United States Society on Dams

Dam Safety Monitoring Training
for Dam Operating Personnel

February 2020

Prepared by the USSD Committee on Monitoring of Dams and Their Foundations
U.S. Society on Dams

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The importance of monitoring programs for dam safety is widely accepted. There are many historical cases of dam failures where early warning signs of failure might have been detected if a well-designed, well-executed dam safety monitoring program had been in place. A monitoring program can provide information that is needed for a good understanding of the on-going performance of a dam. Monitoring programs, including instrumentation and visual inspection, provide dam owners with knowledge that a dam is performing as expected, and the ability to detect a change in performance. The knowledge and ability are critical because the dam owner is directly responsible for the consequences of a dam failure. Therefore, a well-designed, well-executed dam safety monitoring program should be a key part of every dam owner’s risk management program.

This paper is part of a series of White Papers by the United States Society on Dams (USSD) Monitoring of Dams and Their Foundations Committee (the Committee) to address important topics with respect to the development and successful implementation of dam safety monitoring programs, which are:

- Why Include Instrumentation in Dam Monitoring Programs? (November 2008)
- Routine Instrumented and Visual Monitoring of Dams Based on Potential Failure Modes Analysis (March 2013)
- Development of a Dam Safety Instrumentation Program (April 2013)
- O&M of an Instrumentation Program (currently in development)
- Instrumentation Data Collection, Management and Analysis (March 2013)
- Dam Safety Monitoring Training for Dam Operating Personnel (this White Paper)

While each of the above White Papers addresses its topic in a “stand-alone” manner, there are interrelationships between these papers. Readers of this paper may find it beneficial to refer to one or more of the other White Papers for a broader understanding and perspective with respect to dam safety monitoring programs.

This series of White Papers primarily addresses the programmatic aspects of dam safety monitoring rather than technological advances. These papers should provide dam owners, large and small, with basic information to evaluate or implement an adequate dam safety monitoring program. These programs become more and more critical as our nation’s dams (and other infrastructure) reach and extend beyond their design lives.

The “Lead Author” from the Committee for this White Paper was Jay N. Stateler (Bureau of Reclamation, Denver, CO, retired). The co-authors from the Committee were Manoshree Sundaram (Stantec, Chicago, IL), Amanda Sutter (U.S. Army Corps of Engineers, St. Louis, MO), Brett Cochran (Denver Water Board, Denver, CO), and Emeruwa Anyanwu (Federal Energy Regulatory Commission, New York, NY). During the development process for this White Paper, discussions were held over a number of years with Association of State Dam Safety Officials (ASDSO) personnel. In 2014-2015, a core group of ASDSO members participated in a large number of discussions that
provided very substantial input to this White Paper: Susan Sorrell (ASDSO Training Program Director, Lexington, KY), Tom Woosley (Georgia Department of Natural Resources, Atlanta, GA), Jack Byers (Byers Group LLC, Arvada, CO), John Moyle (New Jersey Department of Environmental Protection, Trenton, NJ), and Randy Bass (Schnabel Engineering, Alpharetta, GA). Additionally, Jack Byers performed significant surveying of state dam safety personnel to gather information used in the development of this White Paper.

In the end, this White Paper does not represent a joint ASDSO/USSD White Paper, but instead a White Paper prepared by the USSD Monitoring of Dams and Their Foundations Committee with substantial input from ASDSO. While the ASDSO contributors to this White Paper are in agreement with its basic tenets, there are portions that they do not fully endorse or agree with as being achievable in all states. These areas are noted in the body of the paper. Also, Attachment 18 at the end of this White Paper, titled “Implementation Considerations regarding the Concepts Presented in this Paper from the Association of State Dam Safety Officials, January 25, 2018,” represents ASDSO’s response to the content and recommendations included in this White Paper. In this attachment, ASDSO notes, in their own words, concerns regarding specific content included in this White Paper with respect to the achievability of its implementation in all states.

The “Lead Reviewer” for the Committee for this paper was Georgette Hlepas (U.S. Army Corps of Engineers, Chicago, IL). The USSD “Publication Review Committee (PRC)” for this paper was headed by USSD Board Member Stuart Harris (Tennessee Valley Authority, Chattanooga, TN), with the other members of the PRC being Alex Grenoble (HDR Engineering, Inc., Charlotte, NC), Bruce Rogers (U.S. Army Corps of Engineers, Brooklyn, NY), Wayne Edwards (Consultant, Novato, CA), and Jim Hummert (AECOM, St. Louis, MO). The work of all these individuals, as well as the other members of the USSD Monitoring of Dams and Their Foundations Committee that provided input regarding this paper, is acknowledged and appreciated.
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INTRODUCTION

If a new seepage area develops at a damsite, what would be the best scenario relative to detection of this situation:

- Detection the next time engineering personnel visit the dam?
- Detection at the time of the next scheduled formal or comprehensive inspection of the dam?
- Detection by dam operating personnel?

The last option would be the best, since detection would likely be much more timely. Investigation/evaluation of the situation could initiate weeks, months, or possibly even years earlier than would occur relative to the other two options. It is possible that the dam could fail in the time between when the new seepage area appeared, and the next time engineering or inspection personnel came to the damsite and noticed the seepage area. Therefore, routine dam safety monitoring performed by dam operating personnel (typically performed at least monthly) is very important with respect to timely detection of unusual dam performance. To be effective, appropriate training needs to be provided to dam operating personnel so that the routine dam safety monitoring work is performed to industry standards and expectations, and is successful relative to reducing the likelihood of dam failure. This is the subject of this White Paper. Significant issues associated with this discussion and addressed in this White Paper include:

- How to provide effective project-specific dam operator training for dams that have not undergone a Potential Failure Modes Analysis (PFMA). Without a PFMA, the dam’s potential failure modes (PFMs) have not, by definition, been defined in the manner that is the current standard for the dam safety profession. Since the PFMs represent a very important input for developing an appropriate routine dam safety monitoring program for a dam, a solid basis and underpinning for the dam’s routine dam safety monitoring program (including required monitoring frequencies) is not available. This presents a very significant challenge regarding providing effective training.

- While large dam-owning organizations often have substantial resources to draw upon relative to providing periodic onsite dam operator training, smaller entities, that may own just a few (or perhaps only one) dam, may have a much more difficult time providing the training, given their potentially more limited resources.

- For state-regulated dams, the state dam safety personnel typically oversee a large number of dams, and likely have a very limited opportunity to provide or even participate in onsite project-specific dam operator training.
For smaller, typically state-regulated dams, in some cases the dam owner has very little technical capability regarding their dam(s), and perhaps also has limited time and/or inclination to be very active with respect to operating and maintaining their dam(s).

The issues presented above are central to the discussions in this White Paper. Relative to the overall organization of this White Paper, the following topics will be discussed in the order indicated, and then concluding comments and discussion will be presented for consideration.

- The ideal situation regarding providing onsite, project-specific dam operator training (includes having a PFMA available)
- Discussion of onsite, project-specific dam operator training programs currently in use
- How to deal with the situation when a PFMA is not available
- How to address situations where limited resources are available
- How to deal with a dam owner that has limited interest/involvement with their dam(s)

At the end of this White Paper there are 18 attachments. To facilitate reading this paper and keeping track of the topics associated with the various attachments, a complete listing of them is provided below. Attachment Numbers 1 through 14 were developed in the course of developing this White Paper, or came from a paper presented at the 2013 USSD conference (Stateler. 2013). The source of the other attachments is indicated in the table.

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In this document, the term “monitoring” encompasses both monitoring using instrumentation as well as visual monitoring/visual surveillance. Monitoring efforts need to be appropriate relative to a dam’s hazard classification, which in turn means the training provided to dam operating personnel should be appropriate in light of the dam’s hazard classification.

**THE IDEAL SITUATION**

In the ideal situation, a PFMA has been performed for the dam, and the dam owner has sufficient resources and interest such that efforts can be made to provide pertinent training to dam operating personnel to the full degree that the dam owner deems to be appropriate. The frequency of performance of the routine monitoring for the dam is thoughtfully developed during the PFMA. Often routine monitoring is at least monthly, but it should be customized to the specific circumstances of the dam, and may vary based on reservoir level, time of year, etc. The training program for the dam operating personnel should address the following topics:

A. General background information about the dam, including its purpose, an overview of the site geology and the basics of the dam’s design, relevant information regarding construction of the dam, operational information, and information about the general performance of the dam since its construction.
B. The dam’s PFMs, including discussion about the level of dam safety risk that is believed to be presented by each of the PFMs.

C. The project’s Standing Operating Procedures (SOP) or Operations and Maintenance (O&M) Manual, including discussion of dam-safety-related O&M work, and the maintenance management system used to schedule, track, and document the performance of O&M work.

D. The dam’s Emergency Action Plan (EAP).

E. The dam safety monitoring program for the dam, including discussion of monitoring schedules, forms to be used, instrument reading procedures, procedures for transmitting instrumentation data and visual monitoring information, instrument and instrument readout equipment maintenance requirements and procedures, recognizing and responding appropriately regarding evidence of anomalous dam performance from visual inspection efforts at the dam, recognizing and checking on anomalous instrumentation readings at the time the readings are taken, responding appropriately relative to confirmed anomalous instrument readings, and considering the potential interrelationship between anomalous data/information received from more than one source (i.e. a new wet area and anomalous piezometer data).

F. Actions to take during and following a flood event, including discussion of the relevant information presented in the SOP/O&M Manual and the EAP, discussion of key issues and areas to monitor during the flood event, documentation (videos, photographs, etc.) to be carried out during the flood event, and post-flood inspection and documentation requirements.

G. Actions to take in the event of significant earthquake shaking, including discussion of the relevant information presented in the SOP/O&M Manual and the EAP, and discussion of key issues and areas to be checked promptly after the earthquake from a dam safety and operational perspective.

H. Proper operating procedures for gates, valves, and other mechanical equipment, including discussion of the relevant information presented in the SOP or O&M Manual.

I. Proper maintenance procedures for gates, valves, and other mechanical equipment, including discussion of the relevant information presented in the SOP or O&M Manual.

J. Safety considerations, regarding both the general public and the operating personnel at the dam
K. Dam-safety-related O&M work that needs to be performed at the dam that is particularly significant/noteworthy, such as vegetation control, burrowing animal control, etc.

Discussions regarding some of the above topics should occur as part of a tour/inspection of the dam’s facilities. Topics H, I, J, K, and portions of E fall in this category. Some of the other topics would best be discussed in an office setting, aided by a slide presentation. Topics A, B, and portions of E would fall in this category. For dam’s that have significant size and/or complexity, at least one day, and perhaps as much as two or three days would be required for the training. For small dams, with straightforward spillway and outlet works facilities, the training might last 6 to 8 hours, but in some cases, it may be possible to complete it in as little as 4 hours.

Discussions regarding Topics A through K could all take place during an on-site dam operator training activity. However, another approach would be to conduct the training in two phases, a classroom phase and an on-site phase, with the classroom phase involving discussions about general topics that involve dam operators from a number of different dams, and the on-site phase being site-specific to one dam, and involving just the dam operators associated with that dam. The classroom phase could discuss aspects of Topics B through K that are common to many/most dams, and could involve having subject matter experts make presentations on specialized topics (such as a mechanical engineer being brought in to talk about mechanical equipment, and a materials engineer engaged to talk about corrosion or concrete repair issues) which would be cost-effective since dam operators for many facilities would be gathered for the classroom training phase.

An important benefit of having a classroom phase of the training, that brings together dam operators from many different dams in an area, is the opportunity for the dam operators to informally meet with one another. This gives them the opportunity to discuss common problems/issues and ways to address them, and opens communication channels for future discussions of this type. The value of this side benefit can be very substantial, and should not be overlooked, particularly since consideration is often given to having webinars, where people can participate remotely, and where such informal, in-person discussions would therefore not occur.

The on-site phase of the training program is essential. Site-specific discussions regarding Topics A through K are central to conducting an effective, valuable, and interesting training program for dam operators. The engagement of dam operating personnel is much greater when site-specific discussions about “their dam” are occurring, as opposed to discussions about dams in general. Learning about the PFM(s) for their dam(s), their risks of occurrence, and how required monitoring activities relate to the PFM(s) is essential information that dam operators need to understand to effectively carry out their dam safety responsibilities.
TRAINING APPROACHES CURRENTLY USED BY VARIOUS ORGANIZATIONS

To obtain some perspective regarding the topic of dam operator training, it is useful to review how different dam safety organizations currently approach this issue. To that end, the authors of this White Paper sought out information about dam operator training activities and requirements regarding the following organizations:

- Bureau of Reclamation (BOR)
- Army Corps of Engineers (USACE)
- Tennessee Valley Authority (TVA)
- Federal Energy Regulatory Commission (FERC)
- New York Power Authority (NYPA)
- Metropolitan Water District of Southern California (MWD-SC)
- San Diego Water Authority
- Association of State Dam Safety Officials (ASDSO)
- State of California
- State of Colorado
- State of Indiana
- State of New York
- State of Washington
- Canadian Dam Association (CDA)
- Hydro Quebec
- Centre for Energy Advancement through Technological Innovation (CEATI)

The first four organizations listed above are in the U.S. Federal Government and are required to follow the “Federal Guidelines for Dam Safety” that were prepared by the Interagency Committee on Dam Safety in 1979 (ICODS, 1979). While this document has been around for many years (and is currently in the process of being updated), the document was prescient, far-reaching, and very well done, and still remains relevant today (nearly 40 years after first publication). The Federal Guidelines for Dam Safety include the following discussion regarding dam operator training in the “Internal” portion of the “Training” discussion (Section III.A.3.a.):

“Operation and maintenance personnel should be trained by personnel experienced in operation of similar projects, covering all features of facilities operation and inspection. Thorough training should be provided for the personnel who will take observations on and monitor any installed dam instrumentation. The training should be conducted by experienced observers and by the engineers responsible for analyzing the structure effects revealed by the instrumentation data.”

“Technically qualified operating personnel should be trained in problem detection and evaluation, and application of appropriate remedial (emergency and non-emergency) measures. This is essential for proper evaluation of developing situations at all levels of responsibility which, initially, must be based
on observations made by trained operating personnel at the project. The training should cover the problems that experience has shown are most likely to occur with the type of dam and facilities, and include the kinds of monitoring best suited to early detection of those problems. Such training will permit prompt action when time is a critical factor. A sufficient number of personnel should be trained to ensure adequate coverage of all tasks at all times. If a dam is operated by remote control, training must include procedures for dispatching trained personnel to the site at any reported indication of distress.”

The Bureau of Reclamation (BOR) conducts dam operator training in two phases. Dam operators are required to participate in the “classroom phase” training (which involves presentations to a gathering of dam operators associated with many facilities) every 4 years, and are required to receive site-specific training in the “on-site phase” every 8 years. New dam operators are to receive the classroom phase training within 1 year, and the on-site phase training within 90 days. The two phases of training cover Topics A through K. Details and specifics regarding the dam operator training requirements are presented in BOR’s Reclamation Manual, “Operating Practices and Procedures for High- and Significant-Hazard Dams” (BOR, 2015).

The U.S. Army Corps of Engineers (USACE) requires a minimum of 6 hours of on-site dam operator training be provided to new dam operators shortly after starting their new position, and at least 6 hours of refresher training be provided at least every 5 years. The training covers Topics A through K. Details and specifics regarding the dam operator training requirements are presented in USACE’s ER 1110-2-1156, “Safety of Dams – Policy and Procedures” (USACE, 2014).

The Tennessee Valley Authority (TVA) has a training program that spans 3 years for new dam operators (hydrotechnicians). Thereafter, a 3-hour dam safety awareness class, that is used as a refresher course, is required every 3 years. Contractors that perform mowing are also required to take the 3-hour dam safety awareness class.

The Federal Energy Regulatory Commission (FERC), in its capacity as a regulator of hydropower dams, includes the following discussion in Chapter 14 of its Engineering Guidelines for the Evaluation of Hydropower Projects (FERC, 2005, updated in 2017), Section 14.5.2., that relates to the topic of on-site dam operator training:

“1. Periodic routine inspections/observations – These inspections are typically performed by the licensee or a consultant retained by the licensee. People performing the routine inspections or observations should be provided with background information on the potential failure modes identified for the site along with a surveillance and monitoring plan for each potential failure mode. . . . “

“2. Licensee operation and maintenance inspection and training programs – Those persons performing the inspections or observations should be provided with background information on the potential failure modes identified for the site
along with the surveillance and monitoring plan for each potential failure mode. The licensee is responsible for ensuring that its personnel are properly trained and remain current in the knowledge of proper operation and maintenance of the project. . . . “

FERC periodically holds workshops regarding surveillance and monitoring. While these workshops are not specifically intended to provide training to dam operating personnel, dam operating personnel are welcome and encouraged to attend. These workshops actually better fit the category of “train the trainer” activities, in the sense that attendees likely pass on the “classroom-type” general information (i.e., not site-specific training information) gained at these workshops to dam operating personnel, in one way or another.

Since 2002, the FERC has required licensees to have an Owners Dam Safety Plan (ODSP). The ODSP includes a section on dam safety training. Information regarding ODSP’s can be found at the FERC website.

The New York Power Authority (NYPA) owns facilities that are regulated by FERC and has its own requirements for annual on-site training of all general maintenance, operations, and security staff at all NYPA projects regarding dam safety issues and EAP procedures. The training covers Topics A, B, and D through H. (Other training is used to cover O&M Topics C, and I through K.)

The Metropolitan Water District of Southern California (MWD-SC) accomplishes its on-site dam operator training using informal discussions with dam operating personnel about the PFMs for its dams, and what the signs/indications would likely be regarding PFM initiation/development. Dam operating personnel participate in formal dam inspections as well as EAP exercises. The organization is moving toward a formal dam safety refresher course that is performed using in-house resources and is provided every 2 years.

The San Diego Water Authority provided training to the original crew of dam operators for its Olivenhain Dam when it was first constructed. These individuals, in turn, pass on the information to new dam operating personnel as they come onboard. The O&M Manual for the dam is viewed to be a complete source of information for the dam operators.

The Association of State Dam Safety Officials (ASDSO) periodically presents dam owner workshops that represent classroom-type general training (rather than site-specific training) for owners and dam operators representing a number of different facilities. Three courses have historically been presented:

1. The Need-To-Know Basics of Owning a Dam - An introduction to dam ownership. This is a course emphasizing practical, straightforward information on topics of importance to anyone who owns or operates a dam.

   Session 1: Introduction to Workshop
Session 2: State Dam Safety Laws and Regulations
Session 3: Dam Failure Modes and Case Histories
Session 4: Operation, Maintenance, and Safety Inspection of Dams
Session 5: Emergency Action Plans
Session 6: Public Safety, Security and Dam Owner Liability
Session 7: Repair Projects - Hiring an Engineer Consultant, Costs, and Funding Options
Wrap-Up: Completing the Evaluation Form and Final Questions

2. Dam Engineering 101 - An introduction to how dams work for owners, operators or engineers not familiar with dam safety. This is intended to be an owner-friendly look at dam engineering to help owners/operators recognize problems and emergency situations, improve operations and perform or schedule preventive maintenance.

Session 1: Introduction to Dams and State Regulation
Session 2: Basic Dam Design
Session 3: Erosion Is Your Enemy
Session 4: How Does a Dam Hold Water and Why Does It Leak?
Session 5: Other Common Problems
Session 6: Dam Engineering in Practice: Case Studies

3. Operation & Maintenance - This seminar will assist dam owners to (a) understand the parts that make up a dam and how they work together; (b) recognize typical problem areas that require maintenance; (c) distinguish between maintenance and repair issues; and (d) learn operation and maintenance procedures.

Session 1: Course Introduction
Session 2: Basic Dam Terminology and Function
Session 3: Dam Types and Purpose
Session 4: Causes of Dam Failures and How They Relate to Maintenance
Session 5: Maintenance Problems and Solutions
Session 6: Operation
Session 7: Operation & Maintenance Manual & Wrap-Up

The above information came from the ASDSO website, where further information about these courses can be found. These classroom courses have been presented in over half of the U.S. states. Additionally, ASDSO presents a number of specialized training webinars and programs each year that fall in the category of technical, classroom-type, general training. It is noteworthy that ASDSO is developing an expanded Dam Owner Academy Webinar Program, as discussed in Attachment 18.

Information obtained from dam-regulating personnel in the states of California, Colorado, Indiana, New York, and Washington all indicated that there are basically no requirements imposed by these states on the dam owners they regulate for performing on-site dam operator training. They would like to get to this level, but struggle with
resources and with more basic issues, such as identifying who actually owns some of the dams in their jurisdictions.

Similar to ASDSO, the **Canadian Dam Association (CDA)** conducts technical workshops that are “classroom-type” general technical training events. These are typically held in conjunction with regional and local conferences. In 2007, they published Dam Safety Guidelines that were updated in 2013 (CDA, 2013) that included some discussion relating to dam operator training regarding the following topics: (1) general dam safety aspects, (2) instrumentation and monitoring, (3) potential failure modes, (4) proper protocol for reporting dam deficiencies, and (5) responding to emergencies.

**Hydro-Quebec** has a training program for new dam operators that spans 3 years. This formal training program is in the vein of “classroom-type” general training (as opposed to “site-specific” training). Presumably on-the-job training supplements this formal training to cover site-specific matters.

The **Centre for Energy Advancement through Technological Innovation (CEATI)** published a book titled “Dam Safety Performance Monitoring and Data Management - Best Practices” (CEATI, 2012) that includes discussion about dam operator training. CEATI conducts workshops and specialty conferences that fall into the category of “classroom-type” general technical training events.

In light of the above discussion, several conclusions can be drawn:

- Many sources for classroom-type technical training exist, both on specialized topics and regarding broader treatments of a range of dam and dam safety topics. ASDSO, FERC, CDA, and CEATI all offer such training, as noted above, as do the American Society of Civil Engineers (ASCE) and others. Additionally, BOR annually offers a one-week “Safety Evaluation of Existing Dams (SEED) Seminar” that covers a broad range of dam safety topics, and USACE offers numerous “PROSPECT” courses that relate to dams and dam safety. The area of site-specific, on-site training is the area where the greatest unfulfilled need currently exists, as opposed to the area of classroom-type, general technical training courses. Hence, this site-specific training topic will be the primary focus for the rest of this White Paper.

- Larger organizations, like BOR, USACE, TVA, MWD-SC, NYPA, Hydro-Quebec, etc. typically have dam operator training programs that address Topics A through K and have an on-site training component. For smaller organizations, the ability to provide effective dam operator training can be a significant challenge, in light of the limited available resources. As noted above, for the state-regulated dams in California, Colorado, Indiana, New York, and Washington, no requirements are imposed by these states on the dam owners they regulate for performing on-site dam operator training. The area of site-specific, on-site dam operator training for smaller dam-owning organizations that are state-regulated is
the area where great need currently appears to exist. Hence, this challenging topic will be another primary focus area addressed in this White Paper.

DAM OPERATOR TRAINING IF THERE IS NO PFMA

PFMs form a fundamental basis for effectively defining the dam safety monitoring program (Training Topic E) for a dam, including routine visual monitoring and routine instrumented monitoring. Unfortunately, many dams have never undergone a PFMA to define the dam’s PFMs. While many large and significant size dams are in this predicament, the vast majority of the dams in this situation are smaller, state-regulated dams whose owners own few dams (and often only one dam).

A paper presented at the 2013 USSD Annual Meeting and Conference titled “Dam Safety Training of Dam Operating Personnel” (Stateler, 2013 (listed under References at the end of this paper)) presented an approach for dealing with this situation, which is the basis for the process described below. Though it would be best to perform a PFMA for the dam in question, if this is not going to happen, using “presumptive potential failure modes,” as discussed below, is a way to provide some basis for defining the dam safety monitoring program for a dam, including routine visual monitoring and routine instrumented monitoring. This then allows the dam’s future routine dam safety monitoring program to be discussed during the dam operator training program.

Step 1 - Use presumptive PFMs in lieu of PFMs developed by a PFMA.
Attachment 1, at the end of this White Paper, provides presumptive PFMs for embankment dams, and Attachment 2 presents the same for concrete dams. While not ideal, the history of dam failures and the record of PFMA results inform the profession regarding the most prevalent and noteworthy PFMs. Lacking better information, assuming these PFMs exist for a particular dam provides a starting point for defining the dam safety monitoring program, and provides a basis for discussion of this topic during dam operator training.

Step 2 - Perform a risk analysis. Qualitative assessments for the level of concern associated with the presumptive PFMs for the dam can be done to guide efforts regarding Step 3 below. Alternatively, this step can be skipped if there is not much basis available for developing the qualitative assessments, but it would be preferable to at least try to perform this step, as best as possible, since substantial understanding and benefits can accrue from even fairly brief assessment efforts.

Step 3 - Define an appropriate dam safety monitoring program for the dam based on the presumptive PFMs. Dams that lack a PFMA often will have little to no instrumentation. At a minimum, all seepage and drain flows at the damsite should be routinely monitored (when routine visual inspections are performed), and seepage monitoring installations should be provided as necessary to accomplish this monitoring (e.g., weirs). For embankment dams, monitoring for possible sediment transport by seepage flows is extremely important. Therefore, having
stilling pools in front of weirs, in inspection wells along drain lines, etc. where sediments (if present) can settle out and be observed, is very important.

Other instruments present at the dam (e.g., piezometers, crackmeters, etc.) probably should also be read at the same time routine visual inspections and seepage monitoring are performed, except that surveyed monuments (for monitoring dam or structure settlements and/or deformations) probably need not be surveyed more than once or twice per year, at the most, for dams that have been in place for a number of years. Monitoring frequencies for the program should be defined for normal operating conditions and during flood loading conditions, and should include prompt post-seismic shaking monitoring requirements as well.

While effective instrumented monitoring is very important, effective routine visual monitoring is also very important, as noted previously. A PFMA provides a basis for developing an appropriate checklist to guide routine visual monitoring efforts at a dam. Lacking a PFMA, the presumptive failure modes can be used to do this.

Attachments 3 and 4 present sample visual inspection checklists for an embankment dam and a concrete dam, respectively, where a PFMA was available. Attachments 5 and 6 present sample visual inspection checklists for an embankment dam and a concrete dam, respectively, based on the presumptive PFMs indicated on Attachments 1 and 2, respectively. Obviously, editing of the information shown on Attachments 5 and 6 would occur as necessary so that they would be consistent with the facilities actually present at the damsite. However, these attachments provide a good starting point for having a reasonable visual inspection checklist for a dam that has not had a PFMA.

Considering the process described above, not only has a basis for discussing the routine dam safety monitoring program during the dam operator training been developed, but also a process for assessing the dam safety monitoring program for the dam is available. This effort could point to needed changes in the routine visual and instrumented dam safety monitoring program for the dam. Hopefully such changes can be promptly implemented.

**DAM OPERATOR TRAINING IF THERE IS LIMITED TIME AND/OR BUDGET**

The paper presented at the 2013 USSD Annual Meeting and Conference titled “Dam Safety Training of Dam Operating Personnel” (Stateler, 2013) offered an approach for dealing with the situation where dam operator training efforts are constrained by limited time and/or budget, and is the basis for the discussion below.
The ideal situation would be to provide training to the degree that many large organizations are able to. However, devoting a day or more to the activity, using a program like that used by BOR, USACE, or NYPA (as described above), is simply not realistic for many dam owners and for some state dam-regulating personnel. A more feasible, yet still very beneficial approach, for the situation where time and budget are limited and PFMs have not been developed could consist of the following:

- Concurrent with a dam inspection required by state regulations, performed either by state regulating personnel or by engineering consultants, the routine dam safety monitoring program could be defined (as discussed in the previous section), including developing a visual inspection checklist form (like those shown in Attachments 3 through 6) that would be used by dam operating personnel, would guide their routine visual inspection efforts, and could be referred to during the dam operator training discussions. This activity could also take place whenever engineering evaluation work or other dam-safety-related activities are occurring regarding the dam, including concurrent with EAP exercises.

- Concurrent with a dam inspection required by state regulations, performed either by state regulating personnel or by engineering consultants, a one-page form could be developed that concisely provides key information to dam operating personnel relating to routine dam safety monitoring work. Attachments 7 and 8 show example forms, for an embankment dam and a concrete dam, respectively, where PFMs are available. Attachments 9 and 10 show templates for developing such forms, for embankment and concrete dams, respectively, for situations where a PFMA is not available, and presumptive failure modes (described on Attachments 1 and 2) are employed. This activity could also take place whenever engineering evaluation work or other dam-safety-related activities are occurring regarding the dam, including concurrent with EAP exercises.

- Provide training to the dam operating personnel at any time state regulating personnel or engineering consultants are at the damsite coincident with the performance of a dam inspection, an exercise regarding the Emergency Action Plan, or other work regarding the dam. Full advantage of these situations should be taken. A relatively small amount of time, such as thirty minutes, would be set aside for a discussion revolving around the form noted in the previous bullet item. Another thirty minutes would be devoted to walking around the damsite and reviewing the use of the visual inspection checklist form. The people to be promptly contacted in the event that something unusual is noted during monitoring work would also be discussed (primary and alternate contacts). This modest investment of time with the dam operating personnel almost certainly will yield substantial dividends relative to the performance of future routine dam safety monitoring at the dam.

A response to the above discussion could be:
“There is no time available to do this! There is no time to make Ongoing Visual Inspection Checklist forms like shown in Attachments 3, 4, 5, and 6! There is no time to make Dam Operator Information – Dam Safety Monitoring forms like shown in Attachments 7, 8, 9, and 10!”

One level of response to the above (understandable) reaction would be to suggest that the plight of state regulatory personnel seemingly would be vastly improved if dam operating personnel were able to take a more active and effective role in performing routine dam safety monitoring of their dam(s). As discussed at the beginning of this White Paper, frequent dam safety inspections by dam operating personnel provide much more effective monitoring than visits by engineering inspection personnel that occur annually (or every other year). With an effective routine dam safety monitoring program in place, performed by dam operating personnel, the reliance on inspections by engineering inspection personnel would be reduced (coincident with an improved routine dam safety monitoring situation). An initial investment of time and effort with respect to the dam safety monitoring efforts performed by the dam operating personnel could reap substantial benefits to the cost-effectiveness of a state’s dam safety efforts.

Inspection frequencies by state personnel could be reviewed, with an eye toward focusing efforts where the needs are greatest. State regulations in many cases specify the frequency of state-required dam inspections, which could be a formidable obstacle to changing the frequency of the inspections, but one might hope that the regulations could be altered when a more effective, lower-cost approach was offered as a benefit of changing such regulations.

Another level of response to the above reaction would be to try to simplify things even more. Attachments 11 and 12 show generic visual inspection forms for embankment and concrete dams, respectively, that also include (1) an overt tie between PFMs for the dam and the visual inspection questions, and (2) a recommended approach to carrying out the routine visual inspections. Presumptive PFMs (from Attachments 1 and 2) could be used in developing these forms, and only relative minor form editing might be required to transform the form used at one dam to a form useable at another similar-type dam. These forms could provide the basis for discussions that could occur at the time of dam inspections required by state regulations. The discussions would serve to provide on-site training to dam operators about dam safety matters, as discussed above.

An alternative to using forms like those shown on Attachments 11 and 12 would be to just employ the inspection forms used by the people performing the state-required inspections, and add a cover sheet with information about PFMs and the recommended monitoring approach. Attachment 13 shows the inspection form utilized in the state of Georgia for state-required inspections of embankment dams, and Attachment 14 shows a sample cover sheet that could be used with it regarding embankment dams. Attachment 15 shows the inspection form utilized in the state of Georgia for state-required inspections of concrete dams. Comments associated with a comparison of the “Attachment 11 and 12 approach” versus the “Attachment 13, 14, and 15 approach” are provided below:
• Attachments 13 and 15 are standard forms. No customization of these forms is done, so no time and effort are expended customizing these forms.

• Since Attachments 13 and 15 are not customized, they involve multiple pages and have some questions/information fields that will not be pertinent to any particular dam. This means that these forms are not user-friendly for dam operators to use during routine visual inspections since they are not concise and continually require noting “not applicable” regarding some items listed on the form.

• Attachments 11 and 12 clearly show the tie between PFMs for the dam and the visual inspection questions.

• Attachments 11 and 12 are customized forms that require some initial effort to create them for each dam. However, once they are prepared, they are tailored to the dam and user-friendly for the dam operators using them to perform routine visual inspections of the dam (e.g., only one page long and only pertinent questions included on the form).

Other variations of forms, besides those included as attachments to this White Paper, exist or can be developed (1) for use by dam operators in performing routine (frequent) dam safety inspections, and (2) for use regarding on-site dam operator training. The attachments are simply intended to provide examples and options, which then can be modified to meet the needs and circumstances of situations that are actually encountered. The modified forms developed should be included in the dam’s O&M manual. For reference, the ASDSO website, in the area “Dam Owner Education – Dam Owner Website – Operation, Maintenance, and Inspection,” includes several sample/example inspection forms comparable to the Attachment 13 and 15 forms used in the State of Georgia. Three pages of one of these forms (which in its entirety has a total of 19 pages) are included as Attachment 16, for reference.

(Important Note: Attachment 18 includes implementation considerations regarding the concepts presented in this White Paper from ASDSO. Some significant cost and feasibility concerns are noted in this attachment regarding proposals put forth in this section.)

HOW TO DEAL WITH A DAM OWNER WHO SHOWS LITTLE INTEREST IN PARTICIPATING IN STATE-REQUIRED DAM INSPECTIONS

Providing on-site dam operator training at the time of state-required inspections, as discussed in the previous section, assumes that dam operating personnel will be present at the dam at the time of the inspection. Unfortunately, the experience with state-required inspections is that, for a significant percentage of the inspections, dam operating personnel are in fact not present at the dam at the time of the inspection. Therefore, the approaches discussed in the previous section would not work in these circumstances.
It would be very beneficial for dam owners and dam operators to be present during the state-required inspections so that discussions could occur that would benefit both the dam owners/operators and the dam inspectors. The on-site dam operator training that could take place coincident with the inspection would be beneficial to all participants and stakeholders. Additionally, the dam inspectors could learn specific information from the dam owners/operators that would be of benefit to the inspection being performed, such as information about past and recent performance of the dam, the performance of maintenance work at the dam, operational questions/matters, etc. In light of this, the key issue should be how to motivate and incentivize the dam owners/operators to participate in the inspections. Possibilities in this vein include:

- It could be made a requirement in state law, with consequent penalties/fines for non-attendance.
- A credit could be applied to the annual state permit/registration fee for the dam for attendance at the inspection, or a penalty could be levied for non-attendance.
- A reduction in the allowable operating level of the dam’s reservoir could be imposed by the state in the event of non-attendance.

The first and second bullet item may (probably would) require rule/regulation changes, depending on the state, so this may or may not be a truly feasible approach. The third bullet item seems rather harsh, and may not be practical, but the issue at hand relates to dam safety, and reservoir restrictions can be applied when dam safety concerns of other types exist. Certainly, the possibility of a reservoir restriction would promptly get the attention of most dam owners. (Important Note: Attachment 18 includes implementation considerations regarding the concepts presented in this White Paper from ASDSO. Some significant and strong reservations are noted in this attachment regarding consideration of using the methods noted in the bulleted items above.)

An incentive-based approach will not work if the actual owner of a dam is not known. However, not knowing who owns a dam is a very serious matter that goes beyond the scope of this White Paper, and needs to be appropriately addressed by the regulators.

At the federal level, FERC personnel have a somewhat similar regulatory role with respect to private dam owners as state regulatory personnel have. The FERC requires licensees to prepare and maintain a Dam Safety Surveillance and Monitoring Plan (DSSMP) and to submit an annual Dam Safety Surveillance and Monitoring Report (DSSMR). Also, the Owners Dam Safety Plan (ODSP) requires that the owner designate a Chief Dam Safety Engineer (CDSE) or Chief Dam Safety Coordinator (CDSC) who is responsible for all dam safety activities. For small owners with limited staff, the CDSE role is typically fulfilled by a dam safety consultant.

FERC personnel make every effort to ensure that a dam owner (or his/her representative) who is familiar with the performance history of the dam is present for the inspection. The dam owner is consulted regarding scheduling of the inspection, and receives a copy of the completed report. This coordination and cooperation between the regulator and the dam owner have been found to be mutually beneficial.
When discussing the topic of providing effective on-site dam operator training for smaller, state-regulated dams, sometimes the focus of the discussion becomes heavily weighted on the extra time, expense, and hassle associated with trying to provide such training. However, the status quo of insufficient or non-existent training for many existing dams, particularly many existing high hazard dams, is not desirable. Unfortunately, dam safety monitoring at many of these dams is minimal to non-existent, with the exception of the required state inspections. This does not constitute adequate or effective routine dam safety monitoring. The Federal Guidelines for Dam Safety (FEMA 93, April 2004) includes the following discussion about informal inspections (performed by on-site dam operating personnel) in Section III.D.2.b.(1):

“(1) Informal Inspections. The purpose of informal inspections is to have as far as practicable a continuous surveillance of the dam. Employees at the project are to make frequent observations of the dam and appurtenances and of operation and maintenance. They are to identify and report abnormal conditions in accordance with adequate instructions and guidance. A detailed checklist of items to be inspected may be provided. The instructions or checklists should be prepared specifically for the project by engineering and operating specialists. The personnel performing these inspections should be properly trained and made aware of the heavy reliance placed upon them, and the great importance and absolute necessity of their careful inspection and reporting. Any unusual conditions that seem critical or dangerous should be reported immediately to the agency’s inspection organization or to those assigned inspection responsibility.

Particular attention should be given to detecting evidence of (or changes in) leakage, erosion, sinkholes, boils, seepage, slope instability, undue settlement, displacement, tilting, cracking, deterioration, and improper functioning of drains and relief wells.

(a) Frequency of informal inspections. Informal inspections should be scheduled by experienced, trained engineers as needed according to the dam's size, importance, and potential for loss of life and damage to property. The schedule for inspection should be changed by the engineers as required to be responsive to observed changing conditions. Operating personnel should make an inspection immediately after any unusual event such as large floods, earthquakes, suspected sabotage, or vandalism.

(b) Qualifications of personnel for informal inspections. Informal inspections in most instances can be performed satisfactorily by dam tenders or operation and maintenance personnel not formally educated in the field of engineering or geology. Persons selected to make informal inspections, however, must have sufficient training and experience to allow them to recognize abnormal conditions, must have demonstrated their ability to perform operation and
maintenance functions, and must have an appreciation for the importance of their responsibilities. They must be provided adequate written instructions on performance of responsibilities and must be evaluated periodically to assure that they understand the requirements and are capable of performing them. In addition, procedures for monitoring structural performance, observing the structure, its foundation, abutments, and appurtenances, and reporting abnormal conditions must be clearly defined and understood by these personnel."

The Federal Guidelines for Dam Safety indicates that informal inspections should provide “continuous surveillance” of dams. Clearly, if the only inspections of a dam are the state-required inspections that are performed annually at best, this falls far short of continuous surveillance.

The FEMA/ASDSO Model State Dam Safety Program (FEMA and ASDSO, 2007) includes the following in Chapter 3, Section II.

“H. Owner Responsibilities

A state inspection program depends on dam owners and/or their consultants to provide complimentary and necessary inspections and surveillance. The dam owner and heirs, successors, or assigns is ultimately responsible for the safety of the dam. The owner is directly responsible for the ongoing operation, maintenance, surveillance, and periodic inspection. The owner shall do all of the following:

1. Provide for on-going surveillance of the dam. The level of surveillance will depend on the size, condition and hazard classification of the dam;

2. Train their personnel in the basics of visual inspection techniques. Any person employed by the owner who regularly visits or works at the dam should be trained to inspect part or all of the dam and to report any observed problems;

3. Measure or read appropriate instrumentation and record and evaluate the data at specified time frames;

4. Promptly notify the state dam safety program of any unusual observations. Unusual observations may be indications of distress;

5. Inspect the dam and its appurtenances:

   a. On a regular periodic schedule based on size, condition and consequence of failure, and;
b. During and after any unusual loading including, but not limited to, significant storm/runoff events or earthquakes, to determine if structural or operational problems exist;

6. Maintain records for the dam, including but not limited to construction plans and documents, engineering studies, inspection reports, monitoring records, photos, the emergency action plan, and the operation and maintenance manual;

7. Obtain the services of an engineer or have qualified in-house staff to inspect the dam as required by state regulations.”

The FEMA/ASDSO Model Dam Safety Program recognizes the importance of performing regular surveillance of a dam by the dam owner/operator, and providing training so that this surveillance is effectively performed. Appendix C of the FEMA/ASDSO Model Dam Safety Program includes example information and guidance from the state of Pennsylvania regarding required regular dam surveillance by the dam owners/operators in that state. This information is included as Attachment 17.

As indicated in Attachment 18, ASDSO, FEMA, and the National Dam Safety Review Board have identified the need for an updated Model State Dam Safety Program. It is viewed that new procedures and recommendations should be included to guide States on developing and funding more comprehensive training programs for dam owners, operators, and their independent engineers. It is also viewed that the new guidance should discuss options for incentivizing owners/operators to be present during annual dam safety inspections by professional engineers, for attending classroom or web-based courses, and for improving their operating plans to include detailed monitoring procedures.

As an example of state dam safety regulations regarding the regular surveillance of a dam by the dam owner/operator, the following is from Colorado’s Rules and Regulations for Dam Safety and Dam Construction (Colorado, 2007), Rule 15. Dam Owner's Responsibilities:

“15.2 Owner Observations - The owner is responsible for ensuring frequent observation of the dam, unless prohibited by weather or difficulty of access to the dam, especially at times when the reservoir is full, during heavy rains or flooding, and following an earthquake. When the reservoir water level is greater than half the full storage capacity, High and Significant Hazard dams shall be observed at least twice a month, and a Low Hazard dam shall be observed at least every three months. The observations shall be conducted in accordance with methods acceptable to the State Engineer.”

Twice per month monitoring of high and significant hazard dams by dam owner/operators when the reservoir is at least half full provides a means to detect
anomalous performance at a time when (1) it is first developing, and (2) actions can be taken to prevent dam failure, or at least limit the impacts of dam failure.

ASDSO has created a flyer on “Dam Ownership Responsibility and Liability” (ASDSO, no date) that includes the following discussion:

“In general, a dam owner is required to use “reasonable care” in the operation and maintenance of a dam and reservoir.”

“Each dam should have:
• A state dam safety permit (if applicable)
• An operation plan, documented regular maintenance plan and emergency action plan
• Documented periodic inspections
• Warning signs and controlled access”

“The concept of strict liability imposes liability on a dam owner for damages that occur regardless of the cause of failure. The alternative theory of negligence considers the degree of care employed by the owner in constructing, operating and maintaining a dam. Historically, courts have sought to compensate those injured by a dam failure.”

Since the flyer is directed at dam owners, the statement that each dam should have documented periodic inspections can be interpreted to refer to inspections performed by the dam owner/operator, and not the inspections performed by state personnel or consultants every year or every few years per state regulations. The discussions regarding liability in the ASDSO flyer are also important. The “reasonable care” standard includes the performance of documented periodic inspections by the dam owner/operator. A failure to perform such inspections could expose the dam owner/operator, from a legal responsibility standpoint, should a dam failure occur, particularly under normal operating conditions.

Inspections performed by state personnel or consultants every year or every few years per state regulations do not represent “continuous surveillance of the dam” as discussed in the Federal Guidelines for Dam Safety (ICODS, 1979), nor do they represent “on-going surveillance of the dam,” as described in the FEMA/ASDSO Model State Dam Safety Program (FEMA and ASDSO, 2007). As such, reliance on these inspections, in the absence of frequent visual monitoring performed by the dam owner/operator, falls short of the standard of care expected for dams in the United States. Dam owners/operators and state regulators should have no illusions about this, and state regulators should ensure that dam owners/operators have no illusions about this.

The regular presence of the general public in the vicinity of a dam can be very beneficial (in fact crucial in some instances) relative to the possibility of noting and reporting in a timely fashion, unusual observations that may relate to initiation or progression of a dam failure mode. Such alerts provided by the public could allow emergency response actions
to be taken that could prevent a situation from developing into a dam failure. The lack of such a regular presence of the general public in the vicinity of a dam increases the dam safety risks, since this supplemental surveillance is not available. Considering this factor alone, it would be prudent for dam owners/operators and state regulatory personnel to have increased vigilance and increased efforts regarding dams that are not in an area where a regular presence by the general public exists.

In a similar vein, vigilance and efforts should increase proportionally based on the dam safety risks, considering both the condition of the dam and the population and infrastructure downstream of the dam. Note that Attachment 16 (page 1 of 3) has an area for recording information about the population and infrastructure downstream of the dam. None of the forms included as Attachments to this White Paper have a place for recording information relative to supplemental surveillance that might be provided by the general public.

There often is the tendency to initially make the changes and improvements that can be most easily and readily done. However, while performing effective on-site dam operator training for the responsible, conscientious dam owners/operators may represent the most straightforward path, it may result in only modest dam safety risk reduction benefits, since the responsible, conscientious dam owners/operators probably already are performing some sort of regular surveillance of their dam(s), along with satisfactory O&M work. The most substantial risk reduction benefits almost certainly would come from work with dam owners/operators who may be doing nothing regarding regular surveillance of their dams. Improving these situations, which likely would require much more work, would likely produce the highest benefit/cost ratio regarding time and effort expended.

Previously, there was discussion about providing incentives for dam owner/operators to participate in on-site dam operator training. In a similar vein, incentives could be considered relative to dam owner/operators that regularly and effectively perform routine dam safety surveillance for their dam(s). (Important Note: Attachment 18 includes implementation considerations regarding the concepts presented in this White Paper from ASDSO. Concerns and drawbacks associated with using incentives are noted in this attachment.)

A “Pocket Safety Guide for Dams and Impoundments” (FEMA 2016) has been developed that is intended to provide concise and convenient guidance to dam operating personnel about evaluating and deciding what to do regarding anomalous conditions that might be seen at damsites. Making the 2016 pocket guide available to dam operators/owners, and referring to it and discussing it during on-site dam operator training, could be very beneficial.
Whenever the topic of discussing PFM issues with dam operating personnel comes up in conversations, panel discussions, etc., invariably the experiences that are shared relate to the great benefits associated with such discussions. Often dam operators have never heard the “why” part of what they are asked to do, only the “what” part. Discussions about design, construction, and performance issues about a dam they may have had a long association with, and the PFMs that stem from these issues, commonly are met with great interest. And this interest will benefit their future work activities with respect to the dam, particularly in the area of promptly reporting anomalous behavior, unusual observations, etc.

Conversations with dam operating personnel are not a one-way street. Important information about a dam and its performance is known by dam operating personnel, and professionals doing work regarding a dam need to tap into this information source. The PFMA process used by FERC, USACE, and others calls for discussions with dam operating personnel in preparation for a PFMA, and inclusion of the dam operating personnel in the PFMA meeting. Many PFMs have been developed, or understood to a much greater degree, due to the involvement of dam operating personnel in PFMA efforts. As previously noted, the ability for dam inspectors to have discussions with dam operating personnel at the time of required inspections would increase the quality and benefits derived from these inspections.

After completing on-site dam operator training for a dam, it is not uncommon for a temporary surge in calls and inquiries from dam operating personnel about conditions observed at the dam during routine visual surveillance. A significant percentage of the calls and inquiries often relate to extraneous/low-significance matters. Non-critical items get reported. This is natural as new processes and efforts are being used, and can be considered part of the implementation phase regarding the new processes. In time, dam operating personnel will gain increased understanding of what the new process is intended to accomplish. During the initial surge of calls and inquiries, the calls and inquiries should be treated professionally and with respect, lest important communication channels with dam operators get shut down. With time, the frequency of the calls and inquiries typically subside as the new processes, and what is and is not truly important, are better understood by the dam operators.

In some situations, there is reliance upon existing dam operators to train new dam operators. In other cases, there is a heavy reliance on the review of written information in O&M manuals, SOPs, EAPs, etc. to provide training of new dam operators. While both of these sources of information are very valuable, they are not a substitute for providing a well-designed and effective training activity for the dam operators, as discussed in this White Paper. The investment of time and energy to provide such training should provide vastly greater benefits, both in terms of coverage of important topics and in terms of providing important, in-person, interactive discussions. An existing dam operator may be able to effectively talk about the “what,” but perhaps not the “why” regarding O&M activities, and may not be able to discuss dam safety topics to the full extent that they...
should be discussed. Reading through written information available for a dam is beneficial, but may be a bit boring for the dam operator and does not allow for question-and-answer discussion (which again may be very important with respect to “why” questions).

**FINAL THOUGHTS — SUMMARY**

Frequent, effective routine surveillance of dams by dam operating personnel is extremely important relative to the potential for timely detection of signs of anomalous performance that could be related to initiation or progression of a failure mode for the dam. The performance of such surveillance is a “standard of care” expected for dams in the United States at this time. Effective performance of such surveillance requires training, including on-site, site-specific training of dam operating personnel. There are a number of ways such training can be satisfactorily provided. The challenges for effectively providing such training are typically greatest for smaller, state-regulated dams, where the time and resources required to provide such training may be limited. To address this challenge, this White Paper has presented information and some streamlined approaches that could be used, or alternatively could inspire the development of other approaches that may be feasible regarding this situation:

- The “ideal situation” regarding providing onsite dam operator training (page 3)
- Discussion of onsite dam operator training programs currently in use by various organizations (page 5)
- How to conduct onsite dam operator training when a PFMA is not available (page 11)
- How to conduct onsite dam operator training when limited resources are available (page 12)
- How to conduct onsite dam operator training when dealing with a dam owner that has limited interest/involvement with their dam(s) (page 15)

What might be possible regarding the challenging situation that exists for the smaller, state-regulated dams? Imagine all dam owners/operators performing effective routine surveillance of their dams because (1) their potential liability as dam owners/operators was made clear to them, and (2) they were incentivized to do so. Training would be provided in support of this surveillance work, either by state personnel or consultants. Because the dam owners are now fully involved with their dams, and actively, routinely, and effectively looking after them, the frequency of state-required inspections could be re-visited (to help deal with the time and budget issues associated with supporting the training efforts for the dam owners and operators). Most importantly, a greatly improved dam safety monitoring situation would be in place for the dam(s), more in line with the
notion of “continuous surveillance” indicated in the “Federal Guidelines for Dam Safety” (FEMA, 2004). A “win-win” situation would be achieved for all involved parties. Attachment 18 includes the responses from ASDSO (dated January 25, 2018) regarding the ideas presented herein, noting “real-world” problems and implementation challenges associated with the ideas. Collaboration with ASDSO on this White Paper has been appreciated and has been very beneficial. It is hoped that the information and ideas presented in this White Paper can assist in efforts to seek and work toward improvements in dam operator training and dam safety monitoring for all dams, both those regulated by state agencies and those regulated in other ways.

REFERENCES

ASDSO (no date), Association of State Dam Safety Officials, Flyer on Dam Ownership Responsibility and Liability.


ATTACHMENT 1 - Presumptive Potential Failure Modes (PFMs) and Associated Key Monitoring Questions/Issues – Embankment Dam

Normal Operations
A. Seepage-Related Failure
   1. General Discussion
      Seepage flow can erode embankment, abutment, or foundation materials, which could result in a dam breach. The seepage flow path could be through the dam embankment (only), through the abutments/foundation (only), or involve both the embankment and abutments/foundation. Seepage paths along structures through the dam (e.g. outlet works and spillways) are of particular concern due to the possibility of flow concentrating at the structure interface where the material may be less dense due to compaction complications during construction. Also, joint openings, cracks, etc. in the structure may allow seepage flow into the structure or pressurized flow out of the structure.
   2. Key Monitoring Questions  (Re: monitoring dam, abutments, and downstream areas)
      • Any evidence of sediment transport by any seepage or drain flow (sediment deposits along flow paths, cloudy seepage, etc.)?
      • Any change from historic flow rate performance for any seepage or drain flow?
      • Any visual indications of changes from historic performance at wet areas or seepage areas?
      • Any sinkholes, depressions, or areas of anomalous settlement?
      • Any transverse cracks at the dam crest, or gaps at embankment/structure interfaces, that could allow concentrated seepage flow?
      • Any evidence of a whirlpool in the reservoir?
      • Any changes from historic water pressure performance seen in piezometer data?
B. Failure due to Downstream Slope Instability
   • Any longitudinal cracks at the dam crest, or at the upstream or downstream slopes?
   • Any bulging at the downstream toe of the dam?

Flood Event or Time of Abnormally High Reservoir Levels
A. Initiation/Development of a “Normal Operations” Failure Mode (see the information above)
   Note: Water levels above the historic high puts water against untested embankment and abutment areas, so essentially “continuous” monitoring would be appropriate
B. Overtopping of the Dam Crest, Leading to Erosion and Eventual Dam Breach
   • Any low areas that could be sandbagged, etc. to prevent overtopping?
   • All appropriate Emergency Action Plan actions carried out?
C. Spillway Failure
   • Any evidence of erosion occurring that could undermine the spillway’s foundation?
   • Any indications of spillway performance problems (e.g. unusual flow patterns)?
   • Any evidence of lateral erosion occurring (erosion of spillway sides or walls)?

Earthquake Event
A. Instability of the Dam → Slope Failure → Overtopping Failure of the Deformed Dam
   • All appropriate Emergency Action Plan actions carried out?
B. Damage to the Dam → Cracking of the Dam Embankment → Seepage Failure
   • Any changes in seepage performance – pre-earthquake versus post-earthquake?
   • Any significant post-earthquake cracking or deformations of the dam?
C. Damage to Gates or Gate Supports → Unintended, Uncontrolled Reservoir Releases
   • Any unintended, uncontrolled discharges occurring?
ATTACHMENT 2 - Presumptive Potential Failure Modes (PFMs) and Associated Key Monitoring Questions/Issues – Concrete Dam

Normal Operations
A. Foundation-Related Failure
   1. General Discussion
      Historically, most failures of concrete dams have resulted from a foundation support problem, such as sliding along a low-strength plane in the foundation or movement of a block of rock in the abutment that was receiving loads from the dam. The loss of foundation support leads to over stressing of concrete, and a sudden, “brittle” failure of the dam. Increased water pressure along slide/movement planes can trigger movements of previously marginally stable situations.
   2. Key Monitoring Questions
      • Any new concrete cracks, or changes at existing cracks, with particular focus on concrete cracks that appear to be structural in nature (i.e. long, diagonal cracks)?
      • Any new offsets or openings at contraction joints, or other joints, in the dam?
      • Any changes in drain flows, either increased or decreased flows?
      • Any changes in foundation or abutment water pressure data?
B. Gate Failure or Gate Support Failure → Unintended, Uncontrolled Reservoir Releases
   • Any unintended, uncontrolled discharges occurring?

Flood Event or Time of Abnormally High Reservoir Levels
A. Initiation/Development of a “Normal Operations” Failure Mode (see the information above)
B. Overtopping of the Dam Crest → Leading to Erosion of Abutment/Foundation Areas → Loss of Needed Abutment/Foundation Support for Dam → Sudden Sliding or Overturning Dam Failure
   • Any evidence of erosion occurring that could undermine the dam’s foundation?
   • All appropriate Emergency Action Plan actions carried out?
C. Spillway Failure
   • Any evidence of erosion occurring that could undermine the spillway’s foundation?
   • Any indications of spillway performance problems (e.g. unusual flow patterns)?
   • Any evidence of lateral erosion occurring (erosion of spillway sides or walls)?

Earthquake Event
A. Initiation/Development of a “Normal Operations” Failure Mode (see the information above)
B. Cracking/Damage to the Dam → Loss of a Block/Portion of the Dam → Uncontrolled Reservoir Releases
   • Same questions/issues as for Foundation-Related Failure under Normal Operations
C. Sliding Along a Lift Line → Loss of a Block/Portion of the Dam → Uncontrolled Reservoir Releases
   • Any evident earthquake-caused dam deformations at the exposed surfaces of the dam or at joint locations?
ATTACHMENT 3 - Ongoing Visual Inspection Checklist – Sample Embankment Dam (PFMA available for development of this form)

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Ongoing Visual Inspection Checklist
Sample Embankment Dam

Date: February 30, 2012

Schedule: Perform monthly, except daily inspections are required in the event that the reservoir exceeds elevation 4068.6 (the maximum reservoir elevation to date) and twice daily inspections are required in the event that the reservoir exceeds elevation 4070.5. (24-hour monitoring of the dam should be instituted in the event the reservoir elevation exceeds 4079 feet.) Perform a detailed post-flood inspection following any flood event where the reservoir elevation exceeds 4068 feet. Additionally, perform an immediate inspection following a significant earthquake in the vicinity of the dam (estimated ground acceleration at the dam exceeding 0.05g).

Inspector: ___________________________ Date: ___________________________
Reservoir Elev.: ____________________ feet Time: ___________________________
Weather: ___________________________ Temperature: __________ °F

A “YES” response should be given to question(s) below where observed conditions are different than previously observed conditions. Re-reporting conditions that have previously been reported and currently are unchanged should not be done (“NO” answer would be appropriate). For any question answered “YES”, please provide additional information describing the situation as completely as possible under item 7, "Additional Information.” Also, take photographs and include them with this report, as appropriate.

1. Upstream Slope of the Dam:
   a. Any evidence of significant erosion due to wave action? □ No □ Yes
   b. Any sinkholes, depressions, unusual settlement areas, or sloughs? □ No □ Yes
   c. Any cracks, either transverse or longitudinal? □ No □ Yes
   d. Any evidence of whirlpools in the reservoir? □ No □ Yes

2. Dam Crest:
   a. Any cracks, either transverse or longitudinal? □ No □ Yes
   b. Any sinkholes, depressions, or areas of unusual settlements or deformations? □ No □ Yes
   c. Any evidence of a gap at the embankment/spillway contact? □ No □ Yes

3. Downstream Slope of Dam:
   Note: Inspect the contact between the embankment and the spillway wall for the full height of the dam.
   a. Any evidence of a gap at the embankment/spillway contact? □ No □ Yes
   b. Any new seepage areas or wet areas? □ No □ Yes
   c. Any evidence of materials being transported by seepage flows (such as discolored seepage water or sediment deposits)? □ No □ Yes
   d. Any sinkholes, depressions, sloughs, new bulges, or areas of unusual settlement or deformation? □ No □ Yes

   (Note: A bulge, apparently related to a rock outcrop, already exists near the downstream spillway wall.)

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ATTACHMENT 3 – Page 2 of 2

4. **Downstream Toe Area, and Areas Downstream of the Dam:**
   
   **NOTE:** Extend the inspection to: (1) areas downstream of the toe of the dam along the river channel to a point 400 feet downstream of the spillway and outlet works stilling basin, (2) areas within 50 feet of the right abutment groin of the dam all the way up to the dam crest, and (3) the area between the left abutment and the left spillway wall all the way up to the dam crest.
   
   a. Any new seepage areas or wet areas? □ No □ Yes
   b. Any evidence of materials being transported by seepage flows at new or existing seepage areas (such as discolored seepage water or sediment deposits)? □ No □ Yes
   c. Any change in the conditions at existing seepage area along the right side of the downstream river channel, approximately 200 feet downstream of the spillway and outlet works stilling basins? □ No □ Yes
   d. Any changes in conditions at other existing seepage areas or wet areas? □ No □ Yes
   e. Any sinkholes, depressions, sloughs, or areas of unusual settlement? □ No □ Yes

5. **Outlet Works:**
   
   a. Any new or enlarged cracks, or spalls in concrete? □ No □ Yes
   b. Any evidence of unusual deformations or displacements (including evidence of offsets at the scribe marks across joints at the top of the left stilling basin wall)? □ No □ Yes
   c. Any changes in seepage or evidence of sediment transport at cracks, weepholes, or the weir? □ No □ Yes
   d. Any unusual flow patterns or conditions during releases? □ No □ Yes

6. **Spillway:**
   
   a. Any new or enlarged cracks, or spalls in concrete? □ No □ Yes
   b. Any evidence of unusual deformations or displacements (including evidence of offsets at the scribe marks across joints at the top of the right stilling basin wall)? □ No □ Yes
   c. Any displacement at the scribe mark across a joint in the wall between the outlet works stilling basin and the spillway stilling basin? (Note: The joint was laterally offset approximately 3/4-inch before the scribe mark was established in 1988.) □ No □ Yes
   d. Any material in the spillway or spillway inlet channel due to rockfall or sloughing from the left abutment that would significantly obstruct flow to the spillway? □ No □ Yes
   e. Any unusual flow patterns or conditions during discharges? □ No □ Yes

7. **Additional Information:**
   
   Provide additional information concerning any of the above questions that were answered "YES:"

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**NOTE:** All descriptions should include specific location information and all other seemingly relevant information. Seepage area descriptions should include: estimated seepage amount and water clarity description (clear/cloudy/muddy, etc.). Crack descriptions should include orientation and dimensions. Descriptions of changes at joints should include the estimated amount of movement, and movement direction. Deteriorated or spalled concrete descriptions should include degree of deterioration and approximate dimensions of the affected area.
Ongoing Visual Inspection Checklist
Sample Concrete Dam

Schedule: Perform in March, June, September, and December at the same time the seepage and drain flow monitoring is performed. Additionally, perform immediately following a significant earthquake in the vicinity of the dam (estimated ground acceleration at the dam exceeding 0.05g). Also, in the event that the reservoir elevation exceeds 6044.0 feet, perform inspections at least weekly, with inspections occurring within 24 hours of the time that reservoir elevations 6044.0 and 6046.0 are first exceeded. Should the reservoir ever exceed the dam crest elevation of 6047.0 feet, provide photographic documentation of the situation to the extent possible, given the circumstances. During the September inspections, the diversion tunnel should be inspected, the abutment areas within 1000 feet of the dam should be carefully scanned (with binoculars) from the opposite abutment, and the right abutment area within 1000 feet of the dam should be walked and inspected to the extent that can feasibly be done. These September inspections should include photographic documentation and should focus on detecting significantly changed seepage conditions (as compared to previous inspections). Vegetation may provide important clues regarding changes in abutment seepage.

Inspector: ________________________________ Date: ____________________________
Reservoir Elev.: __________________ feet
Weather: ________________________________ Temperature: ____________ °F

Time: ____________________________

A “YES” response should be given to question(s) below where observed conditions are different than previously observed conditions. Re-reporting conditions that have previously been reported and currently are unchanged should not be done (“NO” answer would be appropriate). For any question answered “YES”, please provide additional information describing the situation as completely as possible under item 9, “Additional Information.” Also, take photographs of the situation, and include with this report.

1. Dam Crest:
   a. Any new cracking of concrete, or significant changes at existing cracks? □ No □ Yes
   b. Any offsets at contraction joints, or changes in openings at these joints? □ No □ Yes

2. Spillway Intake Area and Tunnel:
   a. Any new cracking of concrete, or significant changes at existing cracks? □ No □ Yes
   b. Any evidence of slide mass movement above the spillway intake area? □ No □ Yes

3. Upstream Face of Dam:
   a. Any new cracking of concrete, or significant changes at existing cracks? □ No □ Yes
   b. Any offsets at contraction joints, or changes in openings at these joints? □ No □ Yes

4. Dam Galleries:
   Note: At a minimum, walk the “Foundation Gallery” at elevation 5580, the “Utility Gallery” at elevation 6015, and the galleries following the dam/abutment contacts at both abutments.
   a. Any new cracking, or significant changes at existing cracks? □ No □ Yes
   b. Any new seepage or wet areas? □ No □ Yes
   c. Any apparent offsets at the lines scribed across the contraction joints? □ No □ Yes
   d. Any evidence of calcium carbonate deposits or other deposits at the outfalls of the foundation drains that could impede the drain flows? □ No □ Yes
   e. Any significant changes in foundation or form drain flows from historic performances? □ No □ Yes
6. **Downstream Face of Dam:**
   a. Any new cracking of concrete, or significant changes at existing cracks? □ No □ Yes
   b. Any new seepage areas or wet areas? □ No □ Yes
   c. Any seepage or wet areas at lift lines that exceeds what has been observed previously? □ No □ Yes

6. **Abutments and Downstream Areas:**
   a. Any new seepage areas or wet areas of significance? □ No □ Yes
   b. Any significant changes in conditions at existing seepage areas or wet areas? □ No □ Yes
   c. Any evidence of materials being transported by seepage flows at existing seepage areas (such as discolored seepage water or sediment deposits)? □ No □ Yes
   d. Any significant rockfalls, or evidence of possible movement of major blocks of abutment rock? □ No □ Yes
   e. Any cracking or other evidence of structural distress at any of the concrete protective walls (that cover exposed shale layers near the dam/abutment contact)? □ No □ Yes

7. **Diversion Tunnel, Downstream of Concrete Plug:**
   Note: Inspection of this area is only required once per year, in September. Access into the tunnel by raft is possible only when releases from the dam are at least 4500 ft³/s. At lower release levels, access by foot is possible, but this could be hazardous due to wet slippery surfaces and is not recommended.
   a. Any new cracking of concrete, or significant changes at existing cracks in diversion tunnel, downstream of concrete plug? □ No □ Yes
   b. Any evidence of changes in the location or amount of seepage? □ No □ Yes

8. **Special Observations When Spillway Releases Are Made:**
   Note: The maximum historical release is 5,000 ft³/s, so spillway performance during releases above this level should receive close scrutiny.
   a. Any evidence of unusual spillway flow conditions, such as discolored flow or pulsating flow? □ No □ Yes
   b. Any evidence of changes in the location or amount of seepage? □ No □ Yes

9. **Additional Information:**
   Provide additional information concerning any of the above questions that were answered "YES:"

**NOTE:** All descriptions should include specific location information and all other seemingly relevant information. Seepage area descriptions should include estimated seepage amount and water clarity description (clear/cloudy/muddy, etc.). Crack descriptions should include orientation and dimensions. Descriptions of changes at joints should include the estimated amount of movement, and movement direction. Deteriorated or spalled concrete descriptions should include degree of deterioration and approximate dimensions of the affected area.
ATTACHMENT 5 - Ongoing Visual Inspection Checklist – Sample Embankment Dam (PFMA not available – form based on Attachment 1 information)

Page 1 of 2

Ongoing Visual Inspection Checklist
Sample Embankment Dam

Schedule: Perform weekly, except perform three times per day (early morning, mid-day, and evening) in the event that the reservoir exceeds its maximum reservoir elevation to date. Perform a detailed post-flood inspection following any flood event where the reservoir elevation exceeds its maximum reservoir elevation to date. Additionally, perform an immediate inspection following a significant earthquake in the vicinity of the dam (estimated ground acceleration at the dam exceeding 0.05g).

Inspector: __________________________ Date: __________________________
Reservoir Elev.: ___________ feet Time: __________________________
Weather: __________________________ Temperature: ___________ °F

A “YES” response should be given to question(s) below where observed conditions are different than previously observed conditions. Re-reporting conditions that have previously been reported and currently are unchanged should not be done (“NO” answer would be appropriate). For any question answered “YES”, please provide additional information describing the situation as completely as possible under item 7, “Additional Information.” Also, take photographs and include them with this report, as appropriate.

1. Upstream Slope of the Dam:
   a. Any evidence of significant erosion due to wave action? ☐ No ☐ Yes
   b. Any sinkholes, depressions, unusual settlement areas, or sloughs? ☐ No ☐ Yes
   c. Any cracks, either transverse or longitudinal? ☐ No ☐ Yes
   d. Any evidence of whirlpools in the reservoir? ☐ No ☐ Yes

2. Dam Crest:
   a. Any cracks, either transverse or longitudinal? ☐ No ☐ Yes
   b. Any sinkholes, depressions, or areas of unusual settlements or deformations? ☐ No ☐ Yes
   c. Any evidence of a gap at the embankment/structure contact where embankment material is adjacent to a structure that runs in the upstream/downstream direction through the damsite (spillway or outlet works)? ☐ No ☐ Yes

3. Downstream Slope of Dam:
   Note: Inspect the contact between the dam embankment and structures that run in the upstream/downstream direction through the damsite (spillway or outlet works) for the full height of the dam.
   a. Any evidence of a gap at the embankment/structure contact where embankment material is adjacent to a structure that runs in the upstream/downstream direction through the damsite (spillway or outlet works)? ☐ No ☐ Yes
   b. Any new seepage areas or wet areas, or changes at existing seepage or wet areas? ☐ No ☐ Yes
   c. Any evidence of materials being transported by seepage flows (such as discolored seepage water or sediment deposits)? ☐ No ☐ Yes
   d. Any sinkholes, depressions, sloughs, bulges, or areas of unusual settlements or deformations? ☐ No ☐ Yes
4. **Downstream Toe Area, and Areas Downstream of the Dam:**

**NOTE:** Extend the inspection to: (1) all areas within 150 feet of the downstream of the toe of the dam, and (2) abutment areas within 50 feet of groins of the dam all the way up to the dam crest.

a. Any new seepage areas or wet areas, or changes at existing seepage or wet areas? □ No □ Yes

b. Any changes from historic behavior seen regarding the toe drain flows, or any other drain flows? □ No □ Yes

c. Any evidence of materials being transported by seepage flows (such as discolored seepage water or sediment deposits)? □ No □ Yes

d. Any sinkholes, depressions, sloughs, bulges, or areas of unusual settlements or deformations? □ No □ Yes

5. **Outlet Works:**

a. Any new or enlarged cracks, or spalls in concrete, or significant corrosion of metals? □ No □ Yes

b. Any evidence of unusual deformations or displacements? □ No □ Yes

c. Any evidence of seepage occurring along the outside of the outlet works? □ No □ Yes

d. Any evidence of seepage occurring into the outlet works, and exiting at its outfall? □ No □ Yes

e. Any significant change from historic performance regarding weephole or drain flows? □ No □ Yes

f. Any evidence of materials being transported by seepage flows (such as discolored seepage water or sediment deposits)? □ No □ Yes

g. Any unusual flow patterns or conditions during releases? □ No □ Yes

6. **Spillway:**

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

b. Any evidence of unusual deformations or displacements? □ No □ Yes

c. Any evidence of seepage occurring along the outside of the spillway structure? □ No □ Yes

d. Any evidence of seepage occurring into the spillway, and exiting at the downstream end of the spillway? □ No □ Yes

e. Any significant change from historic performance regarding weephole or drain flows? □ No □ Yes

f. Any evidence of materials being transported by seepage flows (such as discolored seepage water or sediment deposits)? □ No □ Yes

g. Any unusual flow patterns or conditions during discharges? □ No □ Yes

h. Any evidence of erosion occurring that could undermine the spillway's foundation? □ No □ Yes

i. Any evidence of lateral erosion occurring (erosion of spillway walls or sides)? □ No □ Yes

7. **Additional Information:**

Provide additional information concerning any of the above questions that were answered "YES:"

**NOTE:** All descriptions should include specific location information and all other seemingly relevant information. Seepage area descriptions should include: estimated seepage amount and water clarity description (clear/cloudy/muddy, etc.). Crack descriptions should include orientation and dimensions. Descriptions of changes at joints should include the estimated amount of movement, and movement direction. Deteriorated or spalled concrete descriptions should include degree of deterioration and approximate dimensions of the affected area.
**Ongoing Visual Inspection Checklist**

**Sample Concrete Dam**

**Date:**

**Schedule:** Perform weekly, except perform three times per day (early morning, mid-day, and evening) in the event that the reservoir exceeds its maximum reservoir elevation to date. Perform a detailed post-flood inspection following any flood event where the reservoir elevation exceeds its maximum reservoir elevation to date. Additionally, perform an immediate inspection following a significant earthquake in the vicinity of the dam (estimated ground acceleration at the dam exceeding 0.05g).

**Inspector:**

**Reservoir Elev.:** _______ feet

**Weather:**

**Temperature:** _______ °F

A "YES" response should be given to question(s) below where observed conditions are different than previously observed conditions. Re-reporting conditions that have been previously reported and currently are unchanged should not be done ("NO" answer would be appropriate). For any question answered "YES", please provide additional information describing the situation as completely as possible under item 9, "Additional Information." Also, take photographs of the situation, and include with this report.

**1. Dam Crest:**
   a. Any new cracking of concrete, or significant changes at existing cracks?  [ ] No  [ ] Yes
   b. Any offsets at contraction joints, or changes in openings at these joints?  [ ] No  [ ] Yes

**2. Spillway Intake Area:**
   a. Any new cracking of concrete, or significant changes at existing cracks?  [ ] No  [ ] Yes
   b. Any evidence of slide mass movement above the spillway intake area?  [ ] No  [ ] Yes

**3. Upstream Face of Dam:**
   a. Any new cracking of concrete, or significant changes at existing cracks?  [ ] No  [ ] Yes
   b. Any offsets at contraction joints, or changes in openings at these joints?  [ ] No  [ ] Yes

**4. Dam Galleries:**
   **Note:** Walk all the galleries...
   a. Any new cracking, or significant changes at existing cracks?  [ ] No  [ ] Yes
   b. Any new seepage or wet areas?  [ ] No  [ ] Yes
   c. Any offsets at contraction joints, or changes in openings at these joints, or any other noteworthy deformations or deflections observed in gallery walls, floors, or ceilings?  [ ] No  [ ] Yes
   d. Any evidence of calcium carbonate deposits or other deposits at the outfalls of the foundation drains that could impede the drain flows?  [ ] No  [ ] Yes
   e. Any significant changes in foundation or form drain flows from historic performance?  [ ] No  [ ] Yes

**5. Downstream Face of Dam:**
   a. Any new cracking of concrete, or significant changes at existing cracks?  [ ] No  [ ] Yes
   b. Any new seepage areas or wet areas?  [ ] No  [ ] Yes
   c. Any seepage or wet areas at lift lines that exceeds what has been observed previously?  [ ] No  [ ] Yes
6. **Abutments and Downstream Areas:**
   a. Any new seepage areas or wet areas of significance?  
      □ No □ Yes
   b. Any significant changes in conditions at existing seepage areas or wet areas?  
      □ No □ Yes
   c. Any evidence of materials being transported by seepage flows at existing seepage areas (such as discolored seepage water or sediment deposits)?  
      □ No □ Yes
   d. Any significant rockfalls, or evidence of possible movement of major blocks of abutment rock?  
      □ No □ Yes

7. **Outlet Works:**
   a. Any new or enlarged cracks, or spalls in concrete, or significant corrosion of metals?  
      □ No □ Yes
   b. Any evidence of unusual deformations or displacements?  
      □ No □ Yes
   c. Any evidence of seepage occurring along the outside of the outlet works?  
      □ No □ Yes
   d. Any evidence of materials being transported by seepage flows (such as discolored seepage water or sediment deposits)?  
      □ No □ Yes
   e. Any unusual flow patterns or conditions during releases?  
      □ No □ Yes

8. **Spillway:**
   a. Any new or enlarged cracks, or spalls in concrete?  
      □ No □ Yes
   b. Any evidence of unusual deformations or displacements?  
      □ No □ Yes
   c. Any evidence of seepage occurring along the outside of the spillway structure?  
      □ No □ Yes
   d. Any evidence of materials being transported by seepage flows (such as discolored seepage water or sediment deposits)?  
      □ No □ Yes
   e. Any unusual flow patterns or conditions during discharges?  
      □ No □ Yes
   g. Any evidence of erosion occurring that could undermine the spillway’s foundation?  
      □ No □ Yes

9. **Additional Information:**
   Provide additional information concerning any of the above questions that were answered "YES."

**NOTE:** All descriptions should include specific location information and all other seemingly relevant information. Seepage area descriptions should include estimated seepage amount and water clarity description (clear/cloudy/muddy, etc.). Crack descriptions should include orientation and dimensions. Descriptions of changes at joints should include the estimated amount of movement, and movement direction. Deteriorated or spalled concrete descriptions should include degree of deterioration and approximate dimensions of the affected area.
ATTACHMENT 7 - Dam Operator Information – Dam Safety Monitoring – Embankment Dam – Sample Form (PFMA available)

Sample Embankment Dam - Dam Operator Information – Dam Safety Monitoring – February 30, 2012
(Refer to the current EAP, O&M Manual, L-23, OVIC, and CDE for full and complete information)
Prepared by: Joe Fictitious, Bureau of Reclamation, Instrumentation and Inspections Group,
Denver, 999:999-9999, jfictitious@usbr.gov

Important Notes and Information about the Dam (relating to monitoring):
1. Dam built in the 1940’s, and modified in 1992-93: (1) to pass the Probable Maximum Flood (dam crest raised to 769.1 feet, and new spillway constructed), (2) to provide an outlet works (siphon), and (3) to generally improve the dam (new filtered drainage system at dam toe, and flattened upstream and downstream slopes of dam to 3:1).
2. Site geology: Granite gneiss (vertical and angled fractures), Glacial till (sandy silt with gravel), Silt which is highly erodible), Dam Embankment (silty sand, which is highly erodible)
3. The bottom of the corewall in dam was not extended down to bedrock, and may not tie into bedrock at one or both abutments, so the corewall does not provide a full barrier to seepage flow at the dam. Seepage may travel above, below, and/or around the corewall.
4. The filtered drainage system near the toe of the dam only extends 5.5 feet vertically, and for a limited distance horizontally, so seepage can go above, below, and around it.
5. In light of the previous two items, areas downstream of the dam, including the downstream outlet works flow channel, should be closely inspected for changes in seepage flow.
6. The bedding for the siphon outlet works (beyond the first 23 feet) can provide a pervious seepage path. Close monitoring for seepage near the outlet works is important.
7. A low area to the right of the dam (El. 763) serves as an emergency spillway in a major flood. It will flow when 2.8 feet of flow depth is present at the service spillway (sill at El. 760.2)

Most Significant Potential Failure Modes (FMs) for the Dam
1. Seepage through embankment (transporting dam embankment)
2. Seepage through embankment along outlet works (transporting dam embankment)
3. Seepage through embankment into and through bedrock (transporting dam embankment)
4. Seepage through foundation and abutments (transporting foundation/abutment material)
5. Flood → Increased threat of one of the previous four FMs
6. Flood → Lateral erosion (towards the dam embankment) at service spillway
7. Earthquake → Damage to dam embankment → Seepage through crack leads to breach

Elements of Monitoring Program
2. Seepage Monitoring – Visual Inspection Only: Toe Drain Outfall and Downstream Seepage

Monitoring Schedule (See Schedule for Periodic Monitoring (L-23) for Complete Information)
1. Monitoring Program Elements 1 and 2 done monthly, except daily if the reservoir is above 760.5 feet, 3 times per day for reservoir above 761.0 feet, and “continuously” (continuous presence at the dam) for reservoir above 762.8 feet (emergency spillway flows about to begin)
2. Thorough dam inspection after earthquake shaking (estimated 0.05g peak horizontal acceleration at damsite) and after a significant flood (reservoir above 761.0 feet)

Key Monitoring Concerns
1. Material transport by any seepage flow (sediment deposits, discolored water, etc.)
2. Changed seepage (new seepage flows or flow amounts, toe drain flows occurring, etc.)
3. Sinkholes, unusual settlements or deformations, cracks in embankment
4. In a flood – evidence of worse seepage performance or lateral erosion at service spillway
5. After an earthquake – worse seepage performance or significant dam deformations

Questions of Particular Importance Regarding Routine Dam Safety Monitoring Work
1. Potential Failure Modes understood and make sense?
2. Any questions about performing Ongoing Visual Inspections? OVIC use?
3. Any other concerns – of any sort – regarding routine dam safety monitoring efforts?
ATTACHMENT 8 - Dam Operator Information – Dam Safety Monitoring – Concrete Dam – Sample Form (PFMA available)

Sample Concrete Dam - Dam Operator Information – Dam Safety Monitoring – February 30, 2012
(Refer to the current EAP, O&M Manual, L-23, OVIC, and CDE for full and complete information)
Prepared by: Joe Fictitious, Bureau of Reclamation, Instrumentation and Inspections Group,
Denver, 999:999-9999, jfictitious@usbr.gov

Important Notes and Information about the Dam (relating to monitoring)
1. Dam construction completed in 1932. It is a thick arch structure, with a gravity section of
limited height at the right abutment.
2. The dam foundation is rhyolite.
3. The dam represented a test structure for methods to be used at Jones Dam. There are abandoned
instruments in the dam associated with this testing effort.
4. The foundation drains for the dam extend only a short distance into the foundation, much less
than would be done for a dam today. Therefore, the presence and effectiveness of these
foundation drains is not very significant. It has been decided that extraordinary efforts to
remove stairways and other major obstructions at the dam to periodically probe and clean the
foundation drains is not warranted or necessary. The jointing and fractures in the foundation
rock appears to naturally provide sufficient drainage at the damsite.
5. The dam suffers from damage due to Alkali-Aggregate Reaction (AAR). AAR causes swelling
of the concrete, which leads to cracking. The AAR damage is less severe than at some other
Reclamation dams, and it is hard to envision a potential failure mode associated with it.
However, the Whittmore Gauges and Measurement Points at the dam are an attempt to gauge
the continuing movements and damage that is taking place.
6. There are no potential failure modes associated with normal operating conditions – only for
flood loading conditions and earthquake loading conditions.

Most Significant Potential Failure Modes (PFMs) for the Dam
1. Flood → Overtopping → Erosion of Gravity Section Foundation → Gravity Section Failure
2. Earthquake → Sliding on Lift Lines at Gravity Section → Gravity Section Failure
3. Earthquake → Sliding at Gravity Section Foundation Contact → Gravity Section Failure
4. Earthquake → Sliding along Cracks at Arch Section → Arch Section Failure

Elements of Monitoring Program
2. Drain Flow Monitoring (4): In gutters in galleries (form drain and foundation drain flows)
3. Uplift Pressure Monitoring (16): Along 4 sections
4. Whittmore Gauges (7): At seven cracks caused by AAR
5. Measurement Points (9): 4 older points and 5 newer points at dam crest – for AAR monitoring

Monitoring Schedule – Brief Summary (Refer to the L-23 for complete information)
1. Monitoring Elements 1, 2, and 3 done monthly, but every other day for Reservoir > 2673
2. Monitoring Element 4 done quarterly (January, April, July, October)
3. Monitoring Element 5 done twice per year (middle of February and middle of August)
4. If significant earthquake shaking (estimated 0.05g peak horizontal acceleration at damsite),
promptly perform Monitoring Elements 1, 2, 3, and 4

Key Monitoring Concerns
1. Evidence of new cracking of the dam, worsening of existing cracks, and offsets at contraction
joints, most particularly following significant seismic shaking.
2. Evidence of increased drain flows and/or uplift pressures

Questions of Particular Importance Regarding Routine Dam Safety Monitoring Work
1. Potential Failure Modes understood and make sense?
2. Any questions about methods for obtaining instrument readings?
3. Any questions about performing Ongoing Visual Inspections? OVIC use?
4. Any other concerns – of any sort – regarding routine dam safety monitoring efforts?
ATTACHMENT 9 - Dam Operator Information – Dam Safety Monitoring – Sample Embankment Dam
(template for developing the form when a PFMA is not available and Attachment 1 PFMs are utilized)

Embankment Dam Name - Dam Operator Information – Dam Safety Monitoring – February 30, 2012
(Refer to the current EAP, O&M Manual, L-23, OVIC, and CDE for full and complete information)
Prepared by: Name, Organization, Phone Number, email address

Important Notes and Information about the Dam (relating to monitoring):
1. Provide basic information about the dam
2. Provide basic information about the site geology
3. Provide information about unusual aspects of the dam
4. Provide information about noteworthy dam safety performance issues

Most Significant Potential Failure Modes (FM)s for the Dam
1. List all significant potential failure modes for the dam (some presumptive FM are listed below for reference)
2. Seepage through the dam embankment (transporting embankment material)
3. Seepage through the foundation (includes the abutments) transporting foundation material
4. Seepage path involving both the foundation and the dam embankment (transporting embankment material)
5. Seepage along the outside of the outlet works pipe (transporting embankment material)
6. Seepage into the outlet works pipe through a joint opening, crack, etc. (transporting embankment and/or foundation material)
7. Pressurized water exiting the outlet works pipe through a joint opening, crack, etc. and then flowing along the outside of the pipe (transporting embankment and/or foundation material)
8. Downstream slope instability, leading to dam overtopping
9. Flood: Initiation of one of the above FM
10. Flood: Dam overtopping, leading to a dam breach
11. Flood: Spillway failure due to discharges undermining the spillway foundation
12. Flood: Spillway failure due to erosion of the spillway structure by the large discharges
13. Flood: Lateral erosion of spillway walls leading to erosion and breaching of the dam embankment
14. Earthquake: Liquefaction of embankment and/or foundation materials → Slope instability → Dam overtopping
15. Earthquake: Seepage failure through the cracked/damaged dam embankment (FM 2 above)

Elements of Monitoring Program
1. Provide information about the routine visual monitoring program for the dam
2. Provide information about the routine instrumented monitoring program for the dam
3. Provide information about any other elements of the dam safety monitoring program, such as measurement points (monuments) on the dam that are surveyed once every few years

Monitoring Schedule (See Schedule for Periodic Monitoring (L-23) for Complete Information)
1. Provide information about routine dam safety monitoring schedule
2. Provide other schedule information regarding dam safety monitoring for the dam
3. Note earthquake and post-flood monitoring requirements, such as “Thorough dam inspection after earthquake shaking (estimated 0.05g peak horizontal acceleration at damsite) and after a significant flood (reservoir above 761.0 feet)”

Key Monitoring Concerns
1. Note the key monitoring concerns, such as the items noted below:
2. “Material transport by any seepage flow (sediment deposits, discolored water, etc.)”
3. “Changed seepage (new seepage flows or flow amounts, toe drain flows occurring, etc.”
4. “Sinkholes, unusual settlements or deformations, cracks in embankment”
5. “In a flood – evidence of worse seepage performance or lateral erosion at service spillway”
6. “After an earthquake – worse seepage performance or significant dam deformations”

Questions of Particular Importance Regarding Routine Dam Safety Monitoring Work
1. Include items like the ones noted below:
2. “Potential Failure Modes understood and make sense?”
3. “Any questions about performing Ongoing Visual Inspections? OVIC use?”
4. “Any other concerns – of any sort – regarding routine dam safety monitoring efforts?”
ATTACHMENT 10 - Dam Operator Information – Dam Safety Monitoring – Sample Concrete Dam
(template for developing the form when a PFMA is not available and Attachment 2 PFMs are utilized)

Concrete Dam Name - Dam Operator Information – Dam Safety Monitoring – February 30, 2012
(Refer to the current EAP, O&M Manual, L-23, OVIC, and CDE for full and complete information)
Prepared by: Name, Organization, Phone Number, email address

Important Notes and Information about the Dam (relating to monitoring):
1. Provide basic information about the dam
2. Provide basic information about the site geology
3. Provide information about unusual aspects of the dam
4. Provide information about noteworthy dam safety performance issues
5.

Most Significant Potential Failure Modes (FMs) for the Dam
1. List all significant potential failure modes for the dam
2. Sliding along a low-strength plane in the foundation → Overstressed concrete → Sudden failure
3. Movement of a block of rock in the abutment → Overstressed concrete → Sudden failure
4. Gate Failure or Gate Support Failure → Unintended, Uncontrolled Reservoir Releases
5. Flood: Initiation of one of the above FMs
6. Flood: Overtopping → Erosion of Abutment/Foundation → Loss of Foundation Support → Failure
7. Flood: Spillway failure due to discharges undermining the spillway foundation → Uncontrolled reservoir releases
8. Flood: Spillway failure due to erosion of the spillway structure by the large discharges → Uncontrolled reservoir releases
9. Flood: Lateral erosion of spillway walls → Uncontrolled reservoir releases
10. Earthquake: Initiation of FMs 1, 2, or 3
11. Earthquake: Cracking/Damage to the Dam → Loss of a Block/Portion of the Dam → Uncontrolled reservoir releases
12. Earthquake: Sliding Along a Lift Line → Loss of a Block/Portion of the Dam → Uncontrolled reservoir releases

Elements of Monitoring Program
1. Provide information about the routine visual monitoring program for the dam
2. Provide information about the routine instrumented monitoring program for the dam
3. Provide information about any other elements of the dam safety monitoring program, such as measurement points (monuments) on the dam that are surveyed once every few years

Monitoring Schedule (See Schedule for Periodic Monitoring (L-23) for Complete Information)
1. Provide information about routine dam safety monitoring schedule
2. Provide other schedule information regarding dam safety monitoring for the dam
3. Note earthquake and post-flood monitoring requirements, such as “Thorough dam inspection after earthquake shaking (estimated 0.05g peak horizontal acceleration at damsite) and after a significant flood (reservoir above 761.0 feet)”

Key Monitoring Concerns
1. Note the key monitoring concerns, such as the items noted below:
2. “Evidence of new cracking of the dam, worsening of existing cracks, and offsets at contraction joints, most particularly following significant seismic shaking”
3. “Evidence of increased drain flows and/or uplift pressures”

Questions of Particular Importance Regarding Routine Dam Safety Monitoring Work
1. Include items like the ones noted below:
2. “Potential Failure Modes understood and make sense?”
3. “Any questions about performing Ongoing Visual Inspections? OVIC use?”
4. “Any other concerns – of any sort – regarding routine dam safety monitoring efforts?”
ATTACHMENT 11 - GENERIC (Sample) Form for Routine Visual Inspections – Embankment Dam
(ties inspection questions to PFMs)

Sample Embankment Dam – Routine Visual Inspections  Date:  Inspected by: 

Reservoir Elevation:  Temperature:  °F  Weather Conditions: 

<table>
<thead>
<tr>
<th>Potential Failure Mode</th>
<th>Key Monitoring Questions During Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Seepage flow that erodes foundation, abutment, or dam embankment material. (Note: Upstream to downstream seepage paths adjacent to pipes, conduits, concrete structures, etc. are of particular concern.)</td>
<td>A. Any new seepage areas or wet areas?  □ No □ Yes  B. Any significant changes at any existing seepage/wet areas?  □ No □ Yes  C. Any changes in vegetation (like lush, green areas) that could indicate worsening seepage performance?  □ No □ Yes  D. Any indications of soil material being transported by seepage flow (like discolored water, sediment deposits)?  □ No □ Yes  E. Any sinks holes, depressions, etc.?  □ No □ Yes  F. Any animal burrows, root holes, etc. that could affect seepage performance of the dam?  □ No □ Yes</td>
</tr>
<tr>
<td>2. Seepage failure during a flood</td>
<td>G. Any transverse cracks (upstream to downstream direction) in the dam embankment?  □ No □ Yes  H. Any whirlpools in the reservoir not associated with the outlet works or spillway intakes?  □ No □ Yes</td>
</tr>
<tr>
<td>3. Seepage failure following earthquake shaking</td>
<td>I. Any flaws in spillway or outlet works pipes, like corrosion, joint openings, cracks, etc.?  □ No □ Yes  J. Any evidence of seepage flow entering into spillway or outlet works pipes and then exiting at the outfall?  □ No □ Yes</td>
</tr>
<tr>
<td>4. Slope instability causing loss of reservoir containment</td>
<td>K. Any transverse cracks (see F.) or longitudinal cracks (parallel to dam crest) in the dam embankment?  □ No □ Yes</td>
</tr>
<tr>
<td>5. Slope instability caused by earthquake shaking</td>
<td>L. Any bulging areas at the downstream slope or toe area?  □ No □ Yes  M. Any sloughs, slides, scarps, or other deformations?  □ No □ Yes</td>
</tr>
<tr>
<td>6. Dam overtopping and erosion failure of the dam embankment in a flood</td>
<td>N. Any obstructions to flow into and through the spillway (like trees, bushes, and vegetation; debris, logs, etc.)  □ No □ Yes</td>
</tr>
<tr>
<td>7. Spillway erosion failure in a flood (either erosion failure of the spillway itself, or its foundation)</td>
<td>O. Any evidence of erosion along the spillway channel or in the area immediately downstream of the spillway?  □ No □ Yes  P. Any offsets at joints in the spillway structure or other evidence that the flow surface is not smooth?  □ No □ Yes</td>
</tr>
<tr>
<td>Other</td>
<td>Q. Any erosion at the upstream slope due to wave action?  □ No □ Yes  R. Any problems operating outlet works or spillway control valves or other equipment?  □ No □ Yes</td>
</tr>
</tbody>
</table>

Recommended Routine Monitoring Approach:

1. Walk the dam crest along the upstream edge looking at the dam crest, upstream slope, and reservoir. – Look for sinks holes, depressions, etc. (E), transverse cracks (G,K), longitudinal cracks (K), detrimental animal activity (F), wave action erosion at the upstream slope (Q), and whirlpools in the reservoir (H).
2. Walk the dam crest along the downstream edge looking at the dam crest and downstream slope. – Look for any new or changed seepage conditions (A,B,C,D), sinks holes, depressions, etc. (E), transverse cracks (G,K), longitudinal cracks (K), bulging areas or other deformations (L,M), and detrimental animal activity (F).
3. Walk along the abutment groins and downstream toe of the dam looking at the downstream slope, abutment areas, and areas downstream of the dam, with particular attention to the areas around the downstream end of the outlet works and spillway. – Look for any new or changed seepage conditions (A,B,C,D), sinks holes, depressions, etc. (E), transverse cracks (G,K), longitudinal cracks (K), bulging areas or other deformations (L,M), and detrimental animal activity (F).
4. Walk the downstream area along a line about 40 feet downstream of the toe of the dam. – Look for any new or changed seepage conditions (A,B,C,D), sinks holes, depressions, etc. (E), and detrimental animal activity (F).
5. Walk along the alignment of the spillway, from the inlet at the reservoir to the downstream end. – Look for any flow obstructions (N), erosion (Q), and imperfections in the flow surfaces (P).
6. Check the outlet works and spillway for any operational problems or issues (R).

7. Special Attention Items: Potential seepage at or near the outlets of the spillway and outlet works.
8. Provide additional information below regarding any item in the above table marked as “Yes”

Comments on any topic related to the inspection:
**ATTACHMENT 12 - GENERIC (Sample) Form for Routine Visual Inspections – Concrete Dam**

(ties inspection questions to PFMs)

Sample Concrete Dam – Routine Visual Inspections  
Date:_______  Inspected by:______________________

Reservoir Elevation:________  Temperature:____’F  Weather Conditions:________

<table>
<thead>
<tr>
<th>Potential Failure Mode</th>
<th>Key Monitoring Questions During Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sliding in the foundation beneath the dam, or any other foundation movements, that</td>
<td>A. Any unusual deformations or deflections observed at the upstream face, dam crest, downstream face, or in</td>
</tr>
<tr>
<td>result in stresses in the dam's concrete that exceed its strength, leads to cracking of</td>
<td>the galleries? No ☐ Yes ☐</td>
</tr>
<tr>
<td>concrete, displacement of portions of the dam, and ultimately dam failure*</td>
<td>B. Any new cracking of concrete, or significant changes at existing cracks, seen at the upstream face, dam</td>
</tr>
<tr>
<td></td>
<td>crest, downstream face, or in the galleries? No ☐ Yes ☐</td>
</tr>
<tr>
<td>2. Sliding within the dam body along a disbonded lift line*</td>
<td>C. Any offsets at contraction joints, or changes in openings at these joints, as seen at the upstream face,</td>
</tr>
<tr>
<td></td>
<td>dam crest, downstream face, or in the galleries? No ☐ Yes ☐</td>
</tr>
<tr>
<td>3. Gate failure, or failure of a gate support structure, causing uncontrolled</td>
<td>D. Any changes in seepage performance seen in the galleries or at the downstream face, abutments, or</td>
</tr>
<tr>
<td>reservoir releases*</td>
<td>downstream areas? No ☐ Yes ☐</td>
</tr>
<tr>
<td>4. Dam overtopping and erosion failure of the dam's foundation in a flood, that leads</td>
<td>E. Any changes in seepage seen at lift lines? No ☐ Yes ☐</td>
</tr>
<tr>
<td>to instability</td>
<td>F. Any significant changes seen in foundation drain flows or form drain flows, compared to historical performance? No ☐ Yes ☐</td>
</tr>
<tr>
<td>5. Spillway erosion failure in a flood (either erosion failure of the spillway itself,</td>
<td>G. Any problems during test operations of spillway gates? No ☐ Yes ☐</td>
</tr>
<tr>
<td>or its foundation)</td>
<td>H. Any unusual deformations or deflections observed regarding the gate support structures? No ☐ Yes ☐</td>
</tr>
<tr>
<td>Other</td>
<td>I. Any new cracking of concrete, or significant changes at existing cracks, seen at the gate support</td>
</tr>
<tr>
<td></td>
<td>structures? No ☐ Yes ☐</td>
</tr>
<tr>
<td></td>
<td>J. Any debris blockage concerns regarding the spillway? No ☐ Yes ☐</td>
</tr>
<tr>
<td></td>
<td>K. Any evidence of significant erosion along the spillway channel or in the area immediately downstream of</td>
</tr>
<tr>
<td></td>
<td>the spillway? No ☐ Yes ☐</td>
</tr>
<tr>
<td></td>
<td>L. Any offsets at joints in the spillway structure or other evidence that the flow surface is not smooth? No ☐ Yes ☐</td>
</tr>
</tbody>
</table>

* Earthquake-caused shaking could cause these potential failure modes to initiate, so a prompt post-earthquake inspection of the dam is important.

**Recommended Routine Monitoring Approach:**

1. Walk the dam crest, zigzagging back and forth from the upstream edge to the downstream edge, looking at the dam crest, upstream and downstream faces of the dam (to the extent possible), reservoir, and areas downstream of the dam. - Look for unusual deformations or deflections (A), new or changed cracks (B), changes in joint openings or offsets (C), changes in seepage performance (D), and changes in lift line seepage (E).

2. Observe the upstream face of the dam from good vantage points on the abutments. - Look for unusual deformations or deflections (A), and new or changed cracks (B).

3. Observe the downstream face of the dam from good vantage points on the abutments and areas downstream of the dam. - Look for unusual deformations or deflections (A), new or changed cracks (B), changes in joint openings or offsets (C), changes in seepage performance (D), and changes in lift line seepage (E).

4. Observe the spillway gates and gate support structures. - Look for unusual deformations or deflections (H), and (I) new or changed cracks.

5. Walk along the alignment of the spillway, from the inlet at the reservoir to the downstream end. - Look for any flow obstructions (J), erosion (K), and imperfections in the flow surface (L).

6. Check the outlet works and spillway for any operational problems or issues (M). Ensure that all gates are exercised or operated at least annually (G).

7. Provide additional information below regarding any item in the above table marked as “Yes”

**Comments on any topic related to the inspection:**
ATTACHMENT 13 - SAMPLE Embankment Dam Inspection Form
Page 1 of 5 (utilized in Georgia for state-required inspections)

Embankment (Earth) Dam Inspection Form
Name of Dam: ___________________________ Date: __________
Location of Dam (County): ___________________ Weather: __________
Inspected by (Print Name): __________________________

If an inspection item requires further action on your part, place a check mark to the left of the number of the item

A. Crest (refer to Glossary for description)

☐ 1. How would you describe the vegetation on the crest? (Check all that apply)
   Recently Mowed ______ Overgrown ______ Good Cover ______ Sparse ______
   Other/Corrective Action (describe): _______________________________________

☐ 2. Are there any trees or other inappropriate or excessive vegetation on the crest? Yes _____ No _____
   If yes, describe (type of vegetation, size, location, etc.)/Corrective Action: __________

☐ 3. Is there a paved road or driveway on the crest? Yes _____ No _____
   If yes, describe the condition (for example, good condition, numerous cracks, newly paved)/Corrective Action: __________

☐ 4. Are there any depressions, ruts or holes on the crest? Yes _____ No _____
   If yes, describe (size, location, etc.)/Corrective Action: __________

☐ 5. Are there any cracks on the crest? Yes _____ No _____
   If yes, describe (length and width, location, direction of cracking, etc.)/Corrective Action: __________

☐ 6. Other observations on the crest/Corrective Action: __________

B. Upstream Slope (refer to Glossary for description)

☐ 1. What is the reservoir level today? At Normal Pool _____ Above Normal Pool _____ Feet Below Normal Pool _____ Feet

☐ 2. How would you describe the vegetation on the upstream slope? (Check all that apply)
   Recently Mowed ______ Overgrown ______ Good Cover ______ Sparse ______
   Other/Corrective Action (describe): _______________________________________

☐ 3. Are there any trees or other inappropriate or excessive vegetation on the slope? Yes _____ No _____
   If yes, describe (type of vegetation, size, location, etc.)/Corrective Action: __________

☐ 4. Are there any depressions, bulges, ruts or holes (such as animal burrows) on the slope? Yes _____ No _____
   If yes, describe (size, location, etc.)/Corrective Action: __________

☐ 5. Are there any eroded areas on the slope (such as wave erosion along the shoreline)? Yes _____ No _____
   If yes, describe (size of area, location, severity, etc.)/Corrective Action: __________

* Check if corrective action is noted/required.  Version 1.0, Page 1 of 5
Embankment (Earth) Dam Inspection Form

Name of Dam: ___________________________ Date: ___________________________

☐ 6. Are there any cracks, sloughs or slides (vertical cliffs) on the slope? Yes ______ No ______
   If yes, describe (length, width, height, location, etc.): Corrective Action: ___________________________

☐ 7. Is there any type of slope protection along the shoreline (such as riprap)? Yes ______ No ______
   If yes, describe what type and its condition (for example, riprap - adequate, inadequate, sparse): Corrective Action: ___________________________

☐ 8. Other observations on the upstream slope: Corrective Action: ___________________________

C. Downstream Slope (refer to Glossary for description)

☐ 1. How would you describe the vegetation on the downstream slope? (Check all that apply)
   Recently Mowed ______ Overgrown ______ Good Cover ______ Sparse ______
   Other/Corrective Action (describe): ___________________________

☐ 2. Are there any trees or other inappropriate or excessive vegetation on the slope? Yes ______ No ______
   If yes, describe (type of vegetation, size, location, etc.): Corrective Action: ___________________________

☐ 3. Are there any depressions, bulges, ruts or holes (such as animal burrows) on the slope? Yes ______ No ______
   If yes, describe (size, location, etc.): Corrective Action: ___________________________

☐ 4. Are there any eroded areas on the slope (such as along abutment contacts)? Yes ______ No ______
   If yes, describe (size of area, location, severity, etc.): Corrective Action: ___________________________

☐ 5. Are there any cracks, sloughs or slides (vertical cliffs) on the slope? Yes ______ No ______
   If yes, describe (length, width, height, location, etc.): Corrective Action: ___________________________

☐ 6. Are there any wet areas or areas of hydrophilic (flood, water-loving) vegetation? Yes ______ No ______
   If yes, describe (size of area, location, etc.): Corrective Action: ___________________________

☐ 7. Do any wet areas indicate seepage through the dam (such as rust-colored, stained water)? Yes ______ No ______ N/A ______
   If yes, describe (for example, new area of seepage, no change from past observations, size of area, location): Corrective Action: ___________________________

☐ 8. Are there any leaks (flowing water) from the slope or beyond the toe of the dam? Yes ______ No ______
   If yes, describe (location, rate of flow, turbidity of flow): Corrective Action: ___________________________

☐ 9. Other observations on the downstream slope: Corrective Action: ___________________________

* Check if corrective action is noted/required.
Embankment (Earth) Dam Inspection Form

Name of Dam: ____________________________ Date: ____________________________

D. Plunge Pool (refer to Glossary for description)

☐ 1. Is there any type of erosion protection around the plunge pool (such as riprap)? Yes _____ No _____
   If yes, describe the type of protection and its condition (for example, riprap - adequate, riprap - insufficient, overgrown
   with vegetation)/Corrective Action: ____________________________

☐ 2. Is there any erosion and or seeps around or going into the plunge pool? Yes _____ No _____
   If yes, describe (size of area, location, severity, etc.)/Corrective Action: ____________________________

☐ 3. Other observations around the plunge pool/Corrective Action: ____________________________

E. Principal and Emergency Spillways (refer to Glossary for description)

☐ 1. What types of spillways does the dam have (such as corrugated metal, concrete or siphon pipe; concrete or earth channel)?
   Principal Spillway: ____________________________ Emergency Spillway: ____________________________
   Other/Corrective Action: ____________________________

☐ 2. Has the emergency spillway activated (had flow) since the last inspection? Yes _____ No _____
   If yes describe (date(s) of flow, reason for activation, depth of flow)/Corrective Action: ____________________________

☐ 3. For pipe spillways, is the intake obstructed in any way (such as with excessive debris)? Yes _____ No _____
   If yes, describe (type of debris, reason for obstruction, etc.)/Corrective Action: ____________________________

☐ 4. For pipe spillways, what is the condition of any trash racks (for example, adequate, inadequate, damaged)?/Corrective Action: ____________________________

☐ 5. For pipe spillways, are there any visible cracks, separations or holes in the pipe(s) (intake or outlet)? Yes _____ No _____
   If yes, describe (location, width of crack or separation, etc.)/Corrective Action: ____________________________

☐ 6. For pipe spillways, are there any apparent leaks in the pipe(s)? Yes _____ No _____
   If yes, describe (location, rate of flow from leak, etc.)/Corrective Action: ____________________________

☐ 7. For pipe spillways, how would you describe the overall condition of the pipe(s)? (Check all that apply)
   Functioning Normally _____ Not Functional _____ Deteriorated _____ Damaged _____ Adequate _____ Inadequate _____

☐ 8. For concrete or earth channel spillways, is the entrance or channel obstructed in any way? Yes _____ No _____
   If yes, describe (type of obstruction, location, etc.)/Corrective Action: ____________________________

☐ 9. For earth channel spillways, how would you describe the vegetation in the spillway? (Check all that apply)
   Recently Mowed _____ Overgrown _____ Good Cover _____ Sparse _____
   Other (describe)/Corrective Action: ____________________________

Check if corrective action is noted/required.
Embankment (Earth) Dam Inspection Form

Name of Dam: ___________________________ Date: ___________________________

☐ 10. For earth channel spillways, are there any trees or other inappropriate vegetation in the spillway? Yes______ No______
   If yes, describe (type of vegetation, size, location, etc.)/Corrective Action:_____________________________________________________

☐ 11. For earth channel spillways, are there any eroded areas in the spillway? Yes______ No______
   If yes, describe (size of area, location, severity, etc.)/Corrective Action:_____________________________________________________

☐ 12. For concrete channel spillways, are there any cracks or holes in the spillway? Yes______ No______
   If yes, describe (width of crack or hole, location, etc.)/Corrective Action:_____________________________________________________

☐ 13. For concrete channel spillways, are there any leaks or evidence of undermining (flow under the concrete)? Yes______ No______
   If yes, describe (location, rate of flow from leak, indicators of undermining, etc.)/Corrective Action:_____________________________________________________

Principal and Emergency Spillways (continued)

14. For earth or concrete channel spillways, how would you describe the overall condition of the spillway? (Check all that apply)
   Functioning Normally______ Not Functional______ Deteriorated______ Damaged______ Adequate______ Inadequate______

☐ 15. Other observations on the spillways/Corrective Action:_____________________________________________________

F. Instrumentation (refer to Glossary for description)

☐ 1. Are there any toe drains at the downstream toe or any other seepage drains on the dam? Yes______ No______
   If yes, describe the condition (for example, clogged, free flowing, deteriorated, good condition)/Corrective Action:______________________________

☐ 2. For drains, is an animal guard installed at the outlet of each drain? Yes______ No______
   If no, which drains lack animal guards?/Corrective Action:_____________________________________________________

☐ 3. For drains, measure the rate of flow from each drain and record below (use additional pages if necessary):

<table>
<thead>
<tr>
<th>Designation/Location of Drain</th>
<th>Flow Rate</th>
<th>Flow Rate in GPM*</th>
<th>Turbidity of Flow (describe – clear, muddy, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

☐ 4. Are there any piezometers on the dam? Yes______ No______
   If yes, describe the condition (for example, good condition, damaged, etc.)/Corrective Action:_____________________________________________________

↑ Check if corrective action is noted/required.
Embankment (Earth) Dam Inspection Form

Name of Dam: ___________________________ Date: ___________________________

☐ 5. For piezometers, does each piezometer have a cap with a lock? Yes____ No_____  
   If no, which piezometers need caps (to prevent rain water intrusion) and/or locks (to prevent tampering)? /Corrective Action:

☐ 6. For piezometers, are you able to take a measurement (depth to water) in each piezometer? Yes____ No_____  
   If yes, record depth to water (in feet) in each piezometer, record on a separate page, and attach to this form.

☐ 7. Are there any other monitoring devices on the dam? Yes_____ No_____  
   If yes, describe what type and the condition (for example, monitoring wells - good condition, damaged) /Corrective Action:

☐ 8. Other observations on instrumentation/Corrective Action: __________________________

G. Photographs
   At a minimum, photographs should be taken of the crest, upstream slope, downstream slope and any other notable features  
   including areas where corrective action is noted.
   List of photographs (be sure to date stamp the photos): __________________________

*GPM (gallons per minute): to convert from oz/sec multiply by 0.4688; to convert from ml/sec multiply by 0.01585

↑ Check if corrective action is noted/required.
ATTACHMENT 14 - SAMPLE cover sheet that could be utilized with Attachment 13

It is important to understand what to look for when inspecting a dam and the potential impact of noted deficiencies and how they might lead to failure of the dam. A recommendation for how to inspect the earthen dam is given below. You should keep the Potential Failure Modes in mind as you perform your inspection. Note that any deficiency may contribute to more than one Potential Failure Mode (e.g. seepage can lead to erosion of the dam and also impacts stability).

**Recommended Routine Monitoring Approach:**

1. Walk the dam crest along the upstream edge looking at the dam crest, upstream slope, and reservoir. – Look for sinkholes, depressions, etc., transverse cracks, longitudinal cracks, detrimental animal activity, wave action erosion at the upstream slope, and whirlpools in the reservoir.
2. Walk the dam crest along the downstream edge looking at the dam crest and downstream slope. – Look for any new or changed seepage conditions, sinkholes, depressions, etc., transverse cracks, longitudinal cracks, bulging areas or other deformations, and detrimental animal activity.
3. Walk along the abutment groins and downstream toe of the dam looking at the downstream slope, abutment areas, and areas downstream of the dam, with particular attention to the areas around the downstream end of the outlet works and spillway. – Look for any new or changed seepage conditions, sinkholes, depressions, etc., transverse cracks, longitudinal cracks, bulging areas or other deformations, and detrimental animal activity.
4. Walk the downstream area along a line no more than 50 feet downstream of the toe of the dam. – Look for any new or changed seepage conditions, sinkholes, depressions, etc., and detrimental animal activity.
5. Walk along the alignment of the spillway, from the inlet at the reservoir to the downstream end. – Look for any flow obstructions, erosion, and imperfections in the flow surfaces.
6. Check the outlet works and spillway for any operational problems or issues.

**Potential Failure Modes:**

1. Seepage flow that may erode foundation, abutment, or dam embankment material. (Note: Upstream to downstream seepage paths adjacent to pipes, conduits, concrete structures, etc. are of particular concern.)
2. Seepage failure during a flood
3. Seepage failure following earthquake
4. Slope instability causing loss of reservoir containment
5. Slope instability caused by earthquake
6. Dam overtopping and erosion failure of the dam embankment in a flood
7. Spillway erosion failure in a flood (either erosion failure of the spillway itself, or its foundation)
8. Other
Concrete or Masonry Dam Inspection Form

Name of Dam: ____________________________ Date: ____________________________

Location of Dam (County): ____________________________ Weather: ____________________________

Inspected by (Print Name): ____________________________

Type of Dam: Concrete______ Masonry______

A. Crest (refer to Glossary for description)
   1. How would you describe the surface condition of the crest?
      Good ______ Deteriorated ______ Damaged ______ Spalling (loss of surface concrete) ______
      Other (describe): _______________________________________________________________

   2. For dam crests that also serve as spillways, is there flow over the crest of the dam today? Yes____ No____
      If yes, describe the amount of flow (for example, normal flow, more or less than normal, etc.): ____________________________

   3. Are there any signs of displacement (horizontal or vertical movement) on the crest? Yes____ No____
      If yes, describe (extent, size, location, etc.): ______________________________________

   4. Are there any cracks on the crest? Yes____ No____
      If yes, describe (length and width, location, direction of cracking, etc.): ____________________________

   5. Other observations on the crest: _________________________________________________________

B. Upstream Face (refer to Glossary for description)
   1. What is the reservoir level today? At Normal Pool____ Above Normal Pool____ Feet Below Normal Pool____ Feet

   2. How would you describe the surface condition of the upstream face?
      Good ______ Deteriorated ______ Damaged ______ Spalling (loss of surface concrete) ______
      Other (describe): _______________________________________________________________

   3. Are there any indications of distress on the upstream face (unusual cracks, displacement, etc.)? Yes____ No____
      If yes, describe (size, location, etc.): _______________________________________________

   4. Are there any areas of concern along the abutment/dam contact at either end of the upstream face? Yes____ No____
      If yes, describe: ___________________________________________________________________

   5. Other observations on the upstream face: ________________________________________________

C. Downstream Face (refer to Glossary for description)
   1. How would you describe the surface condition of the downstream face?
      Good ______ Deteriorated ______ Damaged ______ Spalling (loss of surface concrete) ______
      Other (describe): _______________________________________________________________
ATTACHMENT 15 – Page 2 of 3

Downstream Face (continued)
2. Are there any indications of distress on the downstream face (unusual cracks, displacement, etc.)? Yes____ No____
   If yes, describe (size, location, etc.):__________________________________________

3. Are there any wet areas on the downstream face indicating seepage through or under the dam? Yes____ No____
   If yes, describe (for example, new area of seepage, no change from past observations, size of area, location):

4. Are there any leaks (flowing water) from the downstream face of the dam? Yes____ No____
   If yes, describe (location, estimated rate of flow):________________________________

5. Are there any areas of concern along the abutment/dam contact at either end of the downstream face? Yes_____ No_____ 
   If yes, describe:______________________________________________________________

6. Other observations on the downstream face:_____________________________________

D. Stilling Basin (refer to Glossary for description)
1. Are there any areas of concern in the stilling basin (such as damage, erosion, excessive debris, etc.)? Yes____ No____
   If yes, describe:______________________________________________________________

2. Other observations on the stilling basin:________________________________________

E. Principal and Emergency Spillways (refer to Glossary for description)
1. What types of spillways does the dam have (such as overflow section, concrete pipe, etc.)? 
   Principal Spillway:________________________ Emergency Spillway:____________________
   Other:____________________________________

2. Has the emergency spillway activated (had flow) since the last inspection? Yes____ No____
   If yes describe (date(s) of flow, reason for activation, depth of flow, erosion damage if any):

3. For pipe spillways, is the intake obstructed in any way (such as with excessive debris)? Yes____ No____
   If yes, describe (type of debris, reason for obstruction, condition of trash rack, etc.):

4. For pipe spillways, are there any visible cracks, separations or holes in the pipe(s) (intake or outlet)? Yes____ No____
   If yes, describe (location, width of crack or separation, etc.):

5. For pipe spillways, are there any apparent leaks in the pipe(s)? Yes____ No____
   If yes, describe (location, estimated rate of flow from leak, etc.):

6. For pipe spillways, how would you describe the overall condition of the pipe(s)?
   Functioning Normally____ Not Functional____ Deteriorated____ Damaged____ Adequate____ Inadequate____

7. For overflow spillways, are the entrance or channel obstructed in any way? Yes____ No____
   If yes, describe (type of obstruction, location, etc.):______________________________

Page 2 of 3
Concrete or Masonry Dam Inspection Form (continued)

Name of Dam: ____________________________ Date: ____________________________

Principal and Emergency Spillways (continued)

8. For overflow spillways, are there any cracks, holes or evidence of undermining in the spillway? Yes____ No____
   If yes, describe (width of crack or hole, location, indicators of undermining, etc.): __________________________________________

9. For overflow spillways, how would you describe the overall condition of the spillway?
   Functioning Normally____ Not Functional____ Deteriorated____ Damaged____ Adequate____ Inadequate____

10. Other observations on the spillways: __________________________________________

F. Instrumentation (refer to Glossary for description)

1. Are there any seepage drains or relief wells on the dam? Yes____ No____
   If yes, describe the condition (for example, clogged, free flowing, deteriorated, good condition): __________________________________________

2. For seepage drains, is an animal guard installed at the outlet of each drain? Yes____ No____
   If no, which drains lack animal guards? __________________________________________

3. For seepage drains, measure the rate of flow from each drain and record below (use additional pages if necessary):

<table>
<thead>
<tr>
<th>Designation/Location of Drain</th>
<th>Flow Rate</th>
<th>Flow Rate in GPM*</th>
<th>Turbidity of Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(describe – clear, muddy, etc.)</td>
</tr>
</tbody>
</table>

   |                              |           |                   |                  |

4. Are there any other monitoring devices on the dam (such as monitoring wells, settlement plates, etc.)? Yes____ No____
   If yes, describe what type and the condition (for example, monitoring wells - good condition, damaged): __________________________

5. Other observations on instrumentation: __________________________________________

G. Photographs

At a minimum, photographs should be taken of the crest, upstream face, downstream face and any other notable features.
List of photographs: __________________________________________

________________________________________

________________________________________

________________________________________

________________________________________

*GPM (gallons per minute): to convert from oz/sec multiply by 0.4688; to convert from ml/sec multiply by 0.01585
ATTACHMENT 16 - SAMPLE Dam Safety Inspection Checklist (from ASDSO website)
Page 1 of 3 (first of 19 pages of this document)

**Dam Safety Inspection Checklist**

**Complete All Portions of This Section (Pre-inspection)**

Date of Inspection: ____________________________

Name of Dam: ____________________________ File Number: ____________________________

EAP: (yes, no) OM&I: (yes, no)

**Review Inventory - Highlight missing information (Pre-inspection)**

Owner(s) Name(s): ____________________________

Address: ____________________________

City: ____________________________ State: __________ Zip (+4): __________

Telephone (Home): ____________________________ Telephone (Work): ____________________________

Contact Person: ____________________________ Telephone: ____________________________

Designed By: ____________________________

Constructed By: ____________________________

Year Completed: ____________________________ Plans Available (Yes, No) (location): ____________________________

Purpose of dam: ____________________________

**Interview with Owner (at the site):**

Owner/Representative present: (Yes, No) Name(s): ____________________________

Double check address, telephone #, purpose (check ->) G

How long have you owned dam - previous name/owner? ____________________________

EAP/OM&I: up-dated-(yes, no) & location: ____________________________

Operate lake drain (times per year, accessibility): ____________________________

Mowing (times per year): ____________________________

Prior problems (wet areas, erosion, slides): ____________________________

Repair or modification (what & when): ____________________________

Failure/Incident/Breach (max. pool): ____________________________

Downstream hazard status (recent changes): ____________________________

Do you know the in-depth details of the construction of your dam? (If yes - ask next three questions, if no - go to Field Information Section)

Core trench material and location: ____________________________

Volume of fill (earth or rock) in dam: ____________________________

Foundation (earth or rock) of dam: ____________________________

**Field Information (while at site)**

Pool Elevation (during inspection): ____________________________ Time: ____________________________ (a.m. p.m.)

Site Conditions (temp., weather, ground moisture): ____________________________

Inspection Party: ____________________________

Maximum Height: ____________________________ (measured or inventory appears correct)

Normal Pool Surface Area: ____________________________ (measured or inventory appears correct)
**UPSTREAM SLOPE**

Gradient: Horizontal: Vertical: (est. mess.)

- **Vegetation** [no problem]
  - Trees: Quantity: (<5, sparse, dense)
    - Diameter: (<6", 6-12", >12")
    - Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
      - Notes:
  - Brush: Quantity: (sparse, dense)
    - Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
      - Notes:
  - Ground Cover: Type: (grass, crown vetch) Other:
    - Quantity: (bare, sparse, adequate, dense)
    - Appearance: (too tall, too short, good)
      - Notes:

- **Slope Protection** [no problem, could not inspect thoroughly]
  - None
  - Riprap: Average Diameter: (adequate, sparse, displaced, weathered, vegetation) (bedding/fabric noted - yes, no)
    - Notes:
  - Wave Berm:
    - Vegetation: (adequate, bare, sparse, improper vegetation)
      - Notes:
  - Concrete Slabs: (cracked, settlement, undermined, voids, deteriorated, vegetation)
    - Notes:
  - Other:
    - Notes:

- **Erosion** [no problem, could not inspect thoroughly]
  - Wave Erosion (Beaching): Scarp: Length: Height:
    - Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
      - Notes:
  - Runoff Erosion (Gullies): Quantity:
    - Depth: Width: Length:
      - Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
        - Notes/Causes:

- **Instabilities** [no problem, could not inspect thoroughly]
  - Slides: Transverse Length: Longitudinal Length:
    - Scarp: Width: Length:
      - Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
    - Crack: Width: Depth:
      - Notes/Causes:
  - Cracks: □ Transverse □ Longitudinal □ Other
    - Quantity: Width: Length: Depth:
      - Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
        - Notes/Causes:

(Upstream Slope, Crest, Downstream Slope, Seepage, Principal Spillway, Emergency Spillway, Lake Drain)
ATTACHMENT 16 – Page 3 of 3 (3rd of 19 pages of this document)

DAM CLASSIFICATION CHECKLIST

<table>
<thead>
<tr>
<th>Name of Dam:</th>
<th>File Number:</th>
<th>Permit Number:</th>
<th>Engineer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>County:</td>
<td>Date:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HEIGHT**

- Height of dam as measured: _______ feet
- Storage volume at top of dam: _______ acre feet

- □ > 60’ - Class I
- □ > 40’ - Class II
- □ > 25’ - Class III
- □ ≤ 25’ - Class IV

**STORAGE**

- □ > 5000 acre-feet - Class I
- □ > 500 acre-feet - Class II
- □ > 50 acre-feet - Class III
- □ ≤ 50 acre-feet - Class IV

**EXEMPT**

- □ Storage ≤ 6 feet
- □ Storage ≤ 15 acre-feet
- □ 6 feet < Height < 10 feet
- □ Volume < 50 acre-feet

**POTENTIAL DOWNSTREAM HAZARD**

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>X</th>
</tr>
</thead>
</table>

- Loss of human life (plausible circumstances envisioned to cause loss of life)
- A possible health hazard (loss of public water treatment facility)
- Damage to public facilities (health hazard, damage to Class I, II, III dams)
- Damage to pipelines & public utilities
- Damage to rural roads & not otherwise high-value property
- Damage to local roads (county & town)
- Damages to buildings
- Damages to structures
- Damages to structures
- Damages to structures
- Damages to structures
- Damages to structures
- Damages to structures
- Damages to structures
- Damages to structures
- Estimated Population at Risk ______

Height Class _____ Storage Class _____ Hazard Class _____

**Final Class:**  Exempt I II III IV (circle one)  Class Changed (Yes, No)
ATTACHMENT 17 - FACT Sheet – Dam Inspections by Owner
Page 1 of 2
(example information and guidance from the state of Pennsylvania regarding required dam surveillance by dam owners/operators, from Appendix C – FEMA/ASDSO Model Dam Safety Program)

Fact Sheet
Commonwealth of Pennsylvania • Department of Environmental Protection

DAM INSPECTIONS BY OWNERS

Although all Hazard Potential Category 1 or 2 (i.e., "High Hazard") dams must be inspected annually by a registered professional engineer, dam owners in Pennsylvania are required to inspect their dam(s) at least once every three months. A manual entitled The Inspection, Maintenance and Operation of Dams in Pennsylvania is available upon request from the Division of Dam Safety.

The Inspection
It is helpful to prepare an inspection route in advance to assure that every part of the dam will be observed. The following is a recommended sequence to assist you in your inspection:

CREST - Walk across the crest from abutment to abutment.

UPSTREAM/DOWNSTREAM SLOPE - Walk across the slope in an up and down or zigzag pattern from abutment to abutment.

EMBANKMENT-ABUTMENT CONTACTS - Walk the entire length of the embankment-abutment contacts (groin).

OUTLET CONDUIT - Observe all accessible features of the outlet conduit.

SPILLWAY - Walk along the entire length of the spillway in a back and forth manner.

ABUTMENTS - Traverse abutments in a practical manner so as to gain a general feel for the conditions which exist along the valley sidewalls.

DOWNSTREAM CHANNEL - Travel the route of the stream below the dam to maintain familiarity with locations of residences and property which can be affected by dam failure.

DOWNSTREAM TOE - Walk the entire length of the downstream toe.

RESERVOIR SLOPES - Scout the reservoir perimeter in an effort to develop an overall familiarity with its conditions.

What To Look For
The following is a partial list of some of the conditions a dam owner may discover. This list does not cover all of the problems which may be encountered.

SETTLEMENT
SINKHOLES
SEEPS
TURBID DISCHARGE

STRUCTURAL CRACKING
ANIMAL BURROWS
EXCESSIVE VEGETATION
FOUNDATION MOVEMENT

EROSION
DEPRESSIONS
BOILS
VANDALISM

54
Keeping Records

It is important for the dam owner/operator to keep records throughout the existence of the dam. Accurate records can better illustrate the dynamic nature of the structure.

DEP requires the dam owner to establish a permanent file to retain inspection records including records of actions taken to correct conditions found in such inspections. The following items will aid the dam owner/operator in keeping good records.

Inspection Checklist - A convenient way of compiling inspection observations is by recording them directly onto an inspection checklist. The checklist should be attached to a clipboard and carried by the dam inspector as he/she traverses the entire structure. Copies of the checklist can be obtained by contacting DEP.

A good practice to follow along with filling out the inspection checklist is to draw a field sketch of observed conditions. The field sketch is intended to supplement the information recorded on the inspection checklist; however, it should never be used as a substitute for clear and concise inspection checklists.

Photographs - Inspection photographs can be vitally important. Over time, photographs serve to provide a pictorial history of the evolving characteristics of a dam. The dam owner/operator often finds them to be great money savers because they can illustrate that some observed conditions (seepage, foundation movement, etc.) have existed for many years and may have reached a state of equilibrium. With this knowledge, quick and economical remedial actions can be developed and implemented. Photographs should be dated on the back and provided with brief descriptions of the locations shown in the pictures.

Monitoring Data - As previously indicated, it may become necessary to make measurements of various items during the course of a dam inspection. This may include measurements of seepage rates, spillway discharge rates, settlement, and for some dam owners, readings from instruments such as piezometers. It is important that this data also be compiled in a systematic manner and placed in a permanent file.

Accompany Your Engineer During Annual Inspections

Many engineers encourage dam owners or operators to accompany them, or even assist them, on annual dam inspections. Also, many owners accompany department engineers during our periodic inspections. Owners can learn many things from experienced inspectors such as:

- What to look for;
- How to photograph certain features of a dam;
- What records to keep; and
- How to read different types of instrumentation.

For more information contact:

Department of Environmental Protection
Bureau of Waterways Engineering
Division of Dam Safety
P.O. Box 8554
Harrisburg, PA 17105-8554
(717) 787-8568

For more information, visit DEP’s Web site at www.depweb.state.pa.us. Keyword: “Dam Safety.”
The Association of State Dam Safety Officials (ASDSO) Board of Directors approved and submits this addendum to the USSD white paper entitled, *Dam Safety Monitoring Training for Dam Operating Personnel* (white paper), on behalf of the its Technical Training and Dam Owner Education Committees.

ASDSO believes it’s important to present consistent messages, avoid duplication of effort, and coordinate as much as possible with regard to educating dam owners. In this spirit of cooperation and coordination, ASDSO is providing the following comments:

Training and education, for all stakeholders within the dam safety community is essential. ASDSO considers training and education of dam owners, operators, and their independent engineers as a main objective within our mission. The ASDSO 2017-22 Strategic Plan says this: “As regulatory inspections alone do not make dams safe, owners play a key role in dam safety and are ultimately liable for dam failures or mis-operation. While all levels of government own some dams, the majority are privately owned. Outreach to dam owners will be an important element over the next five years for ASDSO.”

The paper accurately spells out the dam owning and regulatory backdrop that shapes the issues and recommendations put forth. ASDSO endorses the basic premise of the paper and agrees that there remain significant gaps in knowledge and understanding by dam owners and their staffs or hired engineers when it comes to on-site inspection and monitoring.

ASDSO agrees that there is a gap in training on Potential Failure Mode Analysis (PFMA) – many non-federal, non-FERC regulated dam owners are unaware of this technique, or do not have the financial resources to conduct a PFMA. Tying the inspection and monitoring of dams to their possible failure modes should be stressed to dam owners so that their inspection efforts are focused in the right places.

The appendices created by the committee are valuable. The tools are immediately usable by regulators, owners, and their engineers. The authors clearly worked hard to create these.

There is a subset of recommendations put forward that may be challenging, counter-productive and politically unrealistic. For instance, one recommendation suggests that states could apply penalties or reduce water levels for non-participating owners. This recommendation would be difficult to implement since many states would need to enact legislative and regulatory changes to advance the use of a credit for participation, or a
reservoir reduction for non-participation in the dam inspection. Further, state programs that depend on revenue from fees cannot afford a reduction in funding. ASDSO recommends that this recommendation be removed from the paper if possible.

Finally, providing a comprehensive on-site training program would most likely be cost-prohibitive.

There are less challenging and less costly ways of closing this gap in owner/operator education. Incentivizing owners is a great idea, so it is important to think further about what will really work.

Finally, it is recommended that additional emphasis be placed on the need for owners to periodically review design documents, as pointed out in lessons learned identified in the Oroville Spillway Forensic Team Report.

The following observations and implementation ideas are respectfully offered:

State Dam Safety regulatory officials must continue to adopt and communicate policies that improve the technical knowledge base of dam owners, their operators, and independent engineers. Further, as many State Dam Safety regulatory programs are part of larger agencies that also own dams, it is very important to lead private dam owners by example. State Dam Safety regulators need to facilitate the continuous implementation of improved policies, best practices, and training, with the dam owner/operator groups within their respective state governments.

The national guideline that steers best practices for States is the FEMA, National Dam Safety Program, Model State Dam Safety Program. (FEMA 316). ASDSO and the FEMA, National Dam Safety Review Board have identified the need for an updated Model State Dam Safety Program. When the update is undertaken, new procedures and recommendations should be included to guide States on developing and funding more comprehensive training programs for dam owners, operators, and their independent engineers. The new guidance should discuss options for incentivizing owners/operators to be present during annual dam safety inspections by professional engineers, for attending classroom or web-based courses, and for improving their operating plans to include detailed monitoring procedures (the model checklists provided in this White Paper could be offered).

ASDSO and USSD may want to encourage the FERC leadership to review the Owner’s Dam Safety Program (ODSP) guidance materials to make sure they include recommendations on operator/engineer on-site training.

Another national guide that can be updated is the FEMA Pocket Safety Guide for Dams and Impoundments (FEAM P-911). Building on the example checklists created for the
white paper, the guide could be improved. This would have to go to the FEMA National Dam Safety Program for final approval.

Finally, at the Federal level, the FEMA-produced Dam Owner’s Guidance Manual (FEMA 145), an older product of the National Dam Safety Program, is currently being reviewed by the ASDSO Owner Education Committee for potential update. ASDSO will incorporate the recommendations for improved dam owner visual monitoring into any updates that are put forward and invites members of the USSD committee to serve on a task group to complete this project. This would have to go to the FEMA National Dam Safety Program for final approval.

The White Paper includes 16 attachments with many different versions of dam safety checklists. A potential project is for ASDSO/USSD to develop a more standardized dam safety checklist for both regular and informal inspections that can be placed in the Model Dam Safety Program and ASDSO’s dam owner website.

ASDSO will consider developing, as part of its technical webinar series, a webinar for regulators and engineers on the importance of better on-site monitoring training for dam owners and operators. The discussion could center on the non-PFMA inspection checklists outlined in the USSD White Paper, as well as the need to have the professional engineer, while performing the required annual inspection, discuss the value of the non-PFMA indicators with the dam operators.

ASDSO will incorporate the following updates into its dam owner education program. Our outreach includes website resources, guidance documents and flyers, the owner education classroom workshops, and a new initiative to develop a series of webinars for dam owners/operators. Within these projects, there are many areas where we can focus attention on the points being made in the paper.

ASDSO will review its three one-day classroom course to more clearly emphasize the need for routine visual inspections and monitoring programs by owners and a “101” on the PFMA process.

Similarly, ASDSO will incorporate these additions into its webinar series. The new ASDSO Dam Owner Academy Webinar Program will be a series of free, one-hour online courses and it will look like this:

1. Dams 101
2. Inspecting Dams for Owners and Operators
3. Operation and Maintenance
4. Controlling Plants and Animals
5. Understanding Spillways and Outlet Works (drains, gates, valves, conduits)
6. Outlet Works Maintenance and Repair
7. Spillway Maintenance and Repair
8. Introduction to Seepage, Slope Stability and Seismic Issues
9. Understanding Extreme Weather Events (Hydrology)
10. Hiring an Engineer and a Contractor
11. Overview of Dam Rehabilitation
13. Improving Public Safety Around Your Dam(s)
15. Lessons Learned from Dam Failures
16. An Overview of Best Practices in Dam Ownership (including available tools and resources)
   16A. Focus in Best Practices: The Dam Owners’ Emergency Intervention Toolbox

We proposed to add one or two additional webinars, most likely under Topic 16, on the importance of and how to do proper routine visual inspections and a “101” on potential failure modes. There could be one on the use of checklists and an overview of available checklists for owners/operators. Existing webinar outlines will be reviewed and updated to include instruction and emphasis on being present for routine safety inspections.

We propose to enhance the ASDSO website, which includes a resource center for dam owners, to include information about dam owners being present during inspections, the need for PFMA discussions, need for dam operator training, implementation of informal dam inspection checklists which can also recognize that small dam owners may not have the ability to perform a PFMA but can incorporate the non-PFMA checklist for those formal inspections.

ASDSO will communicate with state dam safety inspectors and dam owners about the importance of improving safety at and around the dam while performing dam inspections.

ASDSO pledges to advocate for the inclusion of these improvements.