction equipment and materials to a site should be considered. In some circumstances, a developing dam failure can be prevented. Some dams have access problems at certain times of the year. For instance, some dams are accessible only by snowmobile in the winter. To allow access for construction equipment and materials, an access road might be kept open for vehicular traffic, or an agreement made with a local entity to open a road under emergency conditions. Such arrangements should be discussed in the Standing Operating Procedures (SOP).

Personnel access to the site in most cases should be evaluated on the basis of persons who are responsible for the day-to-day operation of the dam. In many cases, access to the dam from the owner or operator headquarters is unreliable, but access for a dam tender at or near the site is adequate. Access for construction equipment and materials should be reviewed.

The availability and suitability of access to the site by air should be considered. The location of the nearest Government or commercial helicopter service should be identified in the operating documents. Note if this information is not given, and state the need to include it.

Evaluation of the site for helicopter access is often limited to the availability of landing sites. Air access should not be considered a solution to all access problems. Only personnel and small equipment can be transported by air, and adverse weather conditions (which may be the reason why access to the site is needed) could preclude helicopter use. If any topographical considerations are impediments to air access (e.g, a narrow windy canyon), such problems should be noted in the inspection report.

REPORTING ON ACCESS

The report should include the following information about access to the site:

- A description of the site location, access routes (including alternate routes), and locations of airports in the vicinity

- Year-round and potential emergency access conditions

- Use and availability of special equipment (i.e., four-wheel-drive vehicles, snowmobiles, helicopters, etc.)

If as a result of an inspection, an inspector concludes that access to the site is less than adequate, the report should include the reasons for the conclusion, and discuss the need for additional access capability. Recommendations should be made to provide safe and reliable access to the site, as needed.

IMPORTANCE OF EVALUATING SECURITY

Historically, in the United States, protection from vandalism had been the primary reason for site security. However, recent events have clearly shown that sabotage is a distinct possibility. Vandals or saboteurs may damage or operate equipment at a project, or even threaten the safety of the dam directly, and thus jeopardize downstream residents and property. The security of a project against such potential acts must be assessed and appropriately addressed before such incidents occur. A security assessment evaluates the potential threats to the dam, identifies the potential consequences of a successful attack, and looks at the vulnerabilities of the dam to attack. It is in the best interests of security that a dam has a security plan that identifies the features of the dam that are critical to its purpose and the countermeasures that have been implemented to eliminate, reduce, or mitigate the security risk to the dam.

PREPARING TO EVALUATE SECURITY

The pre-inspection review should focus on the adequacy of the security plan for the dam, if there is one, or otherwise consider what the critical features of the dam are and what countermeasures should be in place to address the security risk.

EVALUATING SECURITY

The evaluation of security should include the appropriateness and condition of:

- Procedures, including the security plan, key control, protection of sensitive information, and advisory system response measures

- Equipment, including barriers, gates, locked doors and hatch covers, log booms, signs, and intrusion detection

- Personnel, including law enforcement, guards, and security awareness training

The evaluation of potential damage due to breaches in security should be limited to areas that might possibly affect the safety of the dam. Controls for a gated spillway or large-capacity outlet works are typical examples of elements that could directly affect safety. Damage resulting in extended inoperability of an outlet works should be considered a safety issue due to the loss of reservoir drawdown capability caused by the damage. Determination of the required level of security for these types of components is a matter of judgment. If it is concluded that security measures probably are inadequate, a recommendation should be made that increased security for the site be considered.

Security measures that may prevent costly damage but do not directly affect operability of the installation, or those that may reduce hazards to the public, usually are considered operation and maintenance responsibilities rather than matters crucial to the safety of the dam.

REPORTING ON SECURITY

Depending on the sensitivity of security issues and whether the inspection report is available to the public, discussion of security may not be included in the inspection report, but may be recorded elsewhere.

IMPORTANCE OF EVALUATING OPERATING PROCEDURES

The Standing Operating Procedures (SOP) or operating manual consist of complete documented operating instructions for dam personnel. A comprehensive SOP or operating manual ensures that:

- A dam and its components will be operated according to design intent. Misoperation could itself create an emergency or dam safety problem.

- Operating instructions are available for authorized persons unfamiliar with the facility who may have to operate equipment when the regular operator is absent.

EVALUATING OPERATING PROCEDURES

Regardless of how apparently simple a piece of equipment may be to operate, instructions should be prepared and included as part of the dam's SOP or operating manual. Review operating instructions for clarity, and determine whether instructions can be accessed quickly by site personnel. If at all possible, instructions should be kept at the site in a secure location.

Check for continuity among operating documents and note whether they match actual site conditions. Assess the operators understanding of instructions and adherence to them.
A commonly encountered problem is actual operation differing from the operating instructions

If an operator appears to lack proper knowledge of equipment operation, or (in cases where hand operation of gates may be required) lacks the physical ability that may be required for operation under adverse conditions, the situation should be noted in the inspection report. The inspection report should also discuss the level of emergency response training for operators and other personnel, and how often training is being provided.

The adequacy of operating instructions, including those for operation with auxiliary power, should be evaluated for normal and emergency conditions.

Consideration should be given to posting operating instructions and labeling equipment if there is a secure place to post instructions, such as a gate house that can be adequately secured.

The operating equipment at some dams is of such a basic nature that no posted operating instructions are required. At other facilities, posted operating instructions are deliberately avoided in case unauthorized persons were to gain access to the equipment. In those cases, considerable downstream damage might result from such unauthorized operation. However, trespassers still might operate equipment even without posted instructions, so the proper approach in those circumstances would be to improve security at the site.

Documentation of problems with posted operating instructions, or the lack of instructions, should be discussed in the inspection report. The report should also include the following items:

- An evaluation of available operating instructions against applicable guidelines and requirements.

- Inaccuracies or omissions discovered during your review of other emergency preparedness factors.
- Inaccurate instructions for operating equipment.

- Errors in the calibration of operating controls.

IMPORTANCE OF EVALUATING THE EMERGENCY ACTION PLAN

An EAP is a set of procedures for responding to an emergency. The EAP should be evaluated with the SOP or operating manual. The two procedures are interdependent, and may be combined in one document. Outdated, confusing, or incomplete procedures and instructions could result in an ineffective response to an emergency.

The purpose of emergency warning and notification procedures is to provide a clear set of instructions for:

- Taking action at the dam site in response to hypothetical emergencies such as floods, earthquakes, or equipment or structural failures such as piping,

- Notifying designated owner or agency personnel of the emergency and issuing warnings to public officials responsible for evacuation.

EVALUATING THE EMERGENCY ACTION PLAN

The EAP should contain a directory with names, titles, telephone numbers, and addresses of persons, authorities, and agencies to notify if an emergency develops at a dam. The inspection report should note how often the information is updated, and whether it is presently up-to-date. A check should be made for the following items on emergency warning and notification plans:

- A clear description of circumstances under which a warning is issued, and to whom it is issued.

- Names, organizations, telephone numbers (day/night), and alternate communications means for individuals responsible for operation of the dam, and the sequence of contacts.

- Names, titles, telephone numbers (day/night), and alternate communications means for representatives of local, State, and Federal agencies, and other officials, including:
  - Law enforcement officials
  - Operators of other dams or water retention facilities
  - Managers/operators of recreational facilities

- Materials and equipment for emergency dam repair:
  - Description, location, and intended use of materials
  - Description and location of equipment, and name(s) or title(s) of operator(s)
  - Procedure for contacting equipment operator(s)

The time for the floodwave caused by a dam failure to reach the nearest dwelling and downstream community and each subsequent endangered community should be estimated. Responsible authorities can base the sequence of warning and defensive actions on this estimate.

Warning time would be very limited for residents of property located immediately downstream of the dam within the potentially inundated area. Names, telephone numbers (day/night), and alternate means of communications with these residents should be recorded.

When a timely personal warning is not feasible for people downstream from the dam, sirens or other alarms may be installed to give a timely warning. This may be effective for people who live very close to the dam, or people who may be in areas that are difficult to reach, such as canyons, or who may lack telephones. The affected population generally needs to be educated in order to understand and respond effectively to the siren or alarm. (A warning system also can be used when the safety of the dam is not threatened. Sirens or alarms sometimes warn boaters and fishermen in downstream river channels before large spillway releases or unusual power releases.)

Some agencies maintain tables or charts of warning and notification procedures with associated operating instructions to be followed during different types of emergencies.

IMPORTANCE OF EVALUATING OPERATING LOGBOOK

Every facility should maintain a permanent record of the activities and at the facility so that their occurrence along with pertinent information can be referenced when needed. Facility operating logbooks can be subpoenaed by a court of law. Information pertaining to operations and maintenance, inspections, and the occurrence of unusual incidents or observations, and site visitation should be recorded in a facility logbook.

EVALUATING THE OPERATING LOGBOOK

Operating logbooks should be bound volumes. Entries should only be made in indelible ink and include the date of the activity or incident and be signed. Mistakes should be crossed out with a single line followed by the correct text. The logbook should be stored at the dam where practicable in a secure, moisture-free location. It should be verified that appropriate entries are being made in the operating logbook.

IMPORTANCE OF EVALUATING OPERATOR TRAINING

It is essential that dam operating personnel receive regular recurring training so that they remain knowledgeable and up to date with regard to their responsibilities concerning operations, maintenance, and responding to emergencies. The training should provide sufficient information for the dam operators to make knowledgeable, correct, and prompt decisions concerning protection to the downstream populace and property.

EVALUATING OPERATOR TRAINING

Both the principal operator(s) and designated backups should receive operator training in accordance with organizational policy, but at least every few years. New operators should be trained before assuming duties at a dam. The training should include both classroom and onsite training. Classroom training should cover:

- General dam safety overview, and site specific potential failure modes and their precursors
- Inspection responsibilities, including any specific concerns
- Operations and reservoir regulation
- Maintenance requirements and practices

- Operating logbook
- Safety
- Site security
- Emergency Action Plan and responsibilities
- Reading instrumentation, if required
- Public relations and recreation management, if required

Onsite training should include:

- Familiarization with the project and equipment
- Review of the facility operating procedures
- Operation of all equipment
- Safety

IMPORTANCE OF INSPECTING COMMUNICATIONS SYSTEMS

Communications systems form the link between a dam, the project or owner's office, and the authorities responsible for the safety of the affected population downstream of the dam. If a threatening situation develops, immediate communication from the site may allow time for flood preparation or evacuation. Failure of communications equipment could have disastrous consequences. Consequently, some agencies require backup communications for high- and moderate-hazard dams.

PREPARING TO INSPECT COMMUNICATIONS SYSTEMS

Telephone, two-way radio, and microwave are the principal communications systems used at facilities. Descriptions of communications equipment at a site are usually included in operating documents used by site personnel, and will be noted in inspection reports. Pre-inspection review of this information is good preparation for discussing communications performance with operating personnel and will enable comparison of the written descriptions to the actual equipment.

INSPECTING COMMUNICATIONS SYSTEMS

To inspect communications systems:

- Verify what communications systems exist at the dam. Note any differences between the written descriptions of the communications systems and the equipment observed at the site. Discuss changes and additions with project personnel.

- Review communications systems performance. Determine what locations and/or offices the communications system can reach reliably from the site, and the attendance at those locations and/or offices. Compare this information with the pre-inspection data review.

- Ask field personnel whether the communications systems have failed or been unreliable in the past and record the reasons for any problems. Ask also for opinions about potential weak links in the systems.

- Evaluate the need for backup communication.

- Evaluate auxiliary power requirements. Make sure that a communications system relying upon auxiliary power will receive adequate power.

If telephone is the primary communications system, a check should be made to see if the telephone lines come into the dam site along the downstream channel (often the case because the channel is the easiest route for installation). These lines could be knocked out during large spillway flows or by a dam failure flood, rendering communications impossible.

REPORTING ON COMMUNICATIONS SYSTEMS

The following information should be included in the inspection report about the communications systems:

- A description of communications facilities at the site.

- Conclusions concerning the suitability of the communications capability and the potential unreliability of individual communications modes.

- A discussion of available auxiliary power for communications and its reliability.

IMPORTANCE OF INSPECTING WARNING SYSTEMS

Some means must exist to detect a developing emergency and convey a warning to persons responsible for taking emergency actions. Electrical/mechanical warning systems may be included in project instrumentation, but most sites rely upon warnings transmitted by site personnel. Without warnings, evacuation or preventative actions may be delayed or made impossible.

PREPARING TO INSPECT WARNING SYSTEMS

Relatively few dams have electrical/mechanical devices to warn of potential adverse conditions at a site. In most cases, an evaluation will be made of the frequency of attendance at the dam and the effectiveness of the communications system for notifying appropriate personnel in an emergency. Attendance requirements given in the SOP and in the EAP should be reviewed prior to an inspection.

INSPECTING WARNING SYSTEMS

If a dam is equipped with a warning system, then the condition of the system should be evaluated. The capabilities and reliability of any existing electrical/ mechanical system should be discussed with site personnel. The inspector should determine the actual attendance pattern at the dam, and the accuracy of the written description of the warning system. Remote monitoring of the site cannot automatically be considered a warning system.

REPORTING ON WARNING SYSTEMS

The inspection report on a dam's warning system should include:

- A description of the warning system
- Specific considerations upon which the evaluation of the warning system (or the determination of the need for a warning system) is based

If the site presently does not have a warning system, the inspector should consider whether a system should be installed.

In deciding whether a mechanized warning system might be needed, the following should be considered:

- Hazards downstream from the dam
- Proximity of hazards to the structure
- Risk of the structure
- Attendance at the site under normal and various potential emergency situations
- Type of dam

- Configuration of appurtenances
- Access to the site
- Communications systems available at the site

IMPORTANCE OF INSPECTING AUXILIARY POWER SYSTEMS

If normal power is disabled during an emergency, auxiliary power may be needed to operate equipment such as gates and communications facilities. Ability to carry out the EAP could be severely hindered without auxiliary power.

PREPARING TO INSPECT AUXILIARY POWER SYSTEMS

Two common types of auxiliary power systems are:

- Engine generator set
- Engine-driven pump

Previous inspection reports and operating procedures usually contain descriptions of auxiliary power sources, equipment to be operated by auxiliary power, and records of breakdowns and repairs. This information should be reviewed before an inspection, so that it can be verified or checked at the site.

INSPECTING AUXILIARY POWER SYSTEMS

The inspection of an auxiliary power system should begin with the operation of the auxiliary power device. Equipment requiring operational capability under auxiliary power should be operated using the auxiliary system, including a representative gate or valve on each appurtenance so equipped. To the extent possible, operation should reflect the largest loads on the operated equipment to verify auxiliary power capability.

A test operation of the power-operated equipment should be performed to verify that the following criteria are met:

- The device moves through full travel operation.
- The maximum probable load is applied (to the degree conditions permit).
- Normal and adverse conditions are simulated.
- Available personnel (usually one person) can reasonably operate the device.

The following issues should be discussed with site personnel:

- Any changes in, or modifications of, auxiliary power equipment.
- Repair of any defects identified in the pre-inspection review.
- Historical performance of the equipment.
- Actual exercising of the equipment.
- Reliability of normal power.

The SOP or operating manual should include a schedule for exercising auxiliary power equipment, description of the fuel needed, periodic replacement of fuel to keep it fresh, and a description of the procedures for using the auxiliary power source.

The condition of the auxiliary power equipment should be examined to the extent possible considering potential performance problems under adverse conditions. If the auxiliary system requires fuel, an adequate supply of fresh fuel must be available. Diesel engine generators tend to have problems with fuel supply lines, particularly under adverse conditions.

Evaluation of auxiliary power systems should be performed in view of problems that might affect facility safety if auxiliary power were nonexistent or if it malfunctioned. Items that should be inspected include (but may not be limited to) spillway gate operation and outlet works gate operation. Also, consider the adequacy of auxiliary power for venting, lighting, and other auxiliary equipment only if a potential safety problem, such as backup power for communications equipment, is involved.

The evaluation of auxiliary power should be based on whether the equipment is suitably functional, rather than on whether it is state-of-the-art. Antiquated equipment may perform the intended functions, even though it may appear to be in an inefficient manner when compared to modern equipment. The determination of the reliability of older equipment under adverse conditions is often a subjective judgement. The suitability of auxiliary power equipment should be assessed in light of the type and reliability of normal power.

In some systems with powerplants, switching auxiliary power to appurtenant devices under unusual operating conditions may be a complicated process, This process should be documented and tested.

REPORTING ON AUXILIARY POWER SYSTEMS

The inspection report should include the following items with regard to auxiliary power systems at a dam:

- A description of the existing auxiliary power equipment.

- A brief discussion of equipment that is to be operated under auxiliary power, and additional equipment that should be considered for auxiliary power operation.

- An evaluation of the existing auxiliary power equipment, and the basis for that evaluation.

If it is concluded that the auxiliary power system probably is inadequate, it should be recommended that the system be fully checked and rehabilitated or replaced.

IMPORTANCE OF INSPECTING REMOTE OPERATIONAL SYSTEMS

The ability to control equipment such as spillway gates or outlet works gates from a location away from the dam permits timely response to emergencies requiring the operation of this equipment, particularly if someone is not at the dam all the time, and access to the site is relatively difficult. If remote operation is a part of the EAP, the system must operate reliably when needed.

PREPARING TO INSPECT REMOTE OPERATIONAL SYSTEMS

Previous inspection reports and project operating procedures should be reviewed for descriptions of the remote operation devices. (NOTE: Remote operation is the operation of an appurtenant device from a location away from the dam site, rather than from a separate location at the site.)

INSPECTING REMOTE OPERATIONAL SYSTEMS

The review of remote operational capability during the onsite inspection is often limited by operational situations. The capability of an existing system to direct remote operations should be verified by gathering pertinent information that describes the system. The operation logbook should be examined to review test performance and to ascertain whether problems have been experienced.

The following issues should be discussed with site personnel during an inspection:

- Testing of remote operational systems.

- Historical reliability of the system.

- Potential weaknesses of the system.

Evaluation of the reliability of remote operational equipment under adverse conditions is often difficult, since a review of complex electrical control systems is beyond the expertise of most inspectors and potential physical weaknesses in the system may be far from the site.

The determination of whether remote operational capability is needed will be based largely on previously discussed emergency preparedness considerations, and the configuration of appurtenances of the dam structure.

A dam with an uncontrolled spillway of adequate capacity for Inflow Design Flood (IDF) discharges would be less likely to require remote operation than an installation with a gated spillway or large outlet works that significantly contributes to flood routing.

An accessible site with a warning system or comprehensive required attendance would be less likely to require remote operation than a site of similar configuration with marginal attendance and accessibility.

REPORTING ON REMOTE OPERATING SYSTEMS

The inspection report on remote operations should include the following information:

- A description of the remote operating capability of the dam inspected.
- If a remote operating system is present, an evaluation of how well the system capabilities match the site requirements for remote operation.
- A discussion of the reliability of any existing remote operational equipment, to the extent possible.

If a remote operating system is not present at the site, the lack of or need for such a system should be discussed in the inspection report. If the improvement of other emergency preparedness considerations would eliminate the need for remote operation, such modifications should be discussed in the report.

IMPORTANCE OF EVALUATING RESERVOIR DRAWDOWN CAPABILITY

The ability to lower the reservoir rapidly during an emergency is vital to emergency preparedness. If design or equipment problems make reservoir drawdown unacceptably slow, the dam could fail and release a full or nearly-full reservoir. For some dam- threatening conditions, such as piping, lowering the reservoir quickly could prevent failure or somewhat mitigate the effects of failure.

The level of risk and the hazard potential at each site may define acceptable drawdown rates. Risk is defined as the probability that the dam may fail, while hazard describes the probable consequences of dam failure, i.e., loss of life and property damage. A dam may be at little risk of failure, and yet present a high hazard should failure occur. The following table lists some possible risk factors. Other risk factors may exist at particular dams.

RISK FACTORS FOR DAMS

Hydrologic factors:

- Floods exceeding those used for design
- Uncertainty of flood estimation
- Ratio of flood to storage volumes in the reservoir
- Reservoir sediment deposition potential

Geologic factors:

- General foundation conditions
- Seismicity of site
- Faulting at site
- Liquefaction potential of dam and foundation
- Rock condition (fractures, shear zones, relief jointing, solubility)
- Seepage potential

Structural factors:

- Dam type and design
- Unprecedented size
- Unusual complexity
- Age and condition

Construction and material factors:

- Construction material characteristics such as permeability, erodibility, and strength
- Quality of construction

Operating factors:

- Remoteness and accessibility of site
- Training and experience of operating personnel
- Reliability of commercial and auxiliary power
- Complexity of equipment and operating procedures

Agencies develop drawdown criteria to judge whether a given facility meets standards for rapid drawdown. These criteria differ from agency to agency.

PREPARING TO EVALUATE RESERVOIR DRAWDOWN CAPABILITY

Design documents should be reviewed for the results of studies on reservoir drawdown capability. Inadequate capability and recommendations for modifications, repairs, or the replacement of structures that affect the reservoir drawdown rates should be noted. If such studies were never done, it should be recommended that they be performed.

EVALUATING RESERVOIR DRAWDOWN CAPABILITY

To assess the adequacy of reservoir drawdown capability, the present condition of the dam appurtenances should be evaluated. If the outlet works or any other appurtenance considered in the evacuation study previously conducted for the dam is incapable of reliably discharging the flows assumed in the studies, this condition should be recognized in the evaluation of drawdown capability.

It is not unusual for reservoir drawdown capability to be theoretically adequate but judged inadequate due to the existing conditions of the discharge features.

Methods and criteria for evaluating the adequacy of drawdown capability vary from agency to agency. Some agencies have developed reservoir drawdown capability worksheets to provide standardized documentation of reservoir drawdown calculations.

Typical required data include:

- Beginning reservoir water surface elevation.
- Reservoir inflow.
- Downstream hazard classification assigned to the dam.
- Level of risk associated with the integrity of the dam.
- Appurtenances assumed to be used in evacuation.
- The percentage of maximum capacity considered reliable for each appurtenance.

REPORTING ON RESERVOIR DRAWDOWN CAPABILITY

The inspection report should document how and why drawdown criteria are met, even if the capability is not a problem. The report should conclude whether drawdown capability is adequate or inadequate.

CONCLUSION

The failure of a dam and the release of the reservoir without adequate warning to those affected can result in catastrophic losses of life and property. By planning in advance for quick and prudent action and by devising an effective, timely method for warning the downstream populace, the disastrous results of a dam failure may be mitigated.