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THE MINE SAFETY AND HEALTH ADMINISTRATION

Metal and Nonmetal Mine Dams

Advance Notice of Proposed Rulemaking

75 Fed. Reg. 44429 (August 13, 2010)

COMMENTS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS*

December 13, 2010

* ASCE was founded in 1852 and is the country's oldest national civil engineering organization. It represents more than 140,000 civil engineers individually in private practice, government, industry, and academia who are dedicated to the advancement of the science and profession of civil engineering. ASCE is a non-profit educational and professional society organized under Part 1.501(c) (3) of the Internal Revenue Code.

PROPOSED RULES
DEPARTMENT OF LABOR
Mine Safety and Health Administration

30 CFR Parts 56 and 57

RIN 1219-AB70

Docket ID: MSHA-2010-0004

Metal and Nonmetal Dams

75 Fed. Reg. 49428

I. SUMMARY

The American Society of Civil Engineers (ASCE) is pleased to comment on the advance notice of proposed rulemaking of August 13, 2010, by the Mine Safety and Health Administration (MSHA). The ANPRM begins a long-overdue agency review of existing federal safety standards for dams at metal and nonmetal mines to protect miners from dam failures.

II. STATUTORY BACKGROUND

Congress established mandatory federal worker safety standards for coal miners under the Federal Coal Mine Health and Safety Act of 1969. In 1977, Congress enacted the Federal Mine Safety and Health Act, Pub.L. 95-164, Nov. 9, 1977, 91 Stat 1290 (codified at 30 U.S.C. §§ 801-965), to create the MSHA and expand the 1969 law's coverage to regulate the safety of workers at metal and nonmetal mines.

The Act protects miners, not the general public, from unsafe conditions at coal and other mines. The MSHA has no specific duty to protect the public from mining hazards. "Congress has declared that the first priority and concern of all in the coal or other mining industry must be the health and safety of its most precious resource—the miner." Solis v. Manalapan Min. Co., Inc., CIV. 10-115-GFVT, 2010 WL 2197534 (E.D. Ky. May 27, 2010) (quoting 30 U.S.C. § 801).

Nevertheless mine impoundment failures can threaten public safety. In February 1972, several coal waste impoundments in West Virginia failed and released 130 million gallons of water and coal slurry. The accident left 124 people dead and 4,000 homeless. Property damage was estimated to be $50 million dollars with 546 homes destroyed and 538 homes damaged. See D.E. Stump, Coal Mine Impoundment Safety, ASCE CONF. PROC. 138, 351 (2004).

Following state common law precedents, the Act broadly defines a "mine" to encompass any facility "from which minerals are extracted." 30 U.S.C. § 802(h) (1) (A). A mine includes "lands, excavations, underground passageways, shafts, slopes, tunnels and workings, structures, facilities, equipment, machines, tools, or other property[,] including impoundments, retention dams, and tailings ponds, on the surface or underground, used in, or to be used in, or resulting from, the work of extracting such minerals from their natural deposits in nonliquid form." Id. § 802(h) (1) (C).[1]

III. METAL AND NONMETAL MINING

The MSHA has jurisdiction over miner safety at 12,500 metal and nonmetal mines nationwide. Mine Safety and Health Administration, Mine Injury Fact Sheets, http://www.msha.gov/MSHAINFO/InjuryRates/InjuryRateshome.asp (last visited Sept. 16, 2010). These mines have approximately 1,600 dams holding back mine tailings and other wastes. Federal Emergency Management Agency, Dam Safety in the United States 50 (February 2009).[2]

Although mining is considered one of the world's most dangerous occupations, death and injuries to miners in all types of mines are declining. The agency has documented safety gains in metal and nonmetal mining. There were an average of 233 deaths yearly in the 1930s, compared to 32 fatalities between 2001 and 2005. Mine Safety and Health Administration, Injury Trends in Mining, http://www.msha.gov/MSHAINFO/FactSheets/MSHAFCT2.HTM (last visited Sept. 16, 2010).

IV. DAMS AT METAL AND NONMETAL MINES

Dams at metal and nonmetal mines typically are not used to provide irrigation or generate hydroelectric power. Rather, mine dams are most often earthen structures that surround reservoirs or retention ponds that contain mining wastes or "tailings," the material generated in the removal of minerals from the ground.

> As ore or aggregate is washed or treated with water or chemicals, some waste refuse is created. This refuse is classified as either

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[1] Based on section 802(h), the MSHA has authority to establish dam safety standards to protect miners from the failure of dams that are essential to mining operations. Secretary of Labor v. W.A. Morris Sand and Gravel, 18 FMSHRC 278, 1995-1997 O.S.H.D. (CCH) P 31004, 1996 WL 75558 (F.M.S.H.R.C.) (concluding that a retention dam that prevented the flooding of a copper mine was "integrally related to the extraction of copper").

[2] Another 650 dams are located at the nation's 2,000 coal mines. FEMA, Dam Safety. These dams are covered by separate MSHA rules.

> [coarse] or fine. Larger materials such as rocks and pieces of ore are defined as [coarse] refuse. Slurry, a combination of silt, dust, water, and bits of ore and clay particles, is considered fine refuse. Slurry is the most commonly disposed of material held in an impoundment. Waste materials, consisting of mostly fine and some coarse refuse, are deposited in impoundments or tailings dams on mine sites. Any structure on a mine or mill site is considered to be an impoundment or tailings dam when it contains mine or mill waste.

MSHA, Metal and Nonmetal General Inspection Procedures Handbook 32 (October 2009).

Some mine operators construct retention dams, which resemble levees used to control flooding in a floodplain. These dams are engineered structures of a fixed size and constructed with an impervious core. Environmental Protection Agency (EPA), Design and Evaluation of Tailings Dams 6 (August 1994).

Unlike retention dams, impoundment dams are not static; they grow taller layer by layer around the impoundment as the mine produces more tailings and the waste volume in the reservoirs increases. "The reservoir gradually fills with the settled material and typically the dam is then raised as needed to create capacity for more waste disposal. This process occurs with a dam, or multiple dams, over the life of the mine." E-mail from John Fredland, Dam Safety Officer, MSHA, to Michael Charles, Senior Manager, Government Relations, ASCE (Sept. 10, 2010, 05:13 p.m. EDT).

Although existing MSHA policies do not establish a maximum safe design height for the dams, mine impoundments can become quite large. "At some projects, tailings embankments reach several hundred feet in height and the impoundments cover several square miles." EPA, Tailings Dams 1.

The impoundments generally are of three types: cross-valley, side-hill and diked. The cross-valley and side-hill impoundments typically are surrounded on three sides by a dam and built on slopes. They retain the waste and slurry uphill, with the uphill slope forming the fourth side of the impoundment. Diked impoundments are built on level ground and are surrounded on four sides by the dam. MSHA, Inspection Handbook at 32.

MSHA inspection procedures define three types of hazard category and require all dams to be assigned to one of the three. Significantly, however, the MSHA says that the mine owner or designer, <u>not</u> the MSHA, must assign the hazard category to the dams.

The agency defines "high hazard potential" as dams, regardless of their condition or size, whose failure will probably cause loss of life. "Significant hazard potential" refers to dams, regardless of their condition or size, whose failure would result in no probable loss of life but would disrupt important utilities or cause significant economic loss or significant environmental damage. Memorandum from Neal H. Merrifield, Acting Administrator, Mine Safety and Health Administration (Sept. 14, 2009), http://www.msha.gov/regs/complian/PILS/2009/PIL09-IV-1.asp

"Low hazard potential" are dams that meet a minimum size criterion and whose failure would not be expected to cause loss of life, disrupt important utilities, or cause significant economic loss or significant environmental damage. To qualify as a low-hazard dam under the agency's guidelines, the dam must be at least 25 feet in height from toe to crest and store at least 15 acre-feet (approximately 4.8 million gallons) or be at least six feet high and store 50 acre-feet (approximately 16 million gallons). Id.

In 1985—eight years after Congress mandated federal safety regulations to protect workers at metal and nonmetal mines—the Secretary for the first time adopted a dam safety rule. Quoted in its entirety, the dam standard states: "If failure of a water or silt retaining dam will create a hazard, it shall be of substantial construction and inspected at regular intervals." Recodification of Safety and Health Standards for Metal and Nonmetal Mines, 50 Fed. Reg. 4048 (1985) (codified at 30 CFR § 57.20011).[3]

In the absence of detailed technical or engineering requirements for the dams, the agency has issued procedural guidelines for the inspection of all potential work safety hazards at the dams.[4]

V. CURRENT MSHA IMPOUNDMENT REGULATIONS

The Mine Safety and Health Administration currently regulates the safety of coal miners through standards applicable to coal slurry impoundments. The regulations at 30 C.F.R. §§ 77.216-77.216.5 establish federal criteria for the design, construction and maintenance of structures that impound water. The rules apply to impoundments five feet or more in height, that have a storage volume of 20 acre-feet or more or that, in MSHA's estimation, "present a hazard to coal miners."

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[3] Safety standards for dams at coal mines were strengthened in 1975 to require, among other things, that a licensed Professional Engineer (PE) certify the dam's design. See 30 C.F.R. § 77.216-2 (a) (17). In a 2009 poll of mine owners, EPA found that 70 percent of 629 surface impoundments at 228 coal mines had been designed by a PE. 75 Fed. Reg. 64974, 64975 (Oct. 20, 2010).

[4] Seven states—Alaska, Arizona, California, Colorado, Florida, Idaho and Oregon—have adopted specific technical engineering and inspection standards for impoundments containing mine tailings from metal and nonmetal mines. Thirteen states have adopted separate regulations for impoundments storing coal mine tailings. Idaho regulates impoundments at metal mines and coal mines under the same standards.

The rules include inspection, recordkeeping and reporting requirements as well as specifications for managing abandoned impoundments.

The Environmental Protection Agency considers the MSHA standards for slurry impoundments to be reasonable for storage units containing coal combustion residues (CCRs). The EPA has proposed a rule that would adopt the MSHA requirements for CCR units under the Resource Conservation and Recovery Act (RCRA).[5]

VI. ASCE RESPONSES TO AUGUST 13 ANPRM

In its August 13 advance notice of proposed rulemaking, the MSHA said that dam failures at some of the dams located at metal and nonmetal mines "have damaged property and equipment, but no deaths or serious injuries have occurred." 75 Fed. Reg. at 49430. Nevertheless, "MSHA investigators have found that design, construction, operation, or maintenance deficiencies have contributed to failures of dams at metal and nonmetal mines and exposed miners to hazards." Id.

The August 13 notice says that the MSHA needs answers to 36 questions before it can undertake a formal rulemaking to upgrade the safety standards for metal and nonmetal mine dams. Because ASCE's expertise is based on its engineering knowledge, we will answer to the best of our ability those questions that pertain directly to or implicate the engineering of safe dams.

A. Design and Construction of Dams

The MSHA regulations ought to begin with the design and construction elements required in its regulations for coal slurry impoundments, which the EPA proposes to adopt for coal combustion disposal units. At the same time, MSHA should carefully assess the utility of the standards outlined in the technical report on mine tailings impoundments published by the Environmental Protection Agency. EPA, Design and Evaluation of Tailings Dams (August 1994).

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[5] Environmental Protection Agency, Hazardous and Solid Waste Management System; Identification and Listing of Special Wastes; Disposal of Coal Combustion Residuals from Electric Utilities, 75 Fed. Reg. 35128 (June 21, 2010) ("MSHA has nearly 40 years of experience writing regulations and inspecting dams associated with coal mining, which is directly relevant to the issues presented by CCRs in this rule. In [EPA's] review of the MSHA regulations, we found them to be comprehensive and directly applicable to the dams used in surface impoundments at coal-fired utilities to manage CCRs. We also believe that, based on the record compiled by MSHA for its rulemaking, and on MSHA's 40 years of experience implementing these regulations, these requirements will prevent the catastrophic release of CCRs from surface impoundments, as occurred at TVA's facility in Kingston, Tennessee, and will generally meet RCRA's mandate to ensure the protection of humans and the environment.")

Because the earthen-walled tailings ponds at metal and nonmetal mines closely resemble surface impoundments that manage hazardous wastes,[6] the MSHA should adopt specific design and operating requirements that match in some respects existing federal regulations governing hazardous waste surface impoundments. 40 C.F.R. § 265.220 et seq.[7] These requirements are stringent due to the inherently hazardous nature of the wastes retained by the impoundments, but they do not conflict with the rules for coal slurry impoundments.

The tailing impoundment must maintain enough freeboard to prevent any overtopping of the dike by overfilling, wave action, or a storm. There must be at least two feet of freeboard. A freeboard level less than two feet may be permitted in cases where the owner or operator obtains certification by a Professional Engineer (PE) that alternate design features or operating plans will, to the best of his knowledge and opinion, prevent overtopping of the dike. The certification, along with a written identification of alternate design features or operating plans preventing overtopping, must be maintained at the facility. Id. § 265.221 (f)-(g). Each dam or dike should have "a protective cover, such as grass, shale, or rock, to minimize wind and water erosion and to preserve their structural integrity." Id. § 265.223.

Embankments and dams must be designed to ensure that the "resisting forces"—the strength of the underlying soil—must be greater than the "driving forces" imposed upon it, that is, the weight of the dike or dam and the pressure of the water acting against it.

Moreover, the design must consider the "factor of safety" against a failure's occurring, which is the ratio of the shear resistance of the soil divided by the shear force that develops along a potential sliding surface. If the factor of safety is less than one, failure will occur. Because the factor of safety is directly proportional to the soil strength, determining the soil strength is one of the most important decisions that an engineer makes for dam and impoundment design. For example, Army Corps of Engineers design guidance documents call for a target factor of safety of at least 1.4 to 1.5 for under long-term conditions. This minimum factor should be incorporated in any design standards for metal and nonmetal dams.[8]

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[6] A "surface impoundment" is a waste management unit that is a natural topographic depression, a man-made excavation, or a diked area formed primarily of earthen materials (although it may be lined with man-made materials), which is designed to hold an accumulation of liquid wastes or waste containing free liquids, and which is not an injection well. 40 C.F.R. § 61.341 (emphasis added).

[7] Mine tailings need not be regulated as RCRA hazardous wastes in order for MSHA to adopt RCRA's design requirements for hazardous-waste impoundments at mining facilities.

[8] A safety factor alone will not reveal design flaws or prevent failure. John T. Christian et al., Reliability Related to Factor of Safety and Uncertainty, ASCE CONF. PROC. 336, 48 (2009) ("[D]ifferent computational techniques yield different factors of safety, even for identical slopes, soils, and failure mechanisms. In summary, before one can state the appropriate value of the factor of safety, one must know the context in which the factor is computed.")

The MSHA should establish uniform federal standards for determining the hazard potential for all metal and nonmetal mine dams. The hazard potential should be based on the height of the dam and its storage capacity. See 33 C.F.R. § 222.6, App. D (Recommended Guidelines for Safety Inspection of Dams).

For "high hazard potential" and "significant hazard potential" structures, mine owners or operators should be required inspect the freeboard level at least once each operating day. The surface impoundment, including dikes and vegetation surrounding the dike, ought to be inspected at least once a week to detect any leaks, deterioration, or failures in the impoundment. 40 C.F.R. § 265.226. All inspections for "low hazard potential" embankments ought to be required no less often than once a month. Every inspection ought to be carried out by a Professional Engineer licensed in the state in which the dam is located.

The MSHA should consider requiring the use of geosynthetics in the design and construction of various mining facilities for process solution containment (heap leach pads, solution ponds and tailings impoundments), foundation stabilization and support, and reclamation.

Due to the nature and location of mining projects, the performance envelope of geosynthetic materials is often pushed beyond the limits of typical design procedures, testing, and construction methods. Common issues addressed in mining applications include: (1) geomembrane liner and plastic pipe performance under very high loads (in excess of three Megapascals [MPa]); (2) solution containment liner systems founded on compressible fills; (3) liner construction under harsh environments; and (4) foundation stabilization over historic mine workings. J. F. Lupo and K. F. Morrison, Innovative Geosynthetic Liner Design Approaches and Construction in the Mining Industry, ASCE Conf. Proc. 166, 18 (2005).[9]

To cope with these harsh conditions, innovative testing, design and construction approaches have been developed. A non-standard laboratory liner-load testing frame is used to define the performance of the liner under high loads. This test frame is also used to evaluate the performance of the over- and under-liner materials. High-load interface shear tests are also used to assess stability of the liner system. The performance of plastic pipe under high loads is evaluated using a modified analytical method that accounts for arching effects in the over-liner material and acceptance of high deformation in the pipe cross-section. Methods to evaluate liner foundation deformation are also discussed with an emphasis on construction [and] stabilization. In addition, considerations for liner deployment and placement in harsh climatic conditions are discussed. Id.

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[9] Composite liners using geosynthetics are an excellent way to contain waste and leachate, but they need to be carefully designed, installed and monitored due to the potential for slope failure. See George M. Filz et al., Progressive Failure of Lined Waste Impoundments, 127 ASCE J. OF GEOTECH. & GEOENVT'L. ENGRG. 841 (2001).

The agency also needs to consider federal employee safety standards for unused or abandoned mine impoundments, including the issue of whether to require the removal of the waste tailings from old mine sites or their permanent containment on-site. Closure and post-closure care standards will be especially important if mining operations are still being conducted near the unused impoundments, regularly exposing workers to potential threats from the failure of the closed reservoirs. These closure requirements would need to take account of complex environments.[10]

All dams should be designed by licensed Professional Engineers (PEs) and subjected to an independent peer review by a PE with no connection to the project. In addition, the MSHA should conduct concurrent engineering reviews within the agency to ensure that each design meets the required engineering standards for dams. Experience in design of other critical life-safety structures, such as large dams or nuclear power plants, has demonstrated that external peer review can be extremely effective in assuring quality design and in embedding an appropriate margin of safety into the culture of the design process.

To ensure that dams are designed and built to protect worker safety to the maximum extent practical, independent peer reviews should be conducted on all dams in which performance is critical to a safe working environment; the reliability of performance under emergency conditions is critical; innovative materials or techniques are used; for projects lacking redundancy in the design; or for projects that have unique construction sequencing or a short or overlapping design and construction schedule.

All dam design specifications must include a requirement for site investigation reports and boring logs, laboratory test data, design memoranda (including original design calculations and analyses), as-built section specifications and details, and maintenance and field inspection records.

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[10] To cite one example in the recent literature, bauxite residues are known leave the mining process stream as a highly alkaline slurry with low solids content, rendering their land disposal a difficult issue. A study was conducted to develop a methodology for environmentally safe dry disposal of bauxite residues in abandoned mine open pits. The methodology included dewatering and controlled disposal of bauxite residues, capping with waste rock or treated bauxite residues and, finally, development of a vegetation cover. This methodology was mainly based on bauxite residue properties, which possess low hydraulic conductivity if compacted at optimum moisture content. Based on the results, the main risk due to bauxite residues disposal was associated with the alkalinity of the material and initially high Na and Al concentrations in the leachate that progressively decreased due to the depletion of these elements. The field tests and simulation indicated that the amount of drainage water would be minimal—about three percent of the annual precipitation. Anthimos Xenidis and Dimitrios Boufounos, Dry Disposal of Bauxite Residues in Abandoned Mine Open Pits, ASCE CONF. PROC. 309, 5 (2008).

The agency should require the mine owner or operator to retain the engineer who designed the impoundment to make regular inspections of the dam during construction. Additionally, the engineer should reassess previous engineering calculations whenever the original design height and loads at the impoundment dams are changed during regular mining operations.

To repeat, all dams should be designed by licensed Professional Engineers (PEs) and subjected to an independent peer review by a PE with no connection to the project. The PE who designed and sealed the plans for the dam should remain as an independent consultant to the mine operator during construction and conduct regular inspections to ensure that the plans are followed.

The technical investigations should be conducted under the direction of licensed Professional Engineers who are experienced in the investigation, design, construction and operation of dams, impoundments, levees and related structures and who are able to apply the disciplines of hydrologic, hydraulic, soils, structural and geotechnical engineering, and engineering geology. All field inspections should be conducted by qualified engineers, engineering geologists and other specialists, including experts on mechanical and electrical operation of gates and controls, knowledgeable in the investigation, design, construction and operation of dams.

Following a technical investigation, hazardous conditions should be reported immediately upon detection to the owner of the dam and the appropriate state regulatory agency without delay for preparation of the formal report. A formal report should be prepared for each dam investigated for submission to the regulatory agency and the owner of the dam. Each report should contain the signature and registration identification of the professional engineer who directed the investigation and who was responsible for evaluation of the dam should be included in the report.

At a minimum, the reports should contain the following information:

1. Description of dam including regional vicinity map showing location and plans, elevations and sections showing the essential project features and the size and hazard potential classifications.

2. Summary of existing engineering data, including geologic maps and information.

3. Results of the visual inspection of each project feature including photographs and drawings to minimize descriptions.

4. Evaluation of operational adequacy of the reservoir regulation plan and maintenance of the dam and operating facilities and features that pertain to the safety of the dam.

5. Description of any warning system in effect.

6. Evaluation of the hydraulic and hydrologic assumptions and structural stability.

7. An assessment of the general condition of the dam with respect to safety based upon the findings of the visual inspection and review of engineering data. Where data on the original design indicate significant departure from or non-conformance with actual conditions, the engineer in charge of the investigation should give his opinion of the significance regarding safety threats posed by the departure. Any additional studies, investigations and analyses considered essential to assessment of the safety of the dam should be listed, together with an opinion about the urgency of additional work.

8. Indicate alternative possible remedial measures or revisions in operating and maintenance procedures which may (subject to further evaluation) correct deficiencies and hazardous conditions found during the investigation.

Engineers must conduct these investigations because they are trained to apply the theories and principles of science and mathematics to research and develop economical solutions to technical problems. Engineers design, plan, and supervise the construction of buildings, highways, and transit systems. They develop and implement improved ways to extract, process, and use raw materials, such as petroleum and natural gas. They develop new materials that both improve the performance of products and take advantage of advances in technology. They analyze the impact of the products they develop or the systems they design on the environment and people using them. Civil engineering, considered one of the oldest engineering disciplines, encompasses many specialties. The major specialties within civil engineering are structural, water resources, environmental, construction, transportation, and geotechnical engineering.

All 50 states and the District of Columbia require licensure for engineers who offer their services directly to the public. Engineers who are licensed are called Professional Engineers. This licensure generally requires a degree from an engineering program recognized by the Accreditation Board for Engineering and Technology (ABET), four years of relevant work experience, and successful completion of a state examination. The licensure mandate is no mere formality. Forty-eight states make it a felony to practice engineering without a license or to offer to practice engineering without a license. Indeed, in 38 states, it is even a felony to use the term "engineer" to describe one's qualifications without a PE license.

Mine owners or operators should make daily inspections of an impoundment's freeboard and weekly inspections (or monthly in the case of low-hazard dams) of its overall structural integrity. Because these impoundments hold back hazardous materials, in some cases in very large amounts, they require frequent inspections by Professional Engineers to ensure their structural integrity. The frequency standard recommended by ASCE is identical to the current federal inspection requirements for analogous impoundments regulated by the EPA.

When investigating the impoundments, the engineer should examine soil conditions within the embankment and the foundation and test for evidence of leakage, erosion, seepage, slope instability, undue settlement, displacement, tilting, cracking, deterioration, and improper functioning of drains and relief wells. The adequacy and quality of maintenance and operating procedures as they pertain to the safety of the dam and operation of the control facilities should also be assessed.

The principal design assumptions and analyses obtained from the project records should be assessed. Original design and construction records should be used judiciously, recognizing the restricted applicability of such data as material strengths and the permeability of the individual dams, geological factors and construction descriptions. Original stability studies and analyses should be acceptable, provided that review of operational and performance data confirm that the original design assumptions were adequately conservative.

B. Operation and Maintenance of Dams

Visual inspections with a photo log should address embankment conditions (new seepage, changing seepage, slope protection, indications of movement, and the like.). Inspections should include trees and woody vegetation or animal burrowing on embankments. These routine inspections are typically performed with a checklist. The rationale is to catch any early changes that may be precursors of a failure which may require more detailed inspections, observations or investigations by an engineer. Additional rationale is to monitor and confirm the assumed design operation such as seepage rates and piezometric levels in the embankment. Typically, instrumentation monitoring is performed during these routine inspections.

In addition, an annual examination should be performed that thoroughly inspects the dam and appurtenances and includes operation of all mechanical equipment. The exam should be performed or peer reviewed by a registered professional engineer knowledgeable about dam design, construction, O&M, and dam safety. Documentation of the examination should be a written narrative with recommendations related to dam safety and O&M, and photographs, describing the condition of the dam and all appurtenant features observed.

Mine owners should commission an examination at least once every five years. It would include a thorough review of the historic performance of the dam and current state-of-the-art practice, including previous examination reports, instrument performance, and design and construction information. This examination should include an inspection of the dam and appurtenances and operation of all mechanical equipment. Documentation of the inspection should be a written narrative with recommendations related to dam safety and O&M, and photographs describing the condition of the dam and all appurtenant features. An assessment of risk posed by the dam under various potential failure modes should be performed. An evaluation of the need for examination of inaccessible features should also be performed.

Minimum inspector qualifications should include: possession of state-of-the-art practice/knowledge; 10 years of experience in inspecting dams and their deficiencies ; registration as a professional engineer; extensive knowledge of dam incidents, concerns, and deficiencies – or be peer reviewed by a person having these qualifications. This examination should be performed by an examiner (or team of examiners) at least one office removed from the dam operators.

Ideally, inaccessible features examinations should be performed the year prior to the comprehensive examination in order to assist in evaluation of the dam during the comprehensive examination process. However, cost and operational constraints sometimes preclude these examinations. The comprehensive examination team should evaluate the facility during the examination and reporting process to identify the need for future examinations of inaccessible features (related to the potential failure modes). These inaccessible features examinations may include, but are not limited to: inlet structures, outlet works penetrations and toe drain conduits.

Documentation of the inspection should be a written narrative with recommendations related to dam safety and O&M, and photographs describing the condition of the dam and all appurtenant features. An evaluation of the need for examination of inaccessible features should also be performed. The report should review the historical performance of the monitoring data to judge it against potential failure modes and the design assumptions. The engineering analyses predicting the dam's response to seismic loadings and hydrologic loadings should be reviewed to assure that the loadings have not been increased as a result of new scientific information and the analytical method used should be reviewed and confirmed to be acceptable. The report should include a list of operation and maintenance recommendations to be addressed. If a risk assessment has been developed for the dam the investigator should reassess the probabilities of failure and the expected consequences and recomputed the risk values if necessary.

C. Qualifications of Personnel

Training should include a basic dam safety course offered by the Association of State Dam Safety Officials (ASDSO) such as:

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; and,

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.

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; d) learn operation and maintenance procedures.

In addition, the Bureau of Reclamation offers an excellent dam safety course entitled "Safety Evaluation of Existing Dams" (SEED). The personnel conducting the routine inspections should be familiar with the normal operations of the dam the appearance of the slopes, the amount and description of seepage, the locations of seepage collection and measurement

Respectfully submitted,

THE AMERICAN SOCIETY OF CIVIL ENGINEERS

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