From: Mark Ellis [mailto:markellis@ima-na.org]
Sent: Friday, December 10, 2010 5:08 PM
To: zzMSHA-Standards - Comments to Fed Reg Group
Cc: 'Mark Ellis'
Subject: RIN 1219-AB70 - Metal and Nonmetal Dams
Importance: High

2010 DEC 10 P 5:15

Dear Sir or Madam:

Attached please find the comments of the Industrial Minerals Association – North America (IMA-NA) on the Mine Safety and Health Administration's (MSHA) Advance Notice of Proposed Rulemaking (ANPR) on Metal and Nonmetal Dams. An attempt will be made to file and download the same comments on the federal e-rulemaking portal: http://www.regulations.gov.

Please let me know if you have any questions, comments or suggestions regarding this matter.

Best—

Mark

Mark G. Ellis
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AB70-COMM-14

Industrial Minerals Association — North America

December 10, 2010

Mine Safety and Health Administration
Office of Standards, Regulations, and Variances
Room 2350
1100 Wilson Boulevard
Arlington, VA 22209-3939

RE: MSHA ANPR on Metal and Nonmetal Dams; RIN No. 1219-AAB70

Dear Sir or Madam:

The Industrial Minerals Association – North America (IMA-NA) is pleased to file the following comments on the Advance Notice of Proposed Rulemaking (ANPR) of the Mine Safety and Health Administration (MSHA) regarding metal and nonmetal dams (75 FR 49429 et seq.; August 13, 2010).

IMA-NA is a Washington, DC-based trade association created to advance the interests of North American companies that mine or process minerals used throughout the manufacturing and agricultural industries. Its producer membership is comprised of companies that are leaders in the ball clay, barite, bentonite, borates, calcium carbonate, diatomite, feldspar, industrial sand, kaolin, magnesia, mica, soda ash (trona), talc, wollastonite and other industrial minerals industries. As such, the majority of these nonmetal mines are subject to the requirements of 30 CFR § 56.20010 or § 57.20010. In addition, IMA-NA represents associate member companies that provide equipment and services to the industrial minerals industry. Additional information on IMA-NA can be accessed through the following hyperlink: http://www.ima-na.org.

Since its inception in 2002, IMA-NA has worked cooperatively with MSHA. IMA-NA recognizes that the first priority and concern of all in the mining industry must be the health and safety of its most precious resource – the miner. To that end, IMA-NA offers the following comments to MSHA.

IMA-NA's comments were prepared in consultation with its technical consultant, Dr. Kelvin Wu, Ph.D. and P.E. Until his retirement from MSHA, Dr. Wu was the Dam Safety Officer at the agency and a professor at Pennsylvania State University. A copy of Dr. Wu's resume is attached. (Attachment 1).

You will note in IMA-NA's comments that we have chosen to use the terms "impoundments" and "impoundment structures" in lieu of "dams." IMA-NA seeks to differentiate the former structures on mine property from the latter structures as generally understood by the public.

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IMA-NA also wishes to emphasize is the difference between above-grade impoundments structures and below-grade (incised) impoundments structures. IMA-NA maintains that no engineering design plan should be required for the latter type of impoundment structure.

IMA-NA is pleased to have had the opportunity to comment on MSHA's ANPR on metal and nonmetal dams and it stands ready to assist in a constructive manner in the promulgation of an appropriate regulation regarding metal and nonmetal impoundments and impoundment structures. Please do not hesitate to contact me should you have any questions, comments or suggestions regarding this matter.

Sincerely,

Mark G. Ellis
President

Attachments

COMMENTS OF THE
INDUSTRIAL MINERALS ASSOCIATION – NORTH AMERICA (IMA-NA)
ON THE
MINE SAFETY AND HEALTH ADMINISTRATION'S (MSHA)
ADVANCE NOTICE OF PROPOSED RULEMAKING (ANPR)
ON METAL AND NONMETAL DAMS

<u>General Questions</u>

1. MSHA is seeking information concerning current dam safety practices at metal and nonmetal mines. What measures do mine operators currently take to design, construct, operate, and maintain safe and effective dams? What measures do mine operators currently take to safely abandon their dams? For mine operators with dams, please provide your experiences.

IMA-NA Comment:

If a state or local jurisdiction has requirements for impoundments, then mine operators necessarily will need to comply with these requirements to ensure safe operation of the impoundment. The same can be said for requirements related to abandonment of the impoundment. MSHA should accept these state and local jurisdiction requirements in lieu of federal regulation to avoid conflict or redundancy of requirements.

In the absence of state or local requirements for impoundments, mine operators necessarily need to comply with MSHA's requirements for retaining dams at 30 CFR 56.20010 and

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57.20010, which provide, "[i]f failure of a water or silt retaining dam will create a hazard, it shall be of substantial construction and inspected at regular intervals." Inherent in these requirements, which have consistently demonstrated their industry-wide effectiveness over decades, are the desired elements of hazard assessment, design, construction, operation and maintenance to ensure safe and effective impoundments and impoundment structures.

2. MSHA is required to inspect every mine in its entirety, which includes dams of all sizes and hazard potential. A common approach for dam safety is to have tiered requirements based on a dam's size and hazard potential. How should MSHA determine safety requirements based on a dam's size and hazard potential? Please include specific recommendations and explain your reasoning.

IMA-NA Comment:

Storage capacity, impoundment structure size and hazard potential rating should be utilized to set safety requirements. Since most industrial minerals operations are in rural and generally flat areas, IMA-NA suggests that MSHA only should concern itself with impoundment storage capacities in excess of 50 acre-feet, impoundment structures in excess of 25 feet in height as measured from the downstream toe, and hazard potential rating should determine the frequency of inspection. Similarly, MSHA should not concern itself with impoundment structure not in excess of six feet in height regardless of storage capacity, or impoundments which have a storage capacity at maximum water storage elevation not in excess of 15 acre-feet regardless of height. These recommendations are consistent with the Federal Guidelines for Dam Safety published by the Federal Emergency Management Agency (FEMA).[1] (Attachment 2). High hazard impoundments (e.g.,

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[1] *Federal Guidelines for Dam Safety* (FEMA)(2004), p. 4, applies the following definition to its guidelines:

"**Dam or Project.** Any artificial barrier, including appurtenant works, which impounds or diverts water, and which (1) is ***twenty-five feet or more in height*** from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of ***fifty acre-feet or more***. These guidelines do not apply to any such barrier which is ***not in excess of six feet in height regardless of storage capacity***, or which has a storage capacity at maximum water storage elevation ***not in excess of fifteen acre-feet regardless of height***. This lower size limitation should be waived if there is a potentially significant downstream hazard. [emphasis added].

The guidelines apply with equal force whether the dam has a permanent reservoir or is a detention dam for temporary storage of floodwaters. The impounding capacity at maximum water storage elevation includes storage of floodwaters above the normal full storage elevation.

In addition to conventional structures, this definition of "dam" specifically includes "tailings dams," embankments built by waste products disposal and retaining a disposal pond."

The above-referenced size criteria are the same as were adopted to determine whether low hazard potential dams should be reported in the National Inventory of Dams maintained by the U.S. Army Corps of Engineers (http://geo.usace.army.mil/pgis/f?p=397:1:4192038895235022).

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potential loss of life) should be inspected more frequently than moderate hazard impoundments (e.g., potential major property damage) or low hazard impoundments (e.g., potential minor property damage). The demonstrated performance of the impoundment also should be a factor in determining the frequency of inspection.

3. What non-Federal authority regulates the safety of dams at metal and nonmetal mines in your state, territory, or local jurisdiction? Please discuss the specific requirements, including the principles that they address. If possible, please provide information about relevant non-federal dam safety requirements through a hyperlink or other means.

IMA-NA Comment:

As a general matter, impoundments at metal and nonmetal mines already are regulated by non-federal authorities, be they state or local jurisdictions. While the attached list of state regulations is not complete, it nevertheless demonstrates the scope, depth and breadth of state regulation of impoundments and impoundment structure. (Attachment 3). Additional research should allow MSHA to compile a compendium of state and local regulation of impoundments.

In this regard, IMA-NA draws MSHA's attention to the Association of State Dam Safety Officials (ASDSO)(http://www.damsafety.org/). The ASDSO is a non-profit organization of state and federal dam safety regulators, dam owners/operators, dam designers, manufacturers/suppliers, academia, contractors and others interested in dam safety.

IMA-NA maintains that variations in federal, state and local regulation of impoundments and impoundment structures should be respected by MSHA and that the agency should not impose an additional layer of regulation to achieve consistency for mining operations where it is not justified. IMA-NA's best advice is that in the absence of state or local requirements for impoundments, mine operators should continue to comply with MSHA's requirements for retaining dams at 30 CFR 56.20010 and 57.20010, which provide, "[i]f failure of a water or silt retaining dam will create a hazard, it shall be of substantial construction and inspected at regular intervals." Inherent in these requirements, which have consistently demonstrated their industry-wide effectiveness over decades, are the desired elements of hazard assessment, design, construction, operation and maintenance to ensure safe and effective impoundments and impoundment structures.

"The NID consists of dams meeting at least one of the following criteria;

1) High hazard classification - loss of one human life is likely if the dam fails,
2) Significant hazard classification - possible loss of human life and likely significant property or environmental destruction,
3) Equal or exceed 25 feet in height and exceed 15 acre-feet in storage,
4) Equal or exceed 50 acre-feet storage and exceed 6 feet in height."

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4. What records should be kept of activities related to the safety of dams? Please be specific and include your rationale. What records should be provided to miners if hazardous conditions are found?

IMA-NA Comment:

The records required to be maintained depend on the requirements of the state or local jurisdiction. These states and local jurisdictions are best positioned to explain the rationale for why the specific records are required to be maintained. In addition, mine operators may maintain business records related to impoundments and impoundment structures, e.g., plans, construction contracts, etc.

If a hazardous condition is found to exist with respect to an impoundment or impoundment structure, it is incumbent on the mine operator to acquaint miners who may be affected by the hazard of its presence and what precautions should be taken to protect against the hazard presented. Records, per se, may not be relevant or adequately address the hazardous condition. Some records may only be intelligible to persons knowledgeable in the subject matter and making the record available to other persons only may cause unnecessary confusion.

<u>Design and Construction of Dams</u>

MSHA's existing standards do not include specific requirements for design of dams. MSHA found that inadequate design contributed to some of the metal and nonmetal dam failures. In responding to the following questions, please discuss how any requirements should vary according to the size or hazard potential of a dam, and why.

5. How should mine operators assure that dams are safely and effectively designed? Please suggest requirements that MSHA should consider for safe design of dams. Please be specific and include your rationale.

IMA-NA Comment:

Mine operators only can assure that impoundments and impoundment structures are safely and effectively designed by two means: 1) they have been designed and certified by a competent engineer practicing in the field; and 2) the design engineering plan has been accepted and approved by the state or local authority with responsibility for impoundments and impoundment structures. Once the above two items have been fulfilled, MSHA should accept the design. This will eliminate overlapping jurisdiction, duplication of effort and additional cost. Should MSHA disagree with a state or local authority, it would be important for MSHA to resolve the issues it has with the state or local authority and provide the necessary technical support to the mine operator.

6. Please suggest requirements for review of dam designs by mine operators and MSHA and include your rationale for specific recommendations and alternatives.

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IMA-NA Comment:

Once a state or local jurisdiction with responsibility for impoundments or impoundment structures has accepted and approved a design there is no need for additional review by MSHA. Again, foregoing additional review by MSHA will eliminate overlapping jurisdiction, duplication of effort and additional cost. If there is no state or local authority with responsibility for impoundments or impoundment structures it is IMA-NA's recommendation that the design engineering plan should be designed and certified by a competent engineer practicing in the field. Further, MSHA should review design plans for impoundments with high-hazard classification (e.g., potential loss of life). MSHA should accept design plans for impoundments with moderate hazard classification (e.g., potential major property damage) or low hazard classification (e.g., potential minor property damage). These latter hazard classifications indicate that failure of the impoundment structure only can cause damage to property, not potential loss of life.

7. With new standards, operators may need to evaluate and upgrade existing dams. Please elaborate on how the safety of existing dams should be addressed.

IMA-NA Comment:

Existing impoundments should be addressed based on the impoundment structure's past performance. If records of routine inspection indicate that the structure has performed normally, then there is no need for re-evaluation. If the inspection records indicate safety concerns then a re-evaluation of the design may be warranted and an upgrade may be required.

8. MSHA's existing standards for dams at metal and nonmetal mines do not address whether a dam is constructed as designed. What measures are necessary to ensure that mine operators construct dams as designed?

IMA-NA Comment:

Whether an impoundment structure has been constructed as designed is best evaluated by reference to the engineering design plan, which should include a section addressing construction specifications. During construction, inspection should verify that the impoundment structure is constructed to the design engineering design plan. Records of construction inspection should be maintained. Records of construction inspection can document the impoundment structure is constructed as designed. This recommendation is best put into practice for proposed new impoundment structures or up-grades to existing impoundment structures.

9. How should MSHA verify that dams have been constructed as designed? Please explain your rationale.

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IMA-NA Comment:

For existing impoundments with no design plan, the impoundment structure's past performance is the best indication of adequate design and construction. If the inspection records indicate safety concerns then a re-evaluation of the impoundment structure may be warranted and an upgrade may be required.

However, if an impoundment structure was constructed according to an engineering design plan, then the engineering design plan should have a construction specification section. MSHA can verify the structure was constructed as designed by examining available construction specification criteria and the construction inspection records.

<u>Operation and Maintenance of Dams</u>

MSHA's existing standards do not contain specific requirements addressing the operation and maintenance of dams.

10. What should a mine operator do to operate and maintain a safe dam? How should MSHA verify that dams are safely operated and maintained? Please be specific.

IMA-NA Comment:

Mine operators are responsible for "routine" inspection by trained and qualified personnel. Records of these inspections should be maintained at the mine site. "Detailed" inspections, as warranted, should be conducted by a competent engineer.

MSHA can verify that impoundments are safely operated and maintained by conducting field inspections and examining the inspection records maintained by the mine operator. MSHA should conduct such routine and detailed inspections as may be required by law.

MSHA's existing standards require dams to be inspected at regular intervals if failure would create a hazard. Inspections can identify hazardous conditions, allowing a mine operator to take corrective action to prevent a failure. The Agency will be referring to two types of inspections in this document, ``routine" and ``detailed." Mine operators should perform frequent, routine dam inspections, which may include monitoring instrumentation, to identify unusual conditions and signs of instability. Personnel with more specialized knowledge of dam safety should conduct detailed inspections to identify less obvious problems and evaluate the safety of the dam. Detailed inspections, occurring less often, would include an examination of the dam and a review of the routine inspections and monitoring data. The Guidelines recommend that inspection personnel be qualified for their level of responsibility and trained in inspection procedures.

11. What measures should mine operators take to assure that dams are adequately inspected for unusual conditions and signs of instability?

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IMA-NA Comment:

Mine personnel assigned to perform routine inspection should receive adequate training to qualify them to carry out these tasks. In IMA-NA's estimation, this training should be comparable to the training an MSHA inspector receives. Such training should provide skills adequate for the responsible person to conduct an inspection for unusual conditions and signs of instability.

12. How often are routine inspections of dams conducted? How often should they be conducted? What determines the frequency? Who conducts the routine inspections? Please be specific and include your rationale.

IMA-NA Comment:

The number of routine inspections conducted of impoundments varies. The frequency of routine inspections should be based on need and the past performance of the impoundment structure.

13. Instruments, such as weirs, provide information on the performance of a dam. How frequently should mine operators monitor dam instrumentation? Please provide your rationale.

IMA-NA Comment:

If any instrumentation has been installed on site, the frequency of the monitoring should be based on the design engineer's requirements and the past performance of the impoundment structure. During construction and the initial filling stage, inspection likely may be more frequent. If after a reasonable period of time the impoundment performs as designed, the inspection frequency can be reduced.

IMA-NA offers the following guidelines: 1) during the construction and initial filling stage, inspection should be conducted every seven (7) days; 2) if after one year the impoundment performs as designed, inspection frequency can be reduced to quarterly inspection.

14. What information should be documented during routine dam inspections? Please provide your rationale.

IMA-NA Comment:

The information required to be documented during routine impoundment inspection should be based on the design engineer's requirements since these data are important for the design engineer to evaluate the performance and safety of the impoundment structure.

15. Does a competent engineer inspect your mine's dam? If so, at what frequency? Please explain the rationale for these inspections and what is evaluated.

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IMA-NA Comment:

Whether, and how frequently, a detailed inspection needs to be conducted by a competent engineer should be a function of need. Qualified personnel trained to conduct routine inspections can reveal a need for further inspection by a competent engineer. Again, the information required to be documented during routine impoundment inspection should be based on the design engineer's requirements since these data are important for the design engineer to evaluate the performance and safety of the impoundment structure.

16. How often should detailed inspections be conducted? Please include your rationale.

IMA-NA Comment:

The frequency of detailed inspection should be consistent with generally accepted practice of applicable federal, state and local agencies responsible for impoundment safety.

17. What information and findings should be documented during detailed dam inspections? Please be specific and include your rationale.

IMA-NA Comment:

What specific information and findings should be documented during detailed impoundment inspections only can be determined by the competent design engineer based on his or her need to ensure the safety of the impoundment and the impoundment structure. However, general information and findings typically would include a visual inspection and examination of records of monitoring instrumentation data. The specific information and findings that should be documented should be based on the design engineer's requirements.

18. How should MSHA verify that mine operators conduct routine and detailed inspections? Please explain how your suggestion would work.

IMA-NA Comment:

It is possible for MSHA to verify that mine operators conduct routine and detailed inspections by examining inspection records maintained by the mine operator. However, MSHA should identify clearly the minimum information or documentation required to be maintained to achieve its objectives and avoid overlapping jurisdiction, duplication of effort and additional cost. If a state or local jurisdiction already is performing this responsibility, there is no need for MSHA to do so. IMA-NA submits that any records MSHA requires to be maintained should focus on the design engineer's requirements.

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Qualifications of Personnel

A mine operator is responsible for the design, construction, operation, and maintenance of dams. For an effective dam safety program, an operator must use personnel who are knowledgeable about dam safety.

19. What qualifications do mine operators currently require of persons who design, inspect, operate, and manage dams? In what capacities are engineers used? Please be specific in your response.

IMA-NA Comment:

For designed impoundments, the design function should be performed by a competent engineer practicing in the field. Individual states will determine whether the engineer needs to be registered in the jurisdiction in which the impoundment structure is situated. This should not be a concern for MSHA. The inspection, operation, and maintenance of impoundments can be performed by mine personnel qualified by training and experience. For non-designed impoundments, the inspection, operation and maintenance functions typically would be performed by mine personnel qualified by training and experience.

20. The Guidelines recommend that dams be designed by competent engineers. What specific qualifications or credentials should persons who design dams possess? Please include your rationale.

IMA-NA Comment:

For designed impoundments, the design function should be performed by a competent engineer practicing in the field. Individual states will determine whether the engineer needs to be registered in the jurisdiction in which the impoundment structure is situated. This should not be a concern for MSHA. The qualifications or credentials of a competent engineer are based on education, work experience and professional engineering registration. The education component typically would cover a B.S., M.S. or Ph.D. in mining engineering, civil engineering or geotechnical engineering. A competent engineer could be qualified by education and experience. He or she typically would have basic training in geology, soil mechanics, rock mechanics, hydraulics, hydrology, mining methods or mining operations. The work experience component typically would include impoundment design and inspection. If applicable, the registered professional engineering component typically would cover the disciplines of mining engineering, civil engineering or geotechnical engineering.

21. The Guidelines recommend that a dam be constructed under the general supervision of a competent engineer knowledgeable about dam construction. What specific qualifications or credentials should a person have who verifies that a dam is being constructed as designed? Please provide your rationale.

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IMA-NA Comment:

The qualifications or credentials of a competent engineer are based on education, work experience and professional engineering registration. The education component typically would cover a B.S., M.S. or Ph.D. in mining engineering, civil engineering or geotechnical engineering. A competent engineer could be qualified by education and experience. He or she typically would have basic training in geology, soil mechanics, rock mechanics, hydraulics, hydrology, mining methods or mining operations. The work experience component typically would include impoundment design and inspection. If applicable, the registered professional engineering component typically would cover the disciplines of mining engineering, civil engineering or geotechnical engineering.

22. What training should personnel receive who perform frequent, routine inspections and who monitor instrumentation at dams? In your response, please suggest course content and the frequency of the training, including the rationale for your recommendations.

IMA-NA Comment:

Mine personnel assigned to perform "routine" inspection should receive adequate training to qualify them to carry out these tasks. In IMA-NA's estimation, this training should be comparable to the training an MSHA inspector receives. Such training should provide skills adequate for the responsible person to conduct an inspection for unusual conditions and signs of instability. Whether mine personnel or MSHA inspectors the course content should be determined by a competent engineer who practices in the field.

23. What qualifications or credentials should be required of persons who perform detailed inspections to evaluate the safety of a dam? Please be specific and include your rationale.

IMA-NA Comment:

The qualifications or credentials of a competent engineer are based on education, work experience and professional engineering registration. The education component typically would cover a B.S., M.S. or Ph.D. in mining engineering, civil engineering or geotechnical engineering. A competent engineer could be qualified by experience and training. He or she typically would have basic training in geology, soil mechanics, rock mechanics, hydraulics, hydrology, mining methods or mining operations. The work experience component typically would include impoundment design and inspection. If applicable, the registered professional engineering component typically would cover the disciplines of mining engineering, civil engineering or geotechnical engineering.

<u>Abandonment of Dams</u>

24. Some regulatory authorities require that dam owners obtain approval of a plan to cap, breach, or otherwise safely abandon dams. What actions should mine operators take to safely abandon dams? Please include specific suggestions and rationale.

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IMA-NA Comment:

Where state or local regulatory authorities require the approval of an abandonment plan, mine operators will comply with the approved abandonment plan. The abandonment plan can be designed for capping, breaching or safe abandonment of the impoundment. Safe abandonment contemplates that the mine operator will receive approval from the state or local regulatory authority for impoundment safety or that a change from mining use to another usage (e.g., recreation, irrigation, etc.) is authorized and has been approved.

25. How can MSHA verify that a mine operator has safely abandoned a dam?

IMA-NA Comment:

MSHA can verify that a mine operator has safely abandoned an impoundment by receiving a copy of the approval or acceptance of the change issued by the state or local regulatory agency responsible for impoundment safety. If the state or locality does not have a dam safety program, MSHA should accept the abandonment plan if it is certified by a competent engineer.

<u>Economic Impact</u>

MSHA seeks information to assist the Agency in deriving the costs and benefits of any regulatory changes for dams at metal and nonmetal mines. In answering the following questions, please indicate the dam's storage capacity, height, and hazard potential and characterize the complexity of each dam referenced. Also, please include the state where each dam is located, and the number of employees at the mine.

26. What are the costs of designing a new dam? Please provide details such as hours, rates of pay, job titles, and any contractual services necessary. How often is the design of an existing dam changed? What are the costs of a redesign?

IMA-NA Comment:

MSHA should obtain this information from reputable design engineering firms practicing in impoundment design.

27. What are the costs of constructing a dam? Please provide details based on: Size of dam; labor costs, including hours, rates of pay, job titles; costs of equipment and materials; and any contractual services necessary.

IMA-NA Comment:

The answer to this question can best be answered by each mine operator.

28. Please describe the oversight you provide during dam construction to assure it complies with the design plan. How much does it cost per year per dam for oversight and quality control?

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What special knowledge, qualifications, or credentials do you require of those who provide oversight?

IMA-NA Comment:

The answer to this question can best be answered by each mine operator.

29. How often do you add height to an existing dam or modify it in some other way? Who supervises the design and construction of these modifications, for example, a professional engineer, competent engineer, contractor, etc? Please be specific and provide rationale for your answer. How much does it cost? Please provide details such as labor costs, including hours, rates of pay, job titles, and costs of equipment and materials and any contractual services necessary.

IMA-NA Comment:

The answer to this question can best be answered by each mine operator.

30. How much does it cost per year per dam for routine inspections? If you incur separate costs for monitoring instrumentation, how much is that cost? How often do you have a detailed inspection conducted? How much does it cost per year for these inspections?

IMA-NA Comment:

The answer to this question can best be answered by each mine operator.

31. Does the state or local jurisdiction in which you operate require you to use a professional engineer? If so, when is a professional engineer specifically required? (If you have dams in more than one state please identify which states require a professional engineer and which do not).

IMA-NA Comment:

The answer to this question can best be answered by each mine operator.

32. What are the costs associated with training personnel who conduct frequent, routine inspections and monitor instrumentation at dams?

IMA-NA Comment:

The answer to this question can best be answered by each mine operator.

33. What costs are involved in capping, breaching, or otherwise properly abandoning a dam? Please provide details of your experience and what was involved when you properly abandoned a dam. Describe any impact of a properly abandoned dam.

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IMA-NA Comment:

The answer to this question can best be answered by each mine operator.

34. What are the costs to a mine operator if a dam fails? Please characterize other impacts such as loss of life, environmental damage, etc.

IMA-NA Comment:

The answer to this question can best be answered by each mine operator.

35. Do you have insurance against a dam failure? If so, please specify cost and coverage. Does the insurance carrier require the use of a professional engineer for specific dam activities? If a professional engineer is not required, does the insurance carrier give a discount if one is used? Does your insurance company have any other requirements related to dam safety?

IMA-NA Comment:

The answer to this question can best be answered by each mine operator.

36. What quantifiable and non-quantifiable costs and benefits for the downstream community are involved when a dam is properly designed and constructed? In addition, MSHA welcomes comments on other relevant indirect costs and benefits.

IMA-NA Comment:

The quantifiable and non-quantifiable costs and benefits for the downstream community when an impoundment is properly designed and constructed can vary from site to site and are site dependent.

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Country of citizenship: United States of America
Veterans' Preference: No
Highest Grade: GS-801-15, 6/2005 to 1/2007

AVAILABILITY

Job Type: Technical Consultant

Work Schedule: As needed

DESIRED LOCATIONS

Home

EDUCATION

University of Wisconsin
Madison, Wisconsin US
Doctorate - 6/1971
42 Semester Hours
Major: Mining Engineering (Rock Mechanics)
Minor: Civil Engineering (Soil Mechanics)

University of Wisconsin
Madison, Wisconsin US
Master's Degree - 8/1965
36 Semester Hours
Major: Mining Engineering

National Cheng-Kung University
Tainan, Taiwan China
Bachelor's Degree - 6/1961
156 Semester Hours
Major: Mining Engineering

PROFESSIONAL REGISTRATION AND ACTIVITIES

P.E. Commonwealth of Pennsylvania

Professional Land Surveyor – Commonwealth of Pennsylvania

Professor of Practice, Penn State University, 2007

Adjunct Professor, University of Pittsburgh

Adjunct Professor, Mining Engineering Department, West Virginia University
1992-1994, 1998, 2000, 2001, 2006

Attachment 1

LANGUAGES

Chinese

Spoken:	Advanced
Written:	Advanced
Read:	Advanced

SCIENTIFIC AND PROFESSIONAL AFFILIATIONS

Society for Mining, Metallurgy, and Exploration	Board of Directors (1991 to Present)
Society for Mining, Metallurgy, and Exploration	Chairman, Pittsburgh Chapter (1996)
Pittsburgh Coal Mine Institute of America	Board Member (1985-Present)
Association of State Dam Safety Officials	Member
United States Society of Dams	Member

INSTITUTIONAL AND PROFESSIONAL SERVICES

SME Mining Engineering Committee	Chair (2005–2007)
FEMA – Dam Safety Officer for U.S. Dept. of Labor	
Department of Homeland Security-Governor / Coordination Council	Member
SME Mining Exploration Division Subcommittee	Member
Rock Mechanics Award Committee SME Coal Div.	Member
Health and Safety Committee SME Coal Division	Member
Coal Executive Committee SME (Coal Division)	Member
Professional Engineer Registration Subcommittee (SME)	Member
PCMIA – Board of Directors	Member

PROFESSIONAL PUBLICATIONS

1. Wu, K. and Gardner, G., "Use of Available and Emerging Methods for Location of Air and Water Filled Cavities in Mines – Status Report on MSHA Demonstration Projects," SME Annual Meeting and Exhibit, 2005.

2. Wu, K., and Gardner, G., "Evaluating the Liquefaction Potential of Coal Waste Impoundments," GeoStra Magazine 2002.

3. Wu, K., and Gardner, G., "Challenges Associated with Evaluating the Liquefaction Potential of Coal Waste Impoundments Subjected to Seismic Loading," Tailing Dam Conference, 2002.

4. Wu, K. and Gardner, G., "Overview of Safety Considerations with Highwall Mining Operations," International Ground Control Conference 2002.

5. Wu, K. and Kelly, C., "Highwall Stability in an Open-Pit Stone Operation," 21st International Conference on Ground Control, 2002.

6. Wu, K. and Michalek, S., "Design Considerations for Breakthrough Issues at Impoundments," Tailing Dam 2002 Conference.

7. Wu, K. and Gardner, G., "Overview of Current Technical Issues in Tailing Dam Design," Tailing Dam Conference, 2002.

8. Wu, K. and Michalek, S., "Potential Problems Related to Mining Under or Adjacent to Flooded Workings," 19th Conference on Ground Control in Mining 2000.

9. Wu, K., Michalek, S., and Gardner, G., "Accidental Releases of Slurry and Water from Coal Impoundments Through Abandoned Underground Coal Mines," Technical Seminar #5, Interagency Conference on Dam Safety-1998.

10. Wu, K.K.; Kirkwood, D. T.; Dubina, S.B.; Snyder, J.L., "Proven Methods of Reducing Non-Fatal Days Lost (NFDL in Coal Preparation Plants," International Coal Preparation Conference, Lexington, KY, p235-246, May 1995.

11. Wu, K.K.; Hugler, E.C., "Safety and Health Practices in the USA Salt Mines," Seventh International Symposium on Salt, Kyoto, Japan, Vol. 1, p233-242, 1992.

12. Wu, K.K.; Mazzei, D.S., "Federal Regulations and Their Impact on Coal Mine Waste Disposal Systems," American Institute of Mining, Metallurgical, and Petroleum Engineers, Society of Mining Engineers of AIME v270, p1860-1864, 1981.

PROFESSIONAL PUBLICATIONS (CONTINUED)

13. Wu, K.K.; Sciulli, A.G., "Economic Considerations for Refuse Impoundments," Symposium on Coal Preparation and Utilization, McGraw-Hill Inc., New York, NY, p231-242, 1981.

14. Wu, K.K.; Fredland, J.W.; Krese, J.M.; Lawless, M. "Factors and Evaluation of Coal Barriers to Prevent Inundation and Effectiveness of Federal Regulations," Society of Mining Engineers of AIME, Littleton, CO, CONF-800205, 1980.

15. Wu, K.K., "Theoretical and Experimental Analysis of the Mechanics of Wedge Penetration into Granular Materials," University of Wisconsin, pp232, Ph.D. Thesis, 1971.

16. Wu, K.K., "An Investigation of Physical Properties of Rock Under Impact Using a Relation Rupturing Force to Hole Diameter Burden," University of Wisconsin, pp76, M.S. Thesis, 1965.

REFERENCES

Dr. Richard J. Sweigard	University of Kentucky	Chairman, Mining Engineering Department
Phone Number:	(859) 257 1173	
Email Address:	rsweiger@engr.uky.edu	
Reference Type:	Professional	
Mr. George Ellis	Pennsylvania Coal Association	President
Phone Number:	(717) 233 7900	
Email Address:	pacoal1@aol.com	
Reference Type:	Professional	
Dr. Michael Karmis	Department of Mining and Minerals Engineering / Virginia Center for Coal and Energy Research (Virginia Tech)	Stonie Barker Professor Director
Phone Number:	(540) 231 5273	
Email Address:	mkarmis@vt.edu	
Reference Type:	Professional	
Mr. Jim Bryja	Foundation Coal Corporation	Senior Vice President of Eastern Operations
Phone Number:	(410) 689 7514	
Email Address:	jbryja@foundationcoal.com	
Reference Type:	Professional	

EMPLOYMENT HISTORY

Jan. 1,2008-present
Consultant

January 16-Dec. 31, 2007
Title of position: Professor of Practice
Penn. State University, Fayette, The Eberly Campus.

(February-November 2006) (June – July 2005)
Title of Position: Acting Center Chief, Pittsburgh Safety and Health Technology Center, Mine Safety and Health Administration, U.S. Department of Labor

Provided engineering and scientific capability to assist the Mine Safety and Health Administration, state mining entities, and the mining industry in delineating technological mine safety and health related problems. This includes conducting field investigations and laboratory studies to develop solutions for specific mining-related problems. The Pittsburgh Safety and Health Technology Center responds to requests for assistance on safety and health related problems for both coal and metal/nonmetal mines throughout the United

States, involving their recognized expertise in a particular field of mine-related work.

June 2005 - Present
Title of Position: Dam Safety Officer
Mine Safety and Health Administration, U.S. Department of Labor

Responsible for coordinating and providing leadership for dam safety activities for the Mine Safety and Health Administration. Oversees the agencies administrative and technical practices related to dam safety including design, construction, operation, maintenance, periodic inspections, and rehabilitation. Assists in defining needs and implementing procedures to enhance the safety of dams under MSHA's jurisdiction.

Responsible for ensuring that the agency, as a matter of policy and in actual practice, makes every reasonable and prudent effort to enhance the safety of dams under the agency's jurisdiction. Duties include surveillance and evaluation of the agency's administrative and technical practices related to dam safety, concerning the design and construction of new dams, or the rehabilitation of existing dams. The Dam Safety Officer also makes recommendations for strengthening safety practices and procedures while

ensuring that the agency maintains an up to date inventory of agency dams.

The Dam Safety Officer reports directly to the agency head on matters of dam safety. The Dam Safety Officer functions as an advisor to the head of the agency and through the head of the agency to the administrative and technical units. The Dam Safety Officer ensures full compliance with all applicable laws, policies, directives, and technical recommendations governing MSHA related dam safety activities.

1991 to Present
Title of Position: Chief, Mine Waste and Geotechnical Engineering Division Pittsburgh Safety and Health Technology Center, Pittsburgh, PA

Responsibilities include supervising and directing the activities of 27 employees in the Mine Waste and Geotechnical Engineering Division (MWGED). MWGED provides technical services and consultation to Federal and State mining enforcement officials and industry regarding complex safety and health problems related to the handling, disposal, and reclamation of mine waste, including refuse piles, mine dumps, waste dams, tailing ponds, and impoundments in the coal, and metal/nonmetal mining industries. Applied research investigations, site reviews, plan reviews and in-depth engineering evaluations are made of conditions, practices, and engineering aspects involved in mine waste disposal with particular emphasis on hazards associated with dam construction and with the integrity of embankments.

The Division also provides occasional consulting services to other Divisions in the Center, and to the mining industry regarding difficult safety problems in mining which require the disciplines of civil and mining engineering. Examples of these assignments include, but not limited to the following:

1. Existing engineering theories and methods are generally not applicable, thus requiring difficult investigative studies to improve and extend knowledge for a wide range of complex situations.
2. These investigative efforts, which are conducted through a series of completed and conceptually related engineering and applied studies include:
   a. Evaluation of slope stability of waste embankments using the latest field investigative tools in conjunction with computer analyses.
   b. The study of the effects of underground mining systems on surface subsidence in the vicinity of mine waste structures.
   c. The determination of engineering properties that can be used in the rationale design of mine waste structures.
   d. The improvement of engineering methods for conducting hydrological calculations related to mine waste dams.
3. The results of such investigations which are conducted in surface and underground mines and in computer and laboratory simulations are published by the incumbent as they advance the state-of-the-art of safe disposal of mine refuse and solve problems encountered by safety and health, the mining industry, and other government agencies.
4. The incumbent is responsible for interpretation of the site investigations and evaluating the usefulness of the information in solving the problems at hand.
5. The incumbent also analyzes results of research conducted by other agencies in fields related to mine waste control and keeps the Mine Safety and Health Administration and industry informed on engineering and scientific developments.
6. The above mentioned (item 5) is accomplished by formal and informal reports,

participation in seminars on mine waste control and active collaboration with other interested and knowledgeable engineers and scientists in this country and abroad.
7. The incumbent is responsible for providing technical services in the field of geotechnical engineering to mine safety and health, industry, and to State and other Federal agencies. Those included are in the areas of highwall, benching, haulage road stability, foundation and structure problems, underground bulkhead and seal design, mining under water bodies, shaft stability, surface and underground water problems, and subsidence problems, etc.

EMPLOYMENT HISTORY (CONTINUED)

May 1982-October 1984
Title of Position: Chief, Mine Waste and Geotechnical Engineering Division and Acting Chief, Industrial Safety Division Bruceton Safety Technology Center

Responsibilities were supervising and directing the activities of eight Industrial Safety Division Personnel. The Division is responsible for providing technical assistance in the areas of fires, explosions, explosives, haulage accidents and other industry related hazards. I had a dual responsibility for the 2-year period.

1979-1985
Title of Position: Adjunct professor at the University of Pittsburgh, Mining & Energy Resources Division

1978-1991
Title of Position: Chief, Mine Waste and Geotechnical Engineering Division, Bruceton Safety Technology Center

As Chief of the Mine Waste and Geotechnical Engineering Division specific responsibilities involve supervising 12 people and directing the activities of each. The Division reviews, evaluates, and recommends action to be taken in connection with the handling and disposal of mine waste and the construction of refuse piles, waste dams, failing embankments, and impoundments in the coal, metal/nonmetal mining industries.

The Division is responsible for any geotechnical engineering problems related to mining operations (such as underground flooding, oil, and gas wells, radioactive and industrial waste storage, highwall and open pit slope stability) and mine construction including foundation, structure, shaft sinking, and tunneling. The work undertaken by the Division includes on-site field investigations, specialized field and lab testing, engineering design and plan review, research contract review, and in-depth engineering evaluation requiring expertise in hydrology, soil and rock mechanics, and structural engineering. The Division also provides consulting services to other safety and health related activities and the mining industry.

1977-1978
Mass transfer to the Department of Labor from the Department of the Interior and from Chief, Mine Waste Branch to Chief, Mine Waste and Geotechnical Engineering Division.

1976-1977
Same as 1973-1976; however, additional duties were assigned to develop courses and teaching seminars for coal waste impoundment investigation and inspection for MESA personnel, the coal industry, and UMWA.

1973-1976
Title of Position: Mining Engineer - Roof Control Division
MESA - Pittsburgh Technical Support Center

Planning and execution of projects pertaining to water impoundment dams/refuse piles and safety problems related to ground and roof control. Developing procedural guidelines on coal waste embankments. Applies research techniques which are used during the execution of investigations conducted to determine optimum support systems. These theoretical studies are used to develop practical applications for the mining industry. In many cases, this requires the design of experimental equipment for the completion of the investigation.

Draft proposed Federal regulations on coal waste impoundment and refuse piles. Special assignment on draft of proposed Federal regulations for the Reclamation bill. Provide technical assistance on engineering problems to other professional MESA personnel.

EMPLOYMENT HISTORY (CONTINUED)

1970-1973
Title of Position: Mining Engineer - U.S. Department of the Interior - Pittsburgh Mining and Safety Research Center

Utilizes rock and soil mechanics knowledge to perform research pertaining to the mechanics of flow and penetration of mined materials. Physical properties are evaluated to determine the net affect these materials have on the material handling system. Apply mathematical techniques to describe the mechanics of flow and penetration of bulk materials. Design and order instruments and apparatus to conduct experimental research to substantiate theoretical mathematical models. Visit mining operations, material laboratories, and plants to observe testing procedures and equipment. Interpret physical property measurements in terms of its effects on materials handling operations for the design of the total mining system. Supervised the physical properties testing laboratory, monitored research contracts as technical project officer. Drafted "RFP" and reviewed proposals.

1968-1970
Title of Position: Mining Engineer - U.S. Department of the Interior-
Bureau of Mines - Pittsburgh Mining Research Center

Worked on the research projects pertaining to the mechanics of penetration, investigated bulk material physical properties which affect the mined materials handling systems, and completed course work, preliminary examination and thesis for Ph.D. program at the University of Wisconsin.

1967-1968
Title of Position: Mining Engineer
Same as period 1970-1973.

1965-1967
Title of Position: Consulting Engineer
D'Appolonia Consulting Engineers

Oversee technicians on rock and soil physical property tests. Perform slope stability analysis. Design tension and embankment structures. Field supervision for the construction of designed structure. Field supervision for sub-surface investigation, rock blasting and excavation, slope stability, and embankment structure measurements.

ADDENDUM

2006 Adjunct Professor - West Virginia University - Courses offered: Surface mining, Safety and Health Mine Management

February/March, 2006 - Acting Center Chief, Pittsburgh Safety and Health Technology Center - Temporary Promotion

June/July, 2005 - Acting Center Chief, Pittsburgh Safety and Health Technology Center - Temporary Promotion

1997 - University of Kentucky - Employer Team for ABET preparation

1997 - University of Maryland - Committee member for Ph.D. candidate.

May 1997 to July 1997 - Acting Chief, Pittsburgh Safety and Health Technology Center - Temporary Promotion

1977 to present – When assigned – Acting Center Chief for Bruceton Safety Technology Center and Pittsburgh Safety and Health Technology Center.

1995-1996 Chief; Mine Waste and Geotechnical Engineering Division - Denver

1995 Virginia Polytechnic Institute and State University - Committee member for Ph.D. candidate.

1993-1994 Acting Chief, Mine Waste and Construction Engineering Division - Denver Safety and Health Technology Center

1990-2002 Adjunct Professor - West Virginia University Courses offered: Safety and Health Law, Surface Mining, Underground Mining Teaching annual professional engineering review classes. Advisor for M.S. and Ph.D. students

1979-1985 Adjunct Professor - University of Pittsburgh, Courses offered: Mine Geology, Mine Valuation, Mine Evaluation, Advanced Strata Control and Longwall Mining
Advisor for M.S. students

1977-1997 When assigned - Acting Center Chief for Bruceton Safety Technology Center and Pittsburgh Safety and Health Technology Center

COMMITTEES

1. Member of the Dams Sector Government Coordinating Council - Dept. of Homeland Security - 2005. As assigned by the Deputy Assistant Secretary.
2. Vice President for Great Lakes and Northeastern Region of SME - 2005.
3. Chair for Mining Engineering Committee of SME - 2005.
4. Board of Directors - PCMIA, 1995 to present. President - 2004.
5. Executive Committee Member – Coal Division SME – 2001 to present.
6. U.S. Society of Dams – Tailings Dam Committee Member – 2001 to present
7. Program Planning Committee for Health and Safety, Sub-committee Society of Mining, Metallurgy & Exploration, Inc. - Coal Division 1998.
8. Society of Mining, Metallurgy & Exploration, Inc. - Member of Professional Registration Committee-1997-2000. Member-at-Large 2000 to present.
9. Chairman Publication Committee - Coal Division - Society of Mining, Metallurgy & Exploration, Inc. (1997).
10. Incoming Safety and Health Committee Chairman - Society of Mining, Metallurgy & Exploration, Inc. (1997).
11. Assigned by the Director of Technical Support, Mine Safety and Health Administration, to serve on the "Surface Haulage Safety Task Committee," 1997.
12. Board of Directors, 1991 to present and Chairman (1996), Society of Mining, Metallurgy & Exploration, Inc. - Pittsburgh Chapter.
13. Rock Mechanics Award Committee - Coal Division - Society of Mining, Metallurgy & exploration, Inc., 1996-1999.
14. Member of Task Group for writing proposed Metal/Nonmetal Structure Regulations for the Mine Safety and Health Administration, 1995 to present
15. Program Planning Committee Chairman for Geomechanics Subcommittee - Society of Mining, Metallurgy & Exploration, Inc. Mining Exploration Division, 1995.
16. Interagency Committee on Dam Safety - Committee member. Recommended by the Director of Technical Support and assigned by the Assistant Secretary for Mine Safety and Health Administration as Dam Safety Officer for the Department of Labor – responsible for coordinating Mine Safety and Health Administration's Dam Safety Program with the Federal Emergency Management Agency, 1995 to present.
17. Ph.D. Candidate Advisory Review Committee at Virginia Polytechnic Institute and State University, and West Virginia University, 1995.
18. Department of Interior Working Group on Dam Safety - Subcommittee member on metal/nonmetal tailings structure, 1995-1996.
19. Assigned by the Director of Technical Support to serve on the Advisory board for the Generic Mineral Technology Center Mine Safety and Environmental Engineering at Virginia Polytechnic Institute and State University, 1995.
20. Member of Task Group for writing proposed Metal/Nonmetal Tailings Structure Regulations for Mine Safety and Health Administration, 1995 to present.
21. Member of the Delegation of U.S. Department of Labor, Mine Safety and Health Administration, visit to China, September 1987.
22. Member of the Task Committee on Strategic Petroleum Reserve Program - Assisting Dept. of Energy, 1976-1978.
23. Member of Task Committee on Nuclear Waste Storage Program - Assisting the Dept. Of Energy and Nuclear Regulatory Commission, 1975-1979.
24. Member of Code of Federal Regulations, Part 30, 77.214-216 in developing the mine waste impoundment and refuse pile regulations for coal for the Mine Safety and Health Administration, 1973-1975.

AWARDS

1. The Coal and Energy Division Distinguished Service Award - Society of MIning Metallurgy and Exploration, Incorporated - March 2005.
2. SME Distinguished Member Award - Society of Mining, Metallurgy and Exploration, Incorporated - March 2005.
3. U.S. Dept. of Labor - MSHA Award for Quecreek Mine Rescue - 2002.
4. The Coal and Energy Division Distinguished Service Award - Society of Mining Metallurgy and Exploration, Incorporated – 2000
5. Service Award - Society of Mining, Metallurgy and Exploration, Incorporated - Pittsburgh Chapter - October 1997.
6. Distinguished Member Award - SME Pittsburgh Chapter, October 1997.
7. Secretary's Performance Award, U.S. Dept. of Labor, December 1996.
8. Secretary's Exceptional Achievement Award, U. S. Department of Labor, April 11, 1996.
9. Elected by the SME Student Chapter of West Virginia University given April 1993.
10. Excellent Teaching Professor of the Mining Engineering Department for the Year 1992.
11. Distinguished Career Service Award, U.S. Department of Labor, 1993.
12. Special Achievement Award, Mine Safety and Health Administration, U.S. Dept. of Labor, January 1992.
13. Special Achievement Award, Mine Safety and Health Administration, May 1988.
14. Engineer of the Year Award (1982) for the U.S. Department of Labor, Mine Safety and Health Administration. This award was based on my professional knowledge, job performance, managerial experience, activities in the educational institution and community.
15. Secretary of Labor's Recognition Award - 1979.
16. Research assistantship received at the University of Wisconsin, 1963, 1964 and 1967.
17. Fellowship received at Taiwan Provincial Cheng-Kung University, 1958, 1959, 1960 and 1961.

PROFESSIONAL ACTIVITIES

Served as Program Chairman for the "Construction Materials and Aggregates Session," SME Annual Meeting 2007

Served as a session chairman on the "First International Computer Application of the Mining Industry" at the West Virginia University.

Served as session chairman on the "Second, 4th, 6th, 10th, 13th, 15th and 16th International Ground Control Conference" at the West Virginia University.

Served as session chairman on the "Third Workshop on Subsidence," West Virginia University, 1992.

Served on the organizing committee, and chaired a session at the "10th International Conference on Ground Control in Mining," June 1991.

Chaired a Longwall Session at the 30th Symposium on Rock Mechanics held at West Virginia University, Morgantown, WV, June 1989.

"Annual Impoundment Specialist Seminar" at the National Mine Health and Safety Academy, Mine Safety and Health Administration, 1984 to present.

"Surface Mining Seminar," coordinator and Chairman at Metal/Nonmetal Mine Safety and Health, Northeastern, Southeastern, North Central and South Central Districts, Mine Safety and Health Administration, U.S. Department of Labor.

"Coal Waste Impoundment Qualify Person Training Course" at Coal Mine Safety and Health, Districts 2, 3, 4 and 8, Mine Safety and Health Administration, 1975-1976.

PRESENTATIONS

Quecreek Rescue Presentations (activities and events that occurred during July 24-28, 2002) given at:
3/10/06 – Green Meadows Assisted Living, Latrobe, PA
4/26/05 - "30th Annual Mine Trainers Association Conference" - Illinois
4/16/04 - ASFE Conference - New York
11/9/03 - Case Western University - Ohio
11/10/03 - Holmes Safety Chapter - Somerset, PA
10/2/03 - Society of Mine Safety Professionals at Appalachian Technical College Georgia
9/29/03-Independent States of the Former Soviet Union- Beckley, WV
4/8/05-New York Chapter of SME
3/3/03-Chicago Chapter of SME
2/18/03-Holmes Safety Association-Indiana Council
1/21/03-Holmes Safety Association-Ohio Council
11/24/02 - University of Kentucky

Presentation on "New Technology for Detecting Old Works" at the MINExpo International 2004 Conference - September 2004.

Presentation on "Tailings Inspection" at Western District of Metal/Nonmetal-July 2003.

Presentation on Highwall Safety - South Central District - June 2003.

Presentation on Geotechnical Methods for the National Research Council-January 2003.

Presentation of Technical Considerations for the Design and Construction of Mine Seals to Withstand Hydraulic Heads in Underground Mines," 1995 SME Annual Meeting and Exhibit in Denver, CO.

Presented "Proven Methods of Reducing Non-Fatal Days Lost (NFDL) in Coal Preparation Plants," May 1995 at Coal Prep 95.

Presented "Mining Near Flooded Mine Works" at the Joint Meeting SME/PCMIA, Pittsburgh, PA, October 1994.

Invited by the Pennsylvania Bureau of Deep Mine Safety to make a presentation at the Pennsylvania Coal Health and Safety Conference, Washington, PA, April 1993.

At the request of District 10, Mine Safety and Health Administration presented a program on highwall stability, May 1992.

Invited by the Arkansas State Department of Mines made a presentation on "Open-Pit Mining Highwall Stability Problems."

Invited by the University of West Virginia, attended graduate student seminar and gave a technical presentation on mine waste handling problems.

Invited by the University of Alabama, taught short course in the area of mine waste disposal.

At the request of Coal Mine Safety and Health, Districts 2 and 10, made a presentation on the "MSHA Concurrence for Mining Permits Related to OSM Regulations" during the public safety meeting.

At the request of Technical Support, a presentation was made at the National Mine Rescue Contest for Metal/Nonmetal in Las Vegas, NV, August 1990.

Made a presentation at the Nevada Governor's Safety and Health Conference, March 1992.

Invited by the Virginia Dept. of Environmental Resources to make a presentation on "Surface Mining Hazards" at the Virginia Safety association Conference, May 1992.

Invited by the UMWA, a presentation was made at the UMWA Quarterly Safety meeting in Birmingham, AL, on "Mining Under Bodies of Water and Mining Through Gas Wells," December 1991.

At the request of Technical Support, a presentation was made at the national Mine Health and Safety Academy for the Chinese Delegation, November 1991.

At the request of Technical Support, a presentation was made on "Mining Safety" at the National Mine Rescue Contest for Coal Mines in Lexington, KY, 1991.

PRESENTATIONS (CONTINUED)

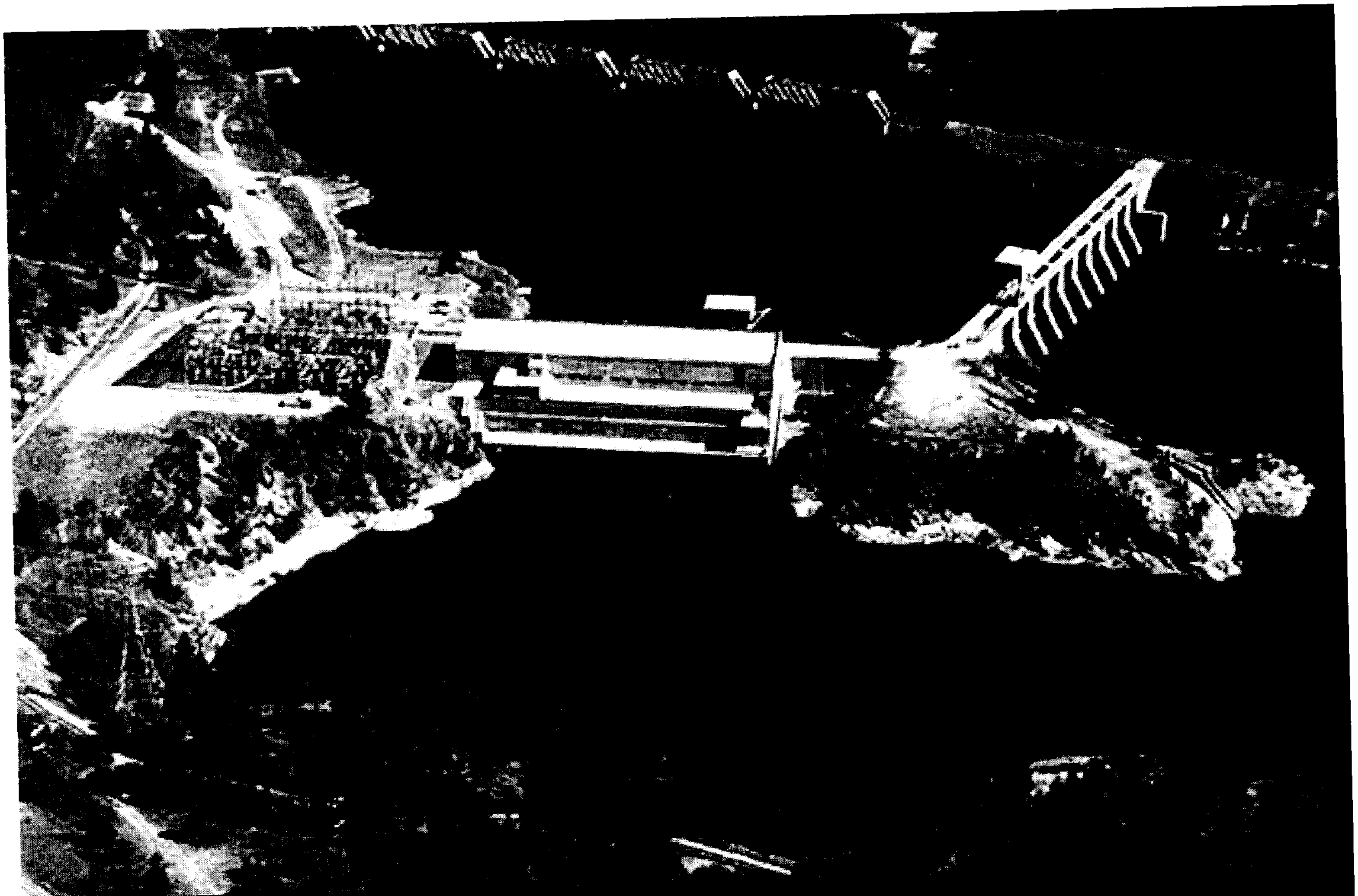
At the request of the Western District, a presentation was made on "Surface Mining Safety," at Vacaville, CA, September 1991.

Invited by the PA Bureau of Deep Mine Safety, to present an informational workshop on mining through gas wells was presented at the Westmoreland County Community College on January 14, 1991.

At the request of Technical Support, a presentation was made on "Mining Safety," at the National Mine Rescue Contest for Metal/Nonmetal Mines in Las Vegas, NV, August 1990.

Presentation at the 5th Joint Safety and Health Conference, Greensburg, PA, January 1987, "Stockpile and Pitfall Hazards."

Presented a technical paper and chair technical sessions at the SME/AIME meeting, 1980, 1981, 1982, 1983 and 1988.



Federal Guidelines for Dam Safety

April 2004

FEMA

Attachment 2

FEDERAL GUIDELINES FOR DAM SAFETY

prepared by the
INTERAGENCY COMMITTEE ON DAM SAFETY

U. S. DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY
JUNE 1979

Reprinted April 2004

PREFACE

These guidelines represent the culmination of efforts, initiated by President Carter in April 1977, to review procedures and criteria used by Federal Agencies involved in the design, construction, operation, and regulation of dams and to prepare guidelines for management procedures to ensure dam safety. The guidelines are based on an intensive review of Agency practices conducted by the Departments and Agencies themselves, by an *ad hoc* interagency committee of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET), and by an Independent Review Panel of recognized experts from the academic and private sectors. These reviews are summarized in two earlier reports: *Improving Federal Dam Safety*, a report of the FCCSET, November 1977, and *Federal Dam Safety Report of the OSTP Independent Review Panel,* December 1978.

Publication of the guidelines marks the final step in the review process. However, the Departments and Agencies recognize that there must be a continuing Federal effort to improve dam safety. Federal dam safety remains a fundamental responsibility of each Federal employee in every Department and Agency involved and it is on their technical expertise and dedication that the safety of Federal dams rests. These guidelines recognize that underlying fact and support management efforts to discharge that responsibility effectively and efficiently.

These guidelines apply to Federal practices for dams with a direct Federal interest and are not intended to supplant or otherwise conflict with State or local government responsibilities for safety of dams under their jurisdiction. Current Federal initiatives to assist States and others with non-Federal dam safety programs are being pursued under other authorities. The objective of both programs, however, is the same: to allow the people of this country to enjoy the benefits of water resource development with the best assurance of dam safety possible.

The members of the FCCSET *Ad Hoc* Committee are to be commended for their diligent and highly professional efforts. Gratitude and appreciation are also due the several Departments and Agencies involved for their whole-hearted interest and support.

Frank Press, Chairman
Federal Coordinating Council
for Science, Engineering and
Technology

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I. INTRODUCTION

These guidelines apply to management practices for dam safety of all Federal agencies responsible for the planning, design, construction, operation, or regulation of dams. They are not intended as guidelines or standards for the technology of dams. The basic principles of the guidelines apply to all dams. However, reasonable judgments need to be made in their application commensurate with each dam's size, complexity, and hazard.

The Federal agencies have a good record and generally sound practices on dam safety. These guidelines are intended to promote management control of dam safety and a common approach to dam safety practices by all the agencies. Although the guidelines are intended for and applicable to all agencies, it is recognized that the methods of the degree of application will vary depending on the agency mission and functions.

A. BACKGROUND

Throughout history, in all parts of the world, dams built to store water have occasionally failed and discharged the stored waters to inflict sometimes incalculable damage in the loss of lives and great damage to property. Failures have involved dams built without application of engineering principles, but have also involved dams built to, at the time, accepted engineering standards of design and construction. The technology of dams has improved with the increased knowledge of design principles and of the characteristics of foundation and dam materials, and it is generally agreed that safe dams can be built and existing dams can be safely maintained with proper application of current technology. It is the intent of these guidelines to outline management practices that will help to ensure the use of the best current technology in the design, construction, and operation of new dams and in the safety evaluation of existing dams.

As early as 1929, following the failure of the St. Francis Dam, the State of California enacted a dam safety program. Subsequently, other dam failures causing loss of life and property have prompted additional legislation on state and national levels.

The Congress in 1972 enacted Public Law 92-367, known as the "National Dam Inspection Act." The Secretary of the Army was authorized to inspect non-Federal dams in the nation meeting the size and storage limitations of the Act to evaluate their safety; report inspection results to the States and advise the States on actions needed to ensure dam safety; report to the Congress the information given to the States; prepare a national inventory of dams; and make recommendations to the Congress "for a comprehensive national program for the inspection and regulation for safety purposes of dams of the nation." Responsibilities under the law were delegated to the Corps of Engineers. The activities performed under the program consisted of an inventory of dams; a survey of each State and Federal agency's capabilities, practices, and regulations regarding the design, construction, operation, and maintenance of dams; development of guidelines for inspection and evaluation of dam safety; and formulation of recommendations for a comprehensive national program. A report on these activities and proposed legislation to implement a Federal dam safety program were transmitted to Congress in November 1976, but lack of funding prevented the execution of the detailed dam inspections.

The failure during initial filling in 1976 of the Teton Dam in Idaho, a Federal earth embankment dam over 300 feet high, reactivated intense public and governmental concern for dam safety. Congressional and Federal agency investigations were made into this disaster and the entire question of dam safety, and new Federal legislation for dam safety was initiated in the Congress.

An April 23, 1977, Presidential memorandum (reproduced in Section I.B) directed federal agencies to review their dam safety practices, addressing many elements of dam safety. Major elements included internal and external review, qualifications of personnel, integration of new technology, emergency preparedness plans, and review of existing dams. The agencies' reviews and the assessment of the reviews by a Federal *ad hoc* interagency committee and by an Independent Review Panel showed that sound practices are generally being used, but concluded that improvement is needed in some management practices for dam safety.

B. AUTHORITY AND IMPLEMENTATION

The authority for preparation of these guidelines is contained in a memorandum from President Carter dated April 23, 1977, which read as follows:

"MEMORANDUM FOR:

The Secretary of the Interior
The Secretary of Agriculture
The Secretary of the Army
The Director, Office of Management and Budget
The President's Adviser on Science and Technology
The Chairman, Federal Power Commission
The Chairman, Tennessee Valley Authority
The Commissioner, U.S. Section, International Boundary and Water Commission

The safety of dams has been a principal concern of Federal agencies that are involved with the various aspects of their planning, construction, operation and ultimate disposal. Events of the past several years have highlighted the need to review procedures and criteria that are being employed by these agencies with the objective of ensuring that the most effective mechanisms are established to give the best assurance of dam safety possible within the limitations of the current state of knowledge available to the scientific and engineering communities. The safety of such projects should continue to be accorded highest consideration, and it is the responsibility of the head of each agency concerned to ensure the adequacy of his agency's dam safety program.

I. Agency Dam Safety Reviews

The head of each Federal agency responsible for, or involved with site selection, design, construction, certification or regulation, inspection, maintenance and operation, repair and ultimate disposition of dams shall immediately undertake a thorough review of practices which could affect the safety and integrity of these structures. This review will encompass all activities which can be controlled or regulated by the agency.

Several aspects of the problem require special attention. In particular, the following items should be investigated: the means of inclusion of new technological methods into existing structures and procedures; the degree to which probabilistic or risk-based analysis is incorporated into the process of site selection, design, construction, and operation; the degree of reliance on in-house, interagency, and outside expert interpretation of geologic data in site selection and design development; the effect on dam safety of earthquake or other earth movement hazards; the effects of cost-saving incentives on decisions both prior to and during construction; the procedures by which dam safety problems are identified, analyzed, and solved; the involvement of local communities in identifying, analyzing, and solving dam safety questions; and the major outstanding dam safety problems of the agency.

II. Interagency Report and Proposed Guidelines
The Chairman of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) shall convene an *ad hoc* interagency committee to coordinate dam safety programs, seeking consistency and commonality as appropriate, and providing recommendations as to the means of improving the effectiveness of the Government-wide dam safety effort. The agency reviews described above should be provided to the FCCSET as a basis for the interagency analysis on a timetable established by the FCCSET group as reasonable and consistent with the October 1, 1977 deadline for a final report. Representation on the FCCSET for this activity should be expanded to include other appropriate Federal agencies or departments including, but not limited to, the Tennessee Valley Authority, the United States Section-International Boundary and Water Commission and the Federal Power Commission. The FCCSET effort will include preparation of proposed Federal dam safety guidelines for management procedures to ensure dam safety. FCCSET should report on all these items.

III. Independent Review Panel
In addition, the Director of the Office of Science and Technology Policy will arrange for review of agency regulations, procedures and practices, and of the proposed federal dam safety guidelines, by a panel of recognized experts to be established immediately. The panel will obtain the views and advice of established organizations, professional societies, and others concerned with the safety of dams which are in any way affected by a Federal role.

The review report thereon should be completed no later than October 1, 1978."

(signed) Jimmy Carter

The *ad hoc* interagency committee called for in paragraph II of the memorandum was established by FCCSET, under the direction of the Office of Science and Technology Policy. The committee was represented by:

Office of Science and Technology Policy (Chairman)
Department of the Army
Department of Agriculture
Department of the Interior
Nuclear Regulatory Commission (NRC)
U.S. Section, International Boundary and Water Commission (IBWC)
Federal Energy Regulatory Commission (FERC) (Formerly Federal Power Commission)
Tennessee Valley Authority (TVA)

The Nuclear Regulatory Commission was added to the dam agencies addressed in the memorandum. Members of the *ad hoc* committee are listed in Appendix A.

Also established were subcommittees for the preparation of the proposed Federal dam safety guidelines called for in paragraph II of the memorandum. These subcommittees and their task groups had representatives from all the agencies with responsibilities for dams. Appendix B lists the members of the subcommittees and task groups and their agencies.

In accordance with the Presidential memorandum, the participating agencies submitted their reports on review of agency management practices involving dam safety; the subcommittees submitted the proposed Federal dam safety guidelines; and the *ad hoc* committee prepared the FCCSET report, *Improving Federal Dam Safety,* dated November 15, 1977. The report contains summaries of the agency reports, and the subcommittee proposed guidelines and summary thereof; assesses the agency reports; and makes recommendations for improvement of management practices for dam safety.

Pursuant to paragraph III of the President's memorandum, the Independent Review Panel was formed with specialists from the academic and private sectors concerned with dams. Members of the panel are listed in Appendix C. The panel reviewed the FCCSET and associated reports and proposed guidelines, and submitted a report, *Federal Dam Safety, Report of the OSTP Independent Review Panel,* December 6, 1978.

These guidelines were developed from the FCCSET report and its proposed guidelines, from Independent Review Panel recommendations, and with the cooperation of the panel.

C. DEFINITIONS

The following definitions apply in these guidelines.

Dam or Project. Any artificial barrier, including appurtenant works, which impounds or diverts water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of fifty acre-feet or more. These guidelines do not apply to any such barrier which is not in excess of six feet in height regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet regardless of height. This lower size limitation should be waived if there is a potentially significant downstream hazard.

The guidelines apply with equal force whether the dam has a permanent reservoir or is a detention dam for temporary storage of floodwaters. The impounding capacity at maximum water storage elevation includes storage of floodwaters above the normal full storage elevation.

In addition to conventional structures, this definition of "dam" specifically includes "tailings dams," embankments built by waste products disposal and retaining a disposal pond.

Dam Failure. Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water. It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters which adversely affect a dam's primary function of impounding water is properly considered a failure. Such lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action.

Contract. Contracts relating to project design, construction equipment, operation, or regulation, as applicable to the project and the agency function. Where work is described using the terms contract or contractor, it is meant to include also similar work by the agency's own personnel

Maintenance. Maintaining structures and equipment in intended operating condition; equipment repair and minor structure repair.

Rehabilitation or Improvement. Repair of structure deterioration to restore original condition; alteration of structures to improve dam stability, enlarge reservoir capacity, or increase spillway and outlet works capacity; replacement of equipment.

Hazard. Potential loss of life or property damage downstream of a dam from floodwaters released at the dam or waters released by partial or complete failure of the dam, and upstream of the dam from effects of rim slides. A hazard is considered significant if there is a potential to cause loss of life or major damage to permanent structures, utilities, or transportation facilities.

Emergency Preparedness Plan. Formal plan of procedures to alleviate hazards during construction of or after completion of a dam or to reduce damages if conditions develop in which dam failure is likely or unpreventable. These emergency plans related to dam safety do not include flood plain management for the controlled release of floodwater for which the project is designed.

II. OBJECTIVES AND SCOPE

The overall purpose of these guidelines is to enhance national dam safety. The immediate objective is to encourage high safety standards in the practices and procedures Federal agencies use or require of those they regulate for dam site investigation, design, construction, operation and maintenance, and emergency preparedness. As these guidelines are directly applied to make Federal dams as safe as practical, it is hoped that they will also influence state dam safety agencies and public and private dam owners to be more safety conscious where programs are now weak.

The guidelines are intended to outline Federal agency management procedures that will continually stimulate technical methods in dam planning, design, construction, and operation for minimizing risk of failure. The objective of dam safety would be achieved as management and technical decisions during all project stages give proper recognition to safety considerations, and the strategy of these guidelines toward that end is to describe definite management practices to reinforce decision-maker awareness of safety needs. Those charged with administering these guidelines must recognize that the achievement of dam safety is through a continuous, dynamic process in which guidelines, practices, and procedures are examined periodically and updated. Technical procedures need to change with technological advancement, and management should ensure that observed deficient practices are corrected and that successful practices are duplicated.

The goal of making dams as safe as practical implies a limit to maximum reasonable effort. Those charged with implementing these guidelines need to recognize that no dam can ever be completely "fail-safe" because of incomplete understanding of or uncertainties associated with natural (earthquakes and floods) and manmade (sabotage) destructive forces; with materials behavior and response to these forces; and in control of the construction process. Management must ensure that uncertainties are properly balanced with competent technical judgment.

Although dams have been built for thousands of years, dam engineering is not an exact science and is more accurately described as an "art." It is true that this branch of engineering, like any other, draws heavily upon mathematical principles and physical laws, but every stage of the planning and execution of a dam project also requires the exercise of experienced judgment. This is true in designing and constructing new dams, and especially true in evaluating and/or improving existing dams. For many of these "older dams," there is little information available to document original site exploration, design, construction, and past operation. These dams must be carefully inspected and observed for indicators of distress.

To illustrate a principle from just one aspect of dam design, there are practical limitations on the amount of physical data that can be obtained during planning and design. Judgment and extrapolation are necessary to assess foundation conditions and to design an appropriate structure. Experience is essential in applying these judgments.

Construction is a critical phase in achieving a safe dam. Any project must be continuously evaluated, and "re-engineered" as required, during construction to assure that the final design is compatible with conditions encountered during construction. Quality of construction is also critical to safety. Deficiencies in materials or construction practices can occur during all stages of the construction, and constant vigilance is necessary to prevent them. Sampling and testing at a completed project cannot be relied on as an effective substitute for inspection and quality control during construction.

Monitoring existing dams and reacting quickly to inadequate performance or to danger signals is a continuing critical aspect for dam safety. Careful monitoring and quick response can prevent failures, including those caused by poor construction.

The guidelines are intended to make as small as possible the failure risk inherent in constructing new dams, and to prioritize needs to improve existing dams according to hazard potential as estimated by technical analysis and as constrained by financial and personnel resources.

In the development of these guidelines, consideration was given to the broad diversity of agency missions. The guidelines were designed to be free of specific agency policies and unnecessary details. The resultant level of detail in the guidelines represents an attempt to achieve a balance between general management goals for assuring dam safety and meaningful principles which can survive technological changes and be useful to the non-Federal community.

A special situation exists regarding the application of these guidelines to dams of international nature. Several dams of concern to the United States are located partially in the United States and partially in Mexico or Canada. Those dams located at the U.S.-Mexican border are only partly subject to the jurisdiction of a U.S. Federal agency, the U.S. Section of the International Boundary and Water Commission. In this case, the U.S. should seek agreement with the Mexican Section of the Commission for adoption of applicable sections of these guidelines for ensuring dam safety. For dams located on the U.S.-Canadian border, the guidelines should be referred to the U.S. Section of the International Joint Commission (IJC) to seek agreement with the Canadian Section of the Commission on means by which the guidelines could be implemented through the entities that are responsible for construction, operation, and maintenance of the projects.

Section III.A., *Organization Management,* outlines the elements of agency management responsibilities for dam safety. Sections III.B, III.C, and III.D, *Management of Technical Activities,* contain additional guidance on technical activities for *Site Investigation and Design, Construction, and Operation and Maintenance* (includes Periodic Inspection Program and Emergency Action Planning). *Appendix E* is a bibliography of references to related guidelines and practices developed by Federal dam building agencies and other scientific and technical organizations. The body of knowledge represented by the bibliography is intended to be representative of dam technology, but not inclusive of all available literature that may be helpful.

III. GUIDELINES

A. ORGANIZATION MANAGEMENT

1. General

Heads of Federal agencies are responsible for the development and implementation of policy, resources and procedures for safe design, construction, operation, and inspection of each dam under their jurisdiction, as applicable to the agency mission. The agency management structure assists the head of the agency in discharging this responsibility and shares in it. The management structure is ultimately responsible for obtaining compliance with the intent of these management and technical activities guidelines, and for assuring that procedures are evaluated and updated periodically.

a. Administration

The head of each Federal agency having responsibility for design, construction, operation, or regulation of dams should establish a dam safety office (officer) which reports directly to the head of the agency or his designated representative. The office should be responsible for ensuring that the agency, as a matter of policy and in actual practice, makes every reasonable and prudent effort to enhance the safety of the dams under its jurisdiction. Duties of the office should include surveillance and evaluation of the agency's administrative and technical or regulatory practices related to dam safety concerning design and construction of new dams, and operation, maintenance and rehabilitation of existing dams; recommending improvements in the practices when evaluation reveals safety-related deficiencies; and maintaining an inventory of agency dams.

The functions of the office should be advisory to the agency head, and through the agency head to the agency administrative and technical units. The staffing and detailed duties of the office should be commensurate with the agency mission.

If a Federal dam safety office is established within the recently proposed Federal Emergency Management Agency (FEMA), the heads of the dam safety offices in the respective agencies should be advisory in FEMA's interagency coordinating functions.

The agency organization for the design, construction, operation, or regulation of a dam project should be structured so that a single identifiable, technically qualified administrative head has the responsibility for assuring that all management and technical safety aspects of dam engineering are adequately considered throughout the development and operation of the project. The position must have continuity of guidance and direction, and the authority and resources to ensure these responsibilities can be carried out.

Management should ensure that organization staffing is sufficient and qualified for the projected workload, and that all programs necessary for the safety of dams are established, continued, and realistically funded. Allocation of manpower and funds should give high priority to safety-related functions. Safety-related functions and features must not be sacrificed to reduce costs, improve project justification, or expedite time schedules.

b. Design Responsibility
The design function can never be considered finished as long as the dam remains in place; design involvement should continue throughout construction and operation of the project. The design office should establish specific programs for onsite construction and operational inspection for review by appropriate design personnel and technical specialists. The programs should include frequent and mandatory inspections during construction to confirm that site conditions conform to those assumed for design or to determine if design changes may be required to suit the actual conditions. A major requirement is inspection and approval of the dam foundation and foundation treatment before placing of dam materials. Final design inspection of the construction should include complete project surveillance and testing of operating equipment. Operational design inspections should continue throughout the life of the project, in accordance with a formal inspection program covering all project features. Management must program adequate funds to assure dam safety is not compromised by failure to conduct regular and thorough inspections and reviews.

The design function includes responsibility for planning any dam instrumentation to be installed during construction and/or operation to monitor conditions that could potentially threaten dam safety. The design should identify the purpose of the instrumentation, and include the plans for timely reading, collecting, reducing, and interpreting the data. It should include an advance determination of critical instrument observations or rates of data change, and a plan of action if observations indicate a critical condition may occur.

c. Construction Responsibility
The responsibility for administering construction and supply contracts, for understanding the design and contract intent, for maintaining technical coordination between design and construction engineers, and for managing the construction staff to assure compliance with specifications should be vested in an identified engineer at the construction project. He should have the administrative and technical control of all resources necessary to accomplish safe construction of the dam. Construction personnel should understand the conditions upon which the design is based and the relationship between these conditions and the design features. When unanticipated conditions are encountered, design personnel should be involved in determining their effect.

d. Operation Responsibility
The responsibility for project operation should be assigned to a single staff member of the operating organization. He should also handle the operating organization requirements for coordination with the design organization, including reporting changed conditions discovered by operators and participation of the operating organization personnel with design personnel in the periodic inspection program.

e. Technical Coordination
All technical specialties required to plan, design, construct, and operate dams to achieve dam safety should be staffed and their efforts coordinated to ensure technical adequacy. A project design engineer should be assigned technical coordination responsibility for each dam. He should handle necessary technical coordination within the agency and with private and public organizations.

Continuing liaison should be maintained among the personnel concerned with the various stages of project development and operation so that each concerned discipline and organizational unit knows and understands the relevant activities of the others. This coordination must be given constant attention to be sure proper action is taken.

f. Emergency Planning

An emergency plan should be formulated for each dam. The plan should be in the detail warranted by the size and location of the dam and reservoir. It should evaluate downstream inundation hazards resulting from floods or dam failure, and upstream conditions that might result from major land displacements or increased flood flows, including the effects from failure of upstream dams.

Where applicable, the plan should include inundation maps for the flows resulting from design floods and from possible failure of the dam. The complete emergency plan should be transmitted to appropriate local, state, and Federal governmental bodies. The plan should be periodically reviewed and kept up to date, and periodically publicized to maintain awareness of its existence.

In addition to the emergency plan for the completed dam, a similar plan should be prepared for the construction period, including area facilities that may remain during the period and floods that may be anticipated.

g. Risk-Based Analysis

Risk-based analytical techniques and methodologies are a relatively recent addition to the tools available for assessing dam safety. With further refinement and improvement, risk-based analyses will probably gain wider acceptance in the engineering profession and realize potential as a major aid to decision-making in the interest of public safety. However, even when fully developed, risk analyses cannot be used as a substitute for sound professional judgment of engineers, contractors, or review boards. In view of the dual problems of uncertainty in analysis and possibility of misinterpretation by the public, but in recognition of the high potential these techniques have, agencies should be encouraged to conduct research to refine and improve the techniques and to develop the methodologies and base of expertise necessary to apply them to dam safety evaluations. Specifically, agencies should strive to perfect techniques for evaluating the probability of possible deficiencies causing dam failure and estimating the potential losses due to such a failure. Meanwhile, the agencies should evaluate the potential consequences of failure of the dams under their jurisdiction. Although the value of potential property losses can be estimated, it is recognized that potential loss of lives can only be quantified, but not evaluated. On new dams, potential losses can be used in study of project alternatives and in assessment of additional safety incorporated into the dam facilities. On existing dams, a risk-based analysis should be considered in establishing priorities for examining and rehabilitating the dams, or for improving their safety.

2. Staffing

a. Technical Support

Management should assure adequate and competent technical staffing to perform the essential functions in planning design, construction, and operation and maintenance of dams. Technical staff should be well supported by administrative, clerical, and other elements to ensure that the technical staff is not diverted from technical work. In the planning and design function, particular emphasis should be given to adequate staffing in hydrology, hydraulics, geology, engineering seismology, field investigation, and geotechnical and structural design. Sufficient expertise should be available on the construction staff and on the operation staff to maintain an understanding of design decisions related to the various design specialties.

Construction inspection staffing should assure quality as well as quantity inspection coverage. Staffing should be reviewed by higher authority than the local construction office. Field personnel should be well trained and experienced if the design is to be implemented and a safe structure is to be constructed. They must not only recognize the need for adherence to the design, but must be able to recognize when the design is at odds with conditions being encountered. The responsibility and importance of the construction staff to dam safety must be given appropriate consideration in organizational and position classification decisions.

The operating personnel must be qualified to perform the many functions required in the operation, including the recognition of conditions possibly detrimental to dam safety. Operation and maintenance staffing requires careful attention to personnel responsible for operating inspections, and to personnel who participate in the periodic inspection program. It is essential that support personnel and equipment are provided to accomplish needed maintenance activities.

b. Competence

Job-related experience, professional aptitudes, and educational background should be major factors in evaluating the competence of individuals for the requirements of each responsible position concerned with the safe design, construction, and operation of dams. All positions should be staffed by competent engineers or specialists in the related disciplines.

c. Continuity

Staffing policies should recognize that continuity of technical positions is essential to maintain consistent high standards of practice. This applies in all elements of project development from design to operation, and is especially critical in those positions having supervisory responsibility related to dam safety.

d. Professional Advancement

The agencies should maintain a positive program for advancement of technical personnel in recognition of acquired experience, training and education, and increased competence. It is essential that agencies maintain the technical as well as the managerial expertise required for safe, effective dam design, construction, and operating programs. Organizational structure, position classification, and career incentives must recognize both technical and managerial responsibility and compensate both equitably.

3. Training

a. Internal

To supplement technical staffing, agency management should provide internal personnel training. A rotational training program should be established to familiarize new personnel with all major aspects of the agency functions and the interrelationships of its organizational units. Provisions should be made for technical personnel to observe and participate in decision-making meetings and to make site visits with more experienced staff. Staff members should be allowed to attend consultant meetings in order to gain valuable experience.

Technical personnel concerned with all phases of project development should be given broad exposure to a variety of field conditions. For example, geologists and geotechnical personnel should gain experience with soil and rock drill crews and in the laboratory testing facilities; design personnel should be familiar with concrete and soil placing and testing techniques; operating personnel should be familiar with equipment installation and testing procedures.

A rotational training program should be considered that would place construction engineers in the design organization during design and design engineers in the field during construction on temporary assignments. Preconstruction training should be provided for inspection personnel, covering the design engineering considerations and the requirements and importance of thorough field inspection. The training should be given by embankment or structural engineers and geologists assigned from design or by the construction engineer who had received preconstruction orientation by the designers, geologists, and embankment and structural engineers (section III.A.4.a). This training should make sure that all inspectors know the expected requirements in detail. Onsite instruction sessions for inspection of new features of construction should be developed and given by supervisors or lead inspectors before initiation of the work.

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.

Personnel involved in inspections should be trained for the requirements of these duties. The training should cover the types of information needed to prepare for the inspections, critical features that should be observed, inspection techniques, and preparation of inspection reports.

b. Academic
Agency management should establish and maintain a program for continuing formal education and training aimed at increasing and broadening the agency's base of professional expertise in areas related to safe design and construction of dams. Such training should provide for part and/or full time attendance at universities and at special courses prepared by technical and professional organizations. Programs should be designed to further the development of younger personnel and to provide refresher training or sabbaticals for senior personnel.

Supervisory construction, inspection, and operation and maintenance staff should keep current on modern methods and techniques by attending technical courses. Pertinent courses are available from private sources and educational institutions. Also, agencies that develop internal educational programs for this purpose should make them available to other agencies, permitting the agencies to gain mutual benefit in the exchange of information on new methods and practices.

c. Professional
Professional growth of personnel should be encouraged by policies which ensure adequate training, support participation in technical and professional societies, and establish attractive career and promotional ladders for technical specialists. Professional registration and active membership in professional and technical societies should be given due consideration in assessing qualifications for higher technical positions.

d. New Technology
Provision should be made for the establishment of procedures to screen and disseminate information on technical advances relating to dam design, construction, and operation. Programs for continuing professional training should be oriented toward keeping the technical staff abreast of improved technology. Interagency coordination on training in new technology should be established in areas of mutual interest.

4. Communication
Effective methods of communication, coordination, and review should be established and functioning properly at all times, and be periodically reviewed and updated. Procedures for communications among Federal, State, and local agencies on safety-related matters should be established. Specific areas of suggested communication are discussed below.

a. Interdisciplinary
Direct and easily accessible means of communication should be established between personnel in planning, design, construction, and operations. Coordination is necessary for preparation of the site investigation plan and for a common understanding of information needed for design. Prior to the site investigation the design staff should arrange for meetings between geologists, geotechnical engineers, and designers to review known site conditions, project functional requirements, and preliminary design concepts. A visit to the site should be included in the review of existing information.

A document, referred to by some agencies as "Design Considerations," should be prepared by the design staff to transmit site-specific design considerations to the construction staff. This document should cover, but not be limited to, hydrologic and hydraulic considerations, geologic and geotechnical data, foundation conditions, foundation treatment details, and anticipated foundation problems. It should specify points at which inspection and approval are required by the design staff. Copies of the document should be furnished to those responsible for dam operation and inspection.

Additionally, the design staff should arrange preconstruction orientation for the construction engineers by the designers, geologists, and embankment and structural engineers so that the construction engineer and his staff fully understand the design concepts and the significance of the results of the exploratory work. The construction engineers need to provide the designers, prior to advertising the construction contract, comments on the constructability and the ease of contract administration for the plans and specifications.

During construction, the construction engineers should be alert for conditions that need to be reported to the design engineers. Field personnel should notify design personnel of any critical construction sequence or of a suspected change in conditions that could affect the design of the structure. Design engineers with relevant expertise must be available to make regular visits to the construction site, and additional visits as needed when varying conditions arc encountered. Changes in construction or materials should be made only after plans for changes are approved by design personnel.

The design staff should furnish to the operation staff documents, referred to by some agencies as "Operation and Maintenance Manuals," containing pertinent design and construction information on structures and equipment required for effective and safe operation of the dam. A conference of design and operating personnel should be held to ensure that the operators understand the operating and inspection procedures required for safe and reliable operation. Both the operators and the designers should have copies of equipment operating and testing manuals and procedures. The operators should notify the designers of any safety-related operating malfunctions and the actions taken to correct them. There should be continuing communication between operating and design staffs regarding plans and schedules for periodic safety inspections of the dam. Copies of operation and maintenance manuals should be furnished to the dam inspection staff.

b. Interagency
Interagency communications should be maintained on safety matters related to design, construction, and operation of dams, and related research. This should include exchange of materials such as design standards, construction specifications, significant research reports, and final design and construction reports on major structures. The agencies should establish communications to periodically review investigation methods, construction materials testing standards, analytical methods, design philosophies, and management procedures.

5. Documentation
Throughout project development (planning, site investigation, design, construction, initial reservoir filling, and operation), all data, computations, and engineering and management decisions should be documented. Documentation should cover investigation and design, construction plans and construction history, operation and maintenance instructions and history,

damage and repairs and improvements, and periodic inspections during construction and operation. It should include, but not be limited to, memoranda, engineering reports, criteria, computations, drawings, and records of all major decisions pertaining to the safety of the dam.

a. Design Record

Written documentation should be maintained in standardized format on all design-related information for the project. Planning design documentation should cover the project objectives and the studies made to locate, size, classify as to potential hazard, and select the type of dam and auxiliary facilities. Site investigation documentation should cover geologic mapping and studies made of the geologic and geotechnical explorations and conditions for the various dam sites considered and the detailed investigations for the chosen site. Geological, seismological, and geotechnical features and considerations, whether specifically identified during the investigation, interpretations from the data and experience at other sites, or suspected by experienced personnel, should be fully documented. Design documentation should include all design criteria, data and qualitative information, assumptions, analyses and computations, studies on discarded alternatives, and derived judgments and decisions.

As-built drawings should be prepared as facilities are completed, and should be made available to operation and maintenance personnel and to the dam inspection staff.

b. Construction Record

All phases of the construction should be documented, including reporting of routine and special activities. Changes in construction plans and departures from expected site conditions should be documented, with any consequent design changes. The record should include information on materials and construction processes, field exploration and test results, geologic mapping of foundations and excavations, inspection records, as-built drawings, and decisions to adapt the design to actual field conditions.

A formal plan for a construction inspection system should be developed, including inspection procedures and types and forms of reports. The system should identify and record the status of inspection of approved and rejected materials. Survey notes, sketches, and records of all materials tests made for the control of construction quality should be maintained for the life of the project. A job diary should be maintained for each construction contract to provide a complete history of the work, listing in chronological order the events having a bearing on performance of the work, and analysis of cause and effects of special events. Photographic documentation of significant events, findings, and safety problems should be provided. The inspection program and record should give special attention to factors that may have a future influence on dam safety.

Documentation must also be provided, as required, by applicable procurement, safety and health personnel, and financial regulations.

c. Initial Reservoir Filling and Surveillance Record

An initial reservoir filling and surveillance plan should be prepared by the design staff. Initial filling should be well documented, including a record of reservoir elevations and controlled water releases during the filling. The record should include complete written justification and design approval of any deviations from the planned filling. The surveillance record should include all information obtained from inspection of the dam, appurtenant structures, abutments, and reservoir rim during the initial filling.

d. Operation and Maintenance Record

Operation and maintenance should be fully documented, including the routine activities and systematic inspection processes, and complete information on project maintenance, rehabilitation, and improvements. In addition to records on the actual operations, the operating record should include data on reservoir levels, inflow and outflow, drainage system discharge and structural behavior.

If there are maintenance problems that require continuing remedial work, a thorough record of the work should be maintained, and a final report made after complete remedy of the problem.

e. Permanent Files

One copy of all documents concerning the project should be assembled in a single project file. The file should be kept up to date and should be maintained as a permanent archival reference. A second file of the materials should always be easily accessible to responsible personnel for reference in future reviews and inspections, and in dealing with problems, repairs, etc. Both files should be continuously updated with records on problems, repairs, operation, instrumentation, and inspection for the life of the project. Information such as foundation reports and as-built drawings and maps should be permanently retained at the project and also at the agency's engineering design office.

6. Reviews

a. Extent

All factors affecting the safety of a dam during design, construction, and operation should be reviewed on a systematic basis at appropriate levels of authority. Reviews include those internal to the agency, and those external to the agency, by individuals or boards (consultants) with recognized expertise in dam planning, design, and construction.

b. Internal

Provision should be made for automatic internal review of all design decisions, methods, and procedures related to dam safety. Review should be at levels of authority above the design section or designer-supervisor relation. Uniformity of criteria and design technique should be maintained, as well as methods to ensure that specific experience is exchanged and used to advance the agency's ability to design, construct, and operate safe dams.

Management technical personnel should review the construction periodically. Reviewing personnel should include geologists, geotechnical engineers, and embankment and/or structural engineers who have had experience in responsible positions relating to similar structures. When appropriate, the reviews should include mechanical and/or electrical equipment engineers. Preconstruction inspection should be made after geologic mapping is done and prior to ground surface disturbance. On large projects, construction reviews would normally be at critical construction periods such as start and completion of foundation preparation and grouting, dam construction at several stages, and completion of the dam. Visits by appropriate personnel are recommended every six months, and to accompany the consultants during scheduled reviews. The final construction inspection should cover inspection of completed structures and equipment, the adjacent valley floor and abutments, and the reservoir rim.

On smaller projects, the frequency of construction review and the disciplines represented in the review would vary with the size and complexity of the project. However, management should make certain that construction reviews arc sufficient to cover the requirements for dam safety.

Reviews should be made of the agency's procedures for post-construction operation and periodic inspections. These would include the responsibilities for collection and evaluation of data from any dam instrumentation.

Reviews should be made to ensure that the project emergency preparedness plan is periodically updated.

Formal documentation should be made of all significant findings from reviews and inspections.

c. External

The need for review of a dam by independent experts (consultant board or firm) from outside the agency should be determined on a case-by-case basis, depending on the degree of hazard, size of the dam, complexity of the site geology and geotechnology, complexity of the design, or a specific need perceived by the public. Consultant reviews should provide appropriate overview evaluations of site investigation, design, and construction.

Consultant reviews of operation and maintenance practices, and of alterations and improvements, should be conducted when the agency considers such reviews advisable.

The following text deals first with design and construction reviews. Applicable portions apply also to post-construction reviews; specifics for post-construction reviews are in the last paragraph of the section.

The agency should be represented at each consultant meeting by appropriate design and construction staff. When appropriate, meetings should include a site visit. At each meeting the agency should formally document all aspects of the continued development of the project for presentation in a meeting-opening briefing to the consultants. The consultants should formally document findings and recommendations and present them at a closing conference with the agency staff.

The consultant board members should be chosen to assure coverage of all areas of expertise needed to assess the dam design, construction, and safety. The board should contain at least three, but normally not more than five, permanent members. The board should always contain a general civil engineer, a geologist and/or geotechnical engineer, as appropriate, a concrete and/or embankment dam engineer, and usually a member for the electrical and mechanical features, especially necessary if a power plant is part of the project. Additional specialists covering specific aspects such as structural integrity, earthquake response, or three-dimensional analysis should be assigned for short intervals as recommended by the board. The board should be formed during the design stage and consulted (if possible) on site selection, on type of structure, and for input to the feasibility study. The board should be kept active throughout design and construction, in order to keep the board completely familiar with all aspects of the project so they are in a position to respond rapidly if problems arise.

During design and construction of large projects, the board should meet every 6 to 12 months, depending upon activities and duration of the work. Meetings should be scheduled to review at specific phases of construction. These phases might include, but not be limited to, review during the early stages of foundation cleanup and treatment, on completion of foundation cleanup, and during the early stages of embankment and/or concrete placement. All board members should attend every meeting even though some meetings may not apply to all members. This would ensure that the entire board is fully aware of the complete work status before being asked for their input on specific points.

The briefing to the board by agency personnel at the start of a meeting should include exploration data, structural adequacy and seepage characteristics of the foundation, proposed foundation treatment, grouting programs, quarry test data, test fill data, embankment requirements for zones and material for those zones, sources of materials, compaction requirements, inspection requirements, instrumentation program, type of spillway (gated or ungated), proposed water release control systems, diversion requirements and care and diversion of water, power generation anticipated, and surge tank design. For concrete dams, the review would include concrete design and placement requirements in lieu of the embankment information.

On a smaller project, the use of consultants should be commensurate with the dam size and complexity, and with the degree of associated hazard. If there is significant hazard, the agency should obtain consultant reviews adequate to assure independent assessment of the dam safety.

Consultants should be engaged during agency evaluations of existing dams if considered necessary to provide independent support for agency assessment of dam safety. This might be in connection with studies for alterations or improvements for potential criticality of dam stability resulting from structure deterioration, or from increased reservoir levels due to possible flood inflows larger than design floods and consequent inadequate spillway capacity. It might involve consultation on seismic design; and in the case of old dams, especially embankment dams with inadequate records of materials properties, it might include consultation on the advisability and procedures for new materials investigations. Consultants on features of existing dams may be individuals rather than formal boards.

7. Research and Development

A strong research and development effort is a necessary element in reducing the uncertainties still present in dam design, hydrology and hydraulics, materials behavior, and construction techniques, equipment and practices. As part of their dam safety programs, agency management should identify opportunities and needs for research and programs to meet those needs both internally and through other agencies such as the National Science Foundation and the U.S. Geological Survey.

a. Methods and Materials
Management should ensure that a continuing review is made of state-of-the-art methods, experience, research, etc., and that improvements are incorporated into agency criteria and methods of analysis, exploration, construction, testing, and instrumentation. The process should build from experience on past projects relating to constructability, observed behavior, problems encountered, and problem solutions tried and their results. Experience histories should be reviewed, summarized, and disseminated to evaluate current practice in order to advance agency practices. Research and development needed on materials and their use as revealed by dam observation and monitoring and new developments should be conducted on a continuing basis. Establishing a schedule of research priorities is necessary for overall research and development goals and for orderly and consistent progress in advancing dam technology.

b. Risk-Based Analysis
The agencies should individually and cooperatively support research and development of risk-based analysis and methodologies as related to the safety of dams. This research should be directed especially to the fields of hydrology, earthquake hazard, and potential for dam failure. Existing agency work in these fields should be continued and expanded more specifically into developing risk concepts useful in evaluating safety issues. Existing work is exemplified by (1) the interagency research conference cited in paragraph c below, (2) its adjunct meetings on hydraulics and earthquakes, and (3) the NRC methods of risk evaluation for nuclear plants as applicable to radiological safety-related dams.

c. Interagency Coordination
Existing interagency research coordination activities should be continued, with attention to minimizing unnecessary duplication. The biennial research coordination conference on water resources among the Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority, and Bonneville Power Administration is an example of beneficial exchange needed on issues relating to dam safety.

8. Contracts

a. Documents
Agency procedures should ensure that all contracts for dam design, construction, and operation are written to accomplish the design intent and to require that contractors provide complete documentation of their work.

b. Modifications
During the construction period, any modifications in the design or construction which result from significant departures from expected field conditions, design reviews, or other studies should be promptly included in revisions to appropriate contracts. Such modifications, and any discovered later, that affect operation should be included in operation contracts (and in agency operation, monitoring, and maintenance policy). The basis and justification for any change should be documented.

9. Constraints
Many constraints which are outside agency authority can directly or indirectly affect dam safety. Managers at all levels must be continually aware of their fundamental responsibilities for dam

safety and exercise vigilance in identifying constraints on fulfilling those responsibilities. Every manager has a duty to seek resolution or mitigation of such constraints through his own agency channels or through interagency or intergovernmental channels as appropriate and available to him.

a. Funding for Organizational Management

Continuity and adequacy of funding are essential to carry out the various programs which ensure safe dams. The Zero Based Budget system offers an opportunity to managers to identify for high funding priority those activities, programs, staff levels, and other operating requirements of a sound dam safety program. Managers should avail themselves of this opportunity. Agencies should cooperatively develop common budgetary terms and consistent processes to provide the necessary visibility of dam safety funding essentials at all levels and within all branches of the government. Long-term programming objectives should be established and adhered to, to meet the requirements of organization management, personnel staffing and training, research and development, quality construction and operation, a complete program of inspection and evaluation of the safety of existing dams, and a planned program for the rehabilitation and/or improvement of existing dams.

b. Public Concerns

Public individuals and groups should have the opportunity to voice their concerns in the development of public works projects and during their operation. These concerns often represent constraints in the form of local or regional political interests, legislation, perceptions of risk and hazard, environmental factors, social conflicts, etc., which can influence technical decisions. Agencies should develop and organize their procedures for early assimilation of those public views which affect possible design, construction, or operating parameters and, in turn, influence dam safety. Resolution of public issues conflicts and problems, including use of executive and legislative government decisions, should be made prior to the start of construction so that dam safety is not compromised.

B. MANAGEMENT OF TECHNICAL ACTIVITIES — SITE INVESTIGATION AND DESIGN (SID)

This section of the guidelines outlines the site investigation and design technical activities that agency management should ensure are undertaken to obtain safe design of dams. It is recognized that the extent of application of these guidelines will vary depending on the size and function of the dam.

1. Hydrology

a. Hazard Evaluation

Areas impacted by dam construction and existing dams should be examined for potential hazards to present and future developments in the event of major flooding by controlled flood discharges or flooding induced by dam failure or misoperation. This hazard evaluation is the basis for selection of the performance standards to be used in dam design or in evaluation of existing dams.

b. Flood Development

Hypothetical floods, generally of severe magnitude, should be developed for use in design or evaluation of major dam and reservoir features, including development of appropriate floods for the construction period.

c. Flood Selection for Design (or Evaluation)

The selection of the design flood should be based on an evaluation of the relative risks and consequences of flooding, under both present and future conditions. Higher risks may have to be accepted for some existing structures because of irreconcilable conditions.

When flooding could cause significant hazards to life or major property damage, the flood selected for design should have virtually no chance of being exceeded. If lesser hazards are involved, a smaller flood may be selected for design. However, all dams should be designed to withstand a relatively large flood without failure even when there is apparently no downstream hazard involved under present conditions of development.

d. Hydrologic Design of Reservoir

In addition to selection of a design flood, the hydrologic design of a new reservoir or the evaluation of an existing project involves consideration of discharge and storage capacities, reservoir regulation plans including constraints, land requirements, and wind/wave effects. The evaluation of existing projects also should include observed performance capabilities and whether improvements are necessary to ensure safety.

Reservoir regulation plans should be developed in the planning of projects so that realistic release rates will be used in routing the design flood. Regulation plans should include the construction period. When gate operations are involved, a water control management plan should be established to direct reservoir regulation in an effective and efficient manner. An emergency regulation plan is also required for use by the dam tender in the event of loss of communication with the water control management staff during a flood. A data information system should be designed to collect and process pertinent hydro meteorological data in a timely and reliable manner.

The reservoir regulation plans, water control management plan, and data information systems should be periodically reviewed for safely deficiencies and potential for misoperation during both severe flood events and normal conditions. Necessary corrections should be made as soon as practicable.

e. Downstream Effects

Safety design includes studies to ascertain areas that would be flooded during occurrence of the design flood and in the event of dam failure. The areas downstream from the project should be evaluated to determine the need for land acquisition, flood plain management, or other methods to prevent major damage. Information should be developed and documented suitable for releasing to downstream interests regarding remaining risks of flooding.

f. Warning Systems
Safety design should include an emergency flood warning system and action plan that would effectively notify all concerned in ample time for appropriate action.

2. Earthquake Investigation and Design

a. Investigation Factors
The following factors should be considered in selection of design earthquakes.

(1) Geologic and tectonic setting of the site area by analysis of the lithology, stratigraphy, structural geology, and tectonic history.

(2) Historical earthquake record to include the size, location, and other seismological characteristics as available, and the relationship, if possible, with the tectonic siting of the area in which the earthquakes have occurred.

(3) Influence of the properties of the surficial materials on the determination of the size of historical earthquakes.

(4) Influence of faulting or other tectonic features on the estimate of the occurrence, size, and location of possible future earthquakes.

b. Selection of Design Earthquakes
From the above factors, earthquakes should be selected that have sufficient potential of occurring to require consideration in the dam design. Earthquake description should include estimates to the extent practical of the size, location, depth, focal mechanism, and frequency of occurrence.

c. Engineering Seismology
Determination should be made of the characteristics of ground motion that would be expected from the design earthquakes, to the extent possible, to include amplitude (displacement, velocity and acceleration), frequency content, and duration.

d. Need for Earthquake Analysis
The probable effects of earthquakes on the dam and its appurtenant structures should be evaluated to determine the need for inclusion of earthquake forces in the structures analyses. Evaluation includes consideration of factors such as the project stage, hazard and risk factors, the size of the dam and reservoir, the potential ground motion at the site, site geology, and type of structure. Where determination is made that no earthquake forces are required in analysis, the determination should be justified.

e. Seismic and Geologic Studies
(1) Earthquake Sources. The essential first step is determination of the design seismic events (usually the maximum credible earthquakes) and an estimate of the ground motion at the site due

to these events. From a study of the regional tectonics and seismicity, and both regional and local geology, potential sources for seismic events are identified, and the maximum credible earthquake magnitudes postulated.

(2) Design Events. A maximum credible earthquake (MCE) is defined herein as the hypothetical earthquake from a given source that could produce the severest vibratory ground motion at the dam. Time histories of the estimated rock motion (accelerograms) at the dam for the various seismic events are selected to characterize the severity of the strong motions by their peak accelerations, frequency content, and duration.

f. Design for Earthquake Forces

(1) Safety Concerns. All earthquake-related safety concerns should be identified. Potential safety concerns include but should not be limited to dam foundation integrity, stability, unacceptable stress levels, fault displacements; abutments stability; effects of dam overtopping; dam stability; susceptibility of embankment dams to embankment or foundation liquefaction, cracking or excessive deformation.

A survey of component and accessory structures and equipment should be made to identify those which have functions that are essential for earthquake-related safety.

(2) Analysis Method. Determination of appropriate earthquake analysis methods for evaluation of safety concerns may be, as appropriate, by qualitative evaluations, pseudostatic analysis, and dynamic analysis. The methods selected should be appropriate to the identified safety concerns, in accordance with good engineering practice and with currently available technology.

(3) Structural Adequacy. Structural adequacy assessments should be made of all safety-related components and concerns identified. These assessments should incorporate all applicable data and analysis.

3. Geotechnics

a. General

(1) Site Specifics. After a site is selected, a program for the geotechnical exploration, design, and analysis of that specific site is required. No checklist can be made which would cover all eventualities at all sites, or at any one site, and attempts to formulate such a list would be counterproductive to the intent to ensure dam safety. The best insurance for adequate geotechnical work is a well-trained and experienced staff actively involved in field inspections throughout all phases of the development of the site.

(2) Documentation. Because many evaluations are possible for a given set of geotechnical conditions, it is important that full documentation be made of the reasoning process involved in geotechnical decisions. General guidelines for documentation are given in section III.A.5.

(3) Management of Diverse Technical Expertise. Geotechnical work encompasses the expertise of geologists, geophysicists, and engineers—all with diverse experience, training, interest, and technical terminology. The administrative and technical supervision of these experts should be structured to optimize coordination and cooperation. Management should encourage intellectual curiosity and an inquisitive approach to all geotechnical work. Since the field of geotechniques is rapidly expanding, management should assure that those associated with site exploration and development maintain currency with the state of the art.

b. Exploration and Identification of Geotechnical Problems

The exploration program needs to be site specific, flexible, and executed so as to obtain the maximum data from each part of the program. Agency management should ensure sufficient funding for an orderly development of the exploration program in order to reduce uncertainties and to make adequate provisions for required corrective measures.

The initial onsite exploration should be preceded by a review of all available information pertinent to the development of the site (literature, maps, photographs, well and spring information, seismic data, area construction records, etc.). This should lead to the preparation of a detailed geological map of the site using all available data. Geotechnical explorations generally proceed from wide-spaced borings and geophysical surveys to determine the general geological conditions, to additional explorations assigned in an ongoing sequence to develop the geologic correlations and to determine the type of dams suitable for the site. The extent, depth, and type of exploration depend on the complexity of the geology and size and type of dam.

Generally, explorations are not complete at the end of the planning phase but continue during the preparation of plans and specifications and into the construction phase. Conditions encountered during construction often require additional explorations to evaluate the need for changes in the design.

All potential geological problems, inferred from onsite data and from experience at similar sites, should be fully explored and described. This information should cover the types of adverse features and geologic processes generally associated with a geological environment similar to that at the site. It should also cover the expected short- and long-term behavior of foundation and reservoir rim materials at the site when subjected to the changed geological environment associated with the construction and operation of the dam and to geologic processes operating during the life of the project.

During the course of the design and continued exploration of the project, all potential problems should be investigated and corrected with appropriate treatment, or where uncertainty remains, design defenses should be provided to control or monitor the problems. Types of problems which might require consideration include reservoir-induced seismicity, solubility, pipability and liquefaction potential of materials, foundation heave or deterioration during excavation, reservoir rim leakage and stability, past and future mining, and differential consolidation associated with petroleum or water extraction.

c. Geotechnical Design
Geotechnical design considerations for the dam foundation and reservoir area are essentially defined after the geologic conditions of the site, the type of dam, and the magnitude of the stresses imposed on the foundation by the dam and reservoir have been determined.

Foundation design typically consists of four distinct elements. These are (1) definition of the geometry of the foundations and areas of potential instability in the foundations, abutments, and slopes; (2) determination of the properties of foundation materials using judgment, past experience, laboratory testing, and in situ testing; (3) an analytical procedure that predicts the behavior of the foundation in terms of stability, permeability, and deformation; and (4) a reevaluation of parts (1) through (3) as construction progresses so that a comparison can be made of preconstruction assumptions and conditions with the actual conditions revealed by the foundation excavation and treatment. Additional exploratory work may be required.

d. Foundation Treatment
(1) General. The preparation of the foundation, including the abutments, is one of the most important phases of construction. The primary purposes of foundation treatment are to provide stability, obtain positive control of seepage, and minimum adverse deformation. The geology, foundation conditions, foundation treatment, and proposed structure should be considered together.

(2) Stability. Surfaces should be prepared to provide a satisfactory contact between the foundation and the overlying structure by removal of unsuitable materials. Deficiencies in the foundation which are not removed should either be treated by modification of the structure or by appropriate foundation treatment tailored to handle the conditions encountered.

(3) Positive Control of Seepage. Highly permeable foundations should be treated by such measures as cutting off the pervious material, grouting, increasing the seepage path by upstream blankets, or controlling the seepage with drainage systems. Where appropriate, surficial cavities should be traced, cleaned out, and backfilled with material satisfying the design requirements. When cavities exist at depth, measures should be taken to ensure against the migration of cavity filling material.

(4) Control of Piping. Silts and fine sands in the foundation, which are susceptible to piping, should be removed if practical, cut off near the downstream limits of the dam, covered with impervious material, or provided with filtered drainage systems. If pipable material is used in the dam, the foundation surface treatment should prevent migration of dam material into the foundation.

(5) Deformation. Foundations subject to differential settlement or foundations having highly compressible anomalies can cause stress concentrations or cracking in dams. The foundation excavation should be shaped to remove abrupt changes in elevation to preclude excessive differential settlement or stress concentrations. Low shear strength material in a foundation can

cause shear failure. Excavation and replacement of low strength material is a positive method for treating a foundation that has either or both of these unfavorable conditions.

e. Instrumentation

Although a well conceived foundation instrumentation program serves to monitor the foundation and gives an indication of distress, it cannot of itself certify the safety of the foundation. The expertise of the engineer/geologist to analyze and design and prepare a foundation that will safely carry the loads and water pressure imposed by the dam and the reservoir is fundamental to the design adequacy of the foundation. The purposes of foundation instrumentation are fourfold: to (1) provide data to validate design assumptions; (2) provide information on the continuing behavior of the foundation; (3) observe the performance of critical known features; and (4) advance the state of the art of foundation engineering.

The general requirements for foundation instrumentation should be determined early in the design of the project, and the rationale for the instrumentation should be thoroughly documented. Factors that will influence the need for and the type of instrumentation include the geology of the foundation, size and type of the dam and reservoir, and the location of the project. Flexibility must be provided in the program to allow for changes from anticipated foundation conditions that are encountered during construction and/or operations.

Intrinsic to an instrumentation program is the schedule for reading the instruments before and during construction, during initial reservoir filling, and through the service life of the project. No less important is the need for clear instructions for the prompt evaluation of data and prompt notification to responsible personnel when observations are atypical or diverge markedly from the design assumptions.

f. Inspection and Continuing Evaluation during Construction

Those responsible for the investigation and design of the foundation should make onsite evaluations to confirm that actual conditions conform to those assumed in the design and to review documentation of site conditions.

A qualified project geologist should examine and map geologic details of the foundation as it is being exposed during construction. Investigation and testing at this point provide details useful in controlling grouting and other improvements and in confirming the competency of the foundation. Even though extensive exploration and testing may have been conducted prior to construction, most foundations can be expected to reveal unanticipated conditions which may require redesign or changes in the type or extent of foundation treatment.

Approval should be obtained from the geotechnical and design staffs before placement of dam materials on the foundation. This approval should be documented and should indicate that all unanticipated conditions encountered were dealt with and that the foundation and its treatment meet the design requirements.

g. Reevaluation at Existing Structures
Older Federal dams may not have been designed to standards equal to current criteria. Also, a substantial portion of safety-related dam incidents are associated with foundation problems which develop in a time-dependent fashion after construction. For these reasons, systematic reevaluation of existing Federal dams should be made.

These reevaluation should go beyond analysis of problems which are observed visually or from instrumentation data. A review should be made of all existing exploratory information, design information, construction records, and operation records, to determine the adequacy of the foundation with respect to the present site of the dam. Where available information is insufficient or where deficiencies are found or suspected, modern criteria for analysis, instrumentation, exploration, and testing should be used as appropriate to gather the necessary data to show that no problem exists or to furnish information to modify the structure or foundation.

4. Hydraulic Appurtenances

a. General
(1) Protective Measures. All hydraulic appurtenances used for releasing water should be designed to preclude jeopardy to the damming provisions.

(2) Blockage. Allowances for or preclusion of blockage of hydraulic facilities should be incorporated in the design.

(3) Reliability. When operational failure of a gated passage would jeopardize the damming provisions, alternate capacity should be provided. When operation of a gated passage is essential to safety, reliable manpower, communications and accessibility should be assured.

(4) Hydraulics and Hydrology. Hydraulic and hydrologic design considerations should be correlated with section III.B.1.

b. Design Flood Releases
(1) Spillway and Outlets. Gated spillways are the usual hydraulic appurtenances for control of all or the major portion of the design flood and major emergency releases. Outlets (sluiceways, conduits and tunnels) may be used alone or in conjunction with spillways to control flood discharges.

(a) Selection of type. Spillways and outlets should be selected to meet the site specific purposes of the project. For a drainage area with short concentration time combined with reservoir storage capacity that is small relative to the flood volume, especially for embankment dams, (1) the spillway should usually be uncontrolled, and (2) outlets should not normally be used for sole or part control of the design flood except in special cases where the outlets can be uncontrolled.

(b) Capacity. Spillway and outlet capacity should be sufficient to satisfy the discharge requirements of the reservoir regulation plan and other design considerations.

(2) Power Facilities. A portion of installed turbine flow capacity may be considered to assist in control of the design flood if it is demonstrated that possible power load interruptions during the design flood would not preclude operation of the power facilities.

c. Other Water Releases

Other water release hydraulic appurtenances such as navigation facilities, locks, fish facilities, ice sluices, trash sluices, and water quality facilities should conform to the requirements of section 4.a.

d. Reservoir Evacuation

Where practicable, reservoir release facilities should be provided to lower the pool to a safe level adequate to correct conditions that might threaten the integrity of the dam.

e. Control of Flows during Construction

The provisions of section 4.a also apply generally to the design of hydraulic appurtenances used during construction. The capacity of these appurtenances should be sufficient to satisfy the discharge requirements of the regulation plan for control of water during construction.

f. Design Criteria and Guidance

(1) General. If existing design criteria and guidance from past projects and experience are used for design of the hydraulic appurtenances, their sufficiency should be documented.

(2) Hydraulic Model Tests. When sufficient criteria and guidance are not available for analytical design of the hydraulic appurtenances, physical hydraulic model studies should be performed.

(3) Prototype Testing. Features of safety-related hydraulic appurtenances that are beyond the state of the art, or for which model to prototype relationships have not been verified, should be tested in the prototype.

g. Reanalysis Because of Changes

Changes in project purpose, new purposes, operational requirements, limitations of constraints, design criteria, or legal requirements may require that a reanalysis be made of the hydraulic appurtenances.

h. Hydraulic Design Involvement during Life of Structure

Hydraulic design engineers should participate in the project periodic inspection program to evaluate the operational adequacy of all hydraulic appurtenances essential to dam safety throughout the life of the structure including final disposition.

5. Concrete Dams and Concrete Elements of Embankment Dams

a. Site Specific Design

Because all dam sites are unique, the type of dam and its appurtenances should be specifically matched to site conditions and project requirements. It is essential when reviewing the safety of existing dams to consider conditions which may have changed physically and new concepts resulting from new technology, or because of additional project information since construction, such as foundation deterioration, increased flood hydrographs, or larger design earthquakes.

b. Materials

Concrete for the structures requires competent investigation of materials sources and adequacy of supply testing of materials properties in accordance with accepted standards, and proper proportioning of concrete mixes (including additives) for strength, durability, control of thermal properties, and economy.

c. Design of Structures

There are three components of a dam which must be considered for safety: the foundation, the dam, and its appurtenant structures.

(1) Foundation. Proper design of a concrete dam requires information on the foundation geological conditions and materials properties to assure its capability to support the loads of the dam and reservoir, in its natural state or as improved by foundation treatment.

(2) Dam. Concrete dams should be designed to be safe against overturning and sliding without exceeding allowable stresses of the foundation and the concrete for all loading conditions imposed on the dam. The shape and/or curvature of a dam and its contact with the foundation are extremely important in providing stability and favorable stress conditions. Proper consideration should be given to ensure the dam's safety in the event of overtopping.

Joints in the dam should be properly designed to control cracking due to thermal, shrinkage, and structural effects. Temperature control measures such as proper concrete mix design, pre-cooling of the concrete mix, and post-cooling of the concrete blocks can also be used to control cracking. Openings in the dam such as waterways, galleries, chambers, and shafts should be designed with consideration for their effects on the behavior of the structure.

(3) Appurtenances. Safety-related appurtenances, such as outlet works structures, spillways, and navigation locks, should be designed with the same degree of safety as the main dam. If the project has a powerhouse as an integral part of the dam, it should be designed for the same safety requirements as the dam.

d. Definition of Loads

The dam and appurtenances should be designed for all static and dynamic loads to which they will be subjected. Dynamic loadings to be considered should include inertial, hydrodynamic, and earth pressures from earthquake ground motions and structural response; and dynamic loads resulting from flowing water.

e. Design Methods

The methods required for design of the several types of concrete dams and their appurtenances vary from simple to complex, depending on the type and size of the structure, the hazard potential of the site, the kinds of loading, and foundation conditions. The design process involves judgment and analytical expertise to select appropriate methods to analyze a structure whether it requires a simple or complex analysis, and to determine design input data that is representative of the range and variation of foundation and structural material properties. The selection of input parameters is just as important as the mechanics of the analysis used.

f. Design Evaluation

Technically qualified supervisory personnel should assure that structures are designed to meet the requirements for safety. This includes confirmation of design input parameters, design methods, and utilization of allowable factors of safety against overturning, sliding, and stressing appropriate to the probability of the loading conditions.

g. Instrumentation

Knowledge of the behavior of structures and their foundations may be gained by studying the service action of the structures using observations on embedded and other internal instrumentation and external measurements. Information from which a continuing assurance of the structural safety of the dam can be assessed is of primary importance, but information on structure behavior and the properties of dam and foundation materials serve to verify the design and to provide information for improvement of design. Observations may be made in the dam and foundation in terms of strain, deflection, pressure, temperature, stress, deformation, and drainage flows. External measurements for deflection and settlements may be made by precise surveys on targets set on the dam, in galleries, in vertical wells in the dam, in tunnels, and on the foundation. Status reports on the condition of structures should be issued regularly. Examinations of existing structures should include assessments of whether additional instrumentation is required.

h. Construction and Operational Follow-up

It is necessary that the designers should be involved in the construction and operation processes to confirm that the design intent is carried out, and to allow changes and modifications resulting from redesign necessitated by differences between design assumptions and actual field or operating conditions.

6. Embankment Dams

Section 5 contains general dam considerations; the following additional considerations are applicable to embankment dams.

a. Site Specific Design

Embankment design should be developed for specific site conditions and based on adequate exploration and testing to determine all pertinent geologic and material factors with particular emphasis on shear strength and stability, permeability and control of seepage, and consolidation and settlement.

Embankment dams are particularly vulnerable to damage and possible failure from internal erosion when founded on rock having large cavities, open joints, discontinuities, or other geologic defects. The sites should be carefully explored and special attention given to design of cutoffs, foundation treatment, and other defensive measures. Special problems related to embankment integrity may include soft rock such as clay shales, areal subsidence, old mining activity, solution-susceptible rock, and collapsing soils.

b. Materials

Embankments can generally be designed to utilize locally available construction material; investigation of materials characteristics is required and problem materials should be either discarded or protected by defensive design. There is often a need for importing special materials for slope protection, filters, and drainage systems. Any embankment zoning should consider the properties and quantities of available materials and the effect of their characteristics on the construction process.

c. Design Constructability

Embankment designs should be constructible with regard to such items as location of borrow areas with respect to flooding, in-situ moisture conditions, climatic effects on construction schedules, width of zoning, and needs for special material processing. Design should include protection of critical features from overtopping by floods during construction.

d. Embankment Design

The safety of an embankment is dependent on its continued stability without excessive deformation under all conditions of environment and operation, and on control of seepage to preclude adverse effects on stability and prevent migration of soil materials. Design considerations given below are specific to embankment dams.

(1) Seismic. Where earthquake design is necessary, consideration should be given to earthquake-related concerns of soil liquefaction and cracking potential, stability and excessive deformation, abutment stability, overtopping effects, and required defensive measures.

(2) Stability. Embankment stability should be analyzed for all pertinent static and dynamic loading conditions without exceeding allowable shearing stresses in the embankment or foundation. Factors of safety should be appropriate to the probability of the loading conditions, and should consider the effects of loading and time on shear strength, particularly if limited placement volume can result in rapid construction. In most cases, embankments should be designed for unrestricted rates of reservoir filling and drawdown.

(3) Settlement and Cracking. The potential for transverse cracking of the embankment caused by differential settlement, tension zones, and possible hydraulic fracturing should be minimized by careful consideration of abutments, foundation and cutoff trenches, and their geometry and treatment. Filter zones of adequate size should be positioned upstream and downstream of the impervious zone at all locations where there is a possibility of transverse cracking regardless of cause. Potential problems of differential settlement should be considered in establishing the construction sequence.

(4) Seepage. The design should attempt to prevent or minimize seepage through the embankment and its foundation and abutments; however, the designer should recognize that seepage usually occurs and that protective control measures must be provided. Filtering transition zones and foundation and abutment treatment to seal openings should be provided wherever necessary to preclude migration of soil materials into or out of all embankment element contacts both upstream and downstream. Filters, drainage blankets, and transitions should be of a quality and size to conservatively control and safely discharge seepage for all conditions for the life of the project. Particular attention should be given to contacts with foundation, abutments, embedded structures, and the end slope of closure sections to ensure adequate compaction and bonding to control seepage.

(5) Zoning. Embankment zoning when used should ensure adequate stability for all pertinent conditions, and should control seepage through the embankment and provide filter action to prevent migration of material.

(6) Erosion. Upstream and downstream slopes and foundation and abutment contacts should be protected against erosion from surface runoff, wave action, and impinging currents. Spillways and outlet works should be located and designed so that discharges do not erode the embankment or its foundation.

e. Instrumentation

Embankment design and prediction of embankment performance are based on an imprecise combination of theory and empirical procedure; consequently, performance during construction and operation should be monitored by a designed system of external measurements and/or installed instrumentation. A well planned system of instruments, when appropriate, should be installed to provide data on internal and external movements and on water pressures at critical locations in the embankment and foundation during both construction and operation.

f. Construction and Operational Follow-up

In addition to the need for designers to be involved in construction and operation of dams in general to confirm the design intent and assess the need for possible design changes, certain other requirements should be observed at embankment dams. Stability should be evaluated during and after construction using strength parameters from as-placed materials and observations of pore pressure and seepage if and when conditions warrant. Designers should inspect and review performance of embankments during and after reservoir impoundment to detect and provide prompt remedial treatment for problems. While major emphasis is placed on initial impoundment, the surveillance should continue for the life of the project. As the state of the art advances in analysis, material behavior, and methods of observation, deficiencies in embankments may be suspected or become obvious and should be investigated and corrected. Collected experience information should be summarized and used to further advance the state of the art.

C. MANAGEMENT OF TECHNICAL ACTIVITIES — CONSTRUCTION (CON)

1. Introduction

This section of the guidelines outlines the construction technical activities that agency management should ensure are undertaken to obtain safe construction of dams. The principles and guidelines arc prepared in a broad sense to ensure that construction of a safe structure is the prime requisite.

a. Construction Contracts

Construction contracts should be based on site conditions as interpreted at the time of contract award. All anticipated work on foundation cleanup, preparation, and treatment should be included as specified items of the work. Contract provisions should require the contractor to submit to the construction engineer advance notice of significant shift change, to enable adequate inspection coverage of multishift operations.

b. Construction/Design Interface

Many aspects of construction directly overlap in design considerations. Reference is made below to numbered paragraphs in Section III.B. Management of Technical Activities-Site Investigation and Design, which concern such common interests:

3. Geotechnics
a. General
(1) Site Specifics
b. Exploration and Identification of Geotechnical Problems
c. Geotechnical Design
d. Foundation Treatment
e. Instrumentation
f. Inspection and Continuing Evaluation during Construction

4. Hydraulic Appurtenances
e. Control of Flows during Construction

5. Concrete Dams and Concrete Elements of Embankment Dams
a. Site Specific Design
b. Materials
c. Design of Structures
(1) Foundation
g. instrumentation
h. Construction and Operational Follow-up

6. Embankment Dams
a. Site Specific Design
b. Materials
c. Design Constructability
d. Embankment Design
(3) Settlement and Cracking
(4) Seepage

e. Instrumentation
f. Construction and Operational Follow-up

2. Evaluation during Construction
Field personnel must be highly trained and experienced if the design principles and site conditions are to be understood and a safe structure is to be constructed.

When differing site conditions (different from those anticipated) are encountered, construction supervisory forces must have authority to suspend any or all portions of the work affected until the design engineers, with assistance as needed, can evaluate the condition and determine if design modification is required.

Construction milestones should be identified when the design engineers will inspect the work and concur with the progress of construction.

3. Orientation of Construction Engineers and Field Inspectors
Construction engineers need to be aware of design philosophies and assumptions as to site conditions and function of project structures, and must understand the designers' intent concerning special technical provisions in the specifications. Identified preconstruction activities should include the orientation of construction engineers to the site specificity of the design and to the close communication requirements with all concerned engineering disciplines during the construction process. For major projects, there should be periodic meetings between design and construction engineers to discuss upcoming construction activities. Also, during the initial stages of important construction activities, the construction engineers should request site inspection by the design engineers to assure construction procedures are in accordance with design requirements.

Construction specifications, supplemental reports, and conferences to orient field personnel to the particular site, the features of the dam, and the designers' intent for construction should, as applicable, include the following:

a. Design Related
(1) Design concepts. Explanation of philosophies and assumptions and the reasons for special requirements in the specifications to assure accomplishment of design intent.

(2) Construction sequence. Identification and explanation of the dates to which construction progress must conform to satisfy project requirements, and the special sequences for construction activities that are required by design.

(3) Instrumentation systems. Description of the instrument types, their purpose, the procedures for installation of each instrument type, the method and time interval for reading each instrument, and the importance of prompt data transmission for analysis and feedback.

(4) Care and diversion of water. Description of the design features included to prevent and/or control flooding and turbidity and accomplish diversion and closure of the dam. This should also contain the design requirements for controlling normal flows through the work area to assure that construction is always accomplished under dry conditions. Critical aspects of the construction schedule related to flood problems should be emphasized.

b. Foundation
(1) Description. Discussion of the type of foundation conditions expected to exist, i.e., over-burden, general rock description, formation weaknesses such as joints, shears and faults, and acceptable foundation conditions.

(2) Excavation. Discussion of the depth and nature of materials expected to be encountered, the controls for dewatering and blasting, identification of critical areas, quantity estimates, and an acceptable foundation.

(3) Preparation. Review of the methods of rock foundation preparations such as: cleaning; the use of wire mesh, mortar, shotcrete, or rock bolts; grouting, and treatment of faults, shears and joints; as well as subsequent exploration to assure desired results. Review of methods of earth foundation preparation.

c. Materials
(1) Materials from required excavation. Definition of acceptable and unacceptable properties of materials, the usage and the processing requirements if used, and identification of waste area locations.

(2) Other excavated materials. Identification of the location and amount of usable material, "based on current test data," available from all designated areas, including borrow pits. Review of the blasting methods that are expected to produce the desired rock quality and sizes. Discussion of the expected amounts of waste and the areas where borderline material may be used in lieu of wasting, such as in berms or certain zones of the downstream shell of an earthfill dam.

(3) Embankment. Description of both acceptable and unacceptable material properties, place-ment, and compaction procedures for each zone. Review of required procedures for areas adjacent to abutments, around instruments, and at interfaces between zones and/or structures.

(4) Concrete and concrete materials. Identification of acceptable aggregate sources and review of mix designs, joint and surface treatment, finish requirements, form tolerances, and placement procedures. Cooling as well as hot and cold weather protection requirements should be defined.

d. Construction General
(1) Field control. Discussion of the quality assurance procedures required to control all phases of construction. Acceptable placement standards should be established for concrete, earth and rock materials, and embankments.

(2) Structural. Discussion of structural steel installation, reinforcing steel placement, and anticipated problem areas and specified treatment for such areas.

(3) Mechanical-electrical. Description of equipment installation requirements, special procedures, performance tests, protective coatings, and protection devices such as ground fault indicators.

(4) Environmental-Identification of those construction controls required to minimize environmental damage, comply with environmental regulations, and assure public involvement.

4. Construction Assurance

a. Construction Procedures
Agency criteria must assure that acceptable methods and procedures are specified and utilized to accomplish design requirements. At the same time, the design and construction organizations must maintain the flexibility necessary to modify design, material requirements, and construction specifications as conditions dictate without altering the basic design intent.

b. Construction Materials Testing
A materials laboratory must be established at the field construction office that is adequately staffed and equipped to accomplish the on-site testing requirements set forth in the engineering considerations and instructions to field inspection personnel. Provisions should be made for a thorough and periodic review "above project level" of the construction materials testing procedures to assure their continued suitability. Periodic companion test samples of embankment material should be checked by higher echelon for uniform test assurance.

c. Quality Assurance
It is mandatory that adequate construction quality assurance systems and procedures be established to assure safe dam construction. The quality assurance system must guarantee, by direct inspection and testing, that construction is accomplished in compliance with the contract plans and specifications. The quality assurance system must identify when site conditions require modification of the design to ensure construction of a safe dam and must document the construction activities and test results. Daily inspector's reports, laboratory test data records, and photographs are the minimum mandatory methods of documentation. General guidelines for documentation are given in section III.A.5.

As a part of the quality assurance program the contractor should normally be required to submit various plans for approval not limited to, but including, the following:

Construction Schedule Safety Program
Care and Diversion of Water (including pollution control)
Fire Protection
Plant Layout (including haulroads)
Environmental Measures
Equipment Inventory
Dewatering Foundations and Borrow Areas

Excavation Sequence of Foundations and Borrow Areas
Drilling and Blasting Procedures
Concrete Placement
Restoration of Construction Area

D. MANAGEMENT OF TECHNICAL ACTIVITIES-OPERATION AND MAINTENANCE (O&M)

This section of the guidelines outlines the technical activities for operation and maintenance, periodic inspection program, and emergency action planning that agency management should ensure are undertaken to obtain safe operation of dams.

1. Operation and Maintenance

a. General

The intent is to define practices which will ensure safe operation of dams and reservoirs and to require a maintenance program that will provide timely repair of facilities. It is assumed that each Federal agency is responsible for proper operation and maintenance of dams that are owned by the agency or that are under its jurisdiction.

Operation and maintenance personnel should be selected on the basis of their capability to acquire the knowledge needed to perform the many functions of operation and maintenance, and should be trained for the associated duties at each specific project.

All operation and maintenance manuals should be kept current, and records should be maintained of instructions, inspections and equipment testing, with copies to those responsible for design and dam safety inspections. General guidelines for documentation are given in section III.A.5.

In the following sections, outlets or outlet gates refer to gates or valves on any outlets such as sluices, conduits or tunnels, pumps, generating units, and infrequently operated plant intake and discharge gates. If the project has a navigation lock, emergency closure and other infrequently operated equipment are also included.

b. Operating Procedures

Written operating instructions should be prepared for the dam and its associated structures and equipment. The instructions should cover the functions of the dam and reservoir and describe procedures to follow during flood conditions to ensure dam safety.

Reservoir operating rule curves should be available for each normal mode of operation and for emergency conditions.

An auxiliary power system, such as a gasoline or diesel-operated generator, is essential if the outlet and spillway gates and other dam facilities are electrically operated.

All spillway and outlet gates should be tested on a regular schedule. The tests should include use of both the primary and the auxiliary power systems.

Project security is a matter of concern at all major dams. This includes preventing structural damage by vandals or saboteurs and unauthorized operation of outlet or spillway gates. In most cases, restricting public access is essential, and in some instances armed guards may be necessary.

Public safety is of paramount importance at all dams and reservoirs. Specifically, public safety on the reservoir, in areas adjacent to the reservoir, and below the dam should be considered, particularly in recreational areas. Safety measures should include identification of high watermarks to indicate past or probable reservoir levels and streamflows, posting of safety instructions at highly visible and key locations, and providing audible safety warnings upstream of and below outlets as appropriate.

Communication should be maintained among affected governmental bodies and with the public to enhance the safety aspects of the operation of the dam. Communication alternatives include written communications, radio, telephone, television, and newspapers.

c. Maintenance Procedures

Written instructions should provide information needed for proper maintenance of all water control facilities.

Specialists should prepare maintenance checklists indicating the maintenance procedures and protective measures for each structure and for each piece of operating, communications, and power equipment, including existing monitoring systems. Special attention should be given to known problem areas.

Special instructions should be provided for checking operating facilities following floods, earthquakes, tornados, and other natural phenomena.

Maintenance procedures include preventive measures such as painting and lubrication as well as repairs to keep equipment in intended operating condition, and minor structural repairs such as maintaining drainage systems and correcting minor deterioration of concrete and embankment surfaces. The design staff should be apprised of any significant maintenance work.

2. Periodic Inspection Program

a. General

The purpose of a periodic inspection program is to verify throughout the operating life of the project the structural integrity of the dam and appurtenant structures, assuring protection of human life and property. Periodic inspections disclose conditions which might disrupt operation or threaten dam safety, in time for them to be corrected. When such conditions are encountered, it is necessary to determine the adequacy of structures and facilities to continue serving the purposes for which they were designed, and to identify the extent of deterioration as a basis for planning maintenance, repair or rehabilitation.

The following general principles and guidelines for a periodic inspection program should be used by Federal agencies responsible for operation or regulation of dams.

All existing dams with a significant hazard potential should have a safety evaluation based on current technical guidelines and criteria. New dams added to the inspection program should be planned, designed. and constructed in accordance with current technical criteria. Improvements in dam technology require that dams and appurtenant structures be reassessed to assure dam safety for more stringent design and materials criteria.

Periodic inspection of dams, reservoirs, and appurtenant structures involves important aspects other than dam safety; however, these guidelines encompass only dam safety issues. Each agency is responsible for assuring that the existing dams for which it is responsible are periodically inspected, and that new dams are re-inspected initially upon completion of construction and periodically thereafter.

b. Types and Frequencies of Inspections

The inspection types and intervals herein recommended are for general guidance in developing inspection programs for all Federal dams. These guidelines do not preclude other inspections or more frequent inspections if deemed necessary depending on project history and importance of the facility. For some projects less frequent inspections may be permissible where hazard potential and structural integrity warrant such relaxation.

To maintain control of the inspection program, a formal inspection schedule should be maintained which lists each feature to be inspected, frequency of inspection, date last inspected, date of last inspection report, maintenance record, description of repairs made, and date of next inspection. The schedule should also have a note on major alterations that are made.

Inspection personnel should be selected carefully, have qualifications commensurate with their assigned levels of responsibility, and receive training in the inspection procedures. Qualifications and training required for inspection personnel may vary with the complexity of the facility and with the level of inspection.

(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.

(2) Intermediate Inspections. Intermediate inspections should include a thorough field inspection of the dam and appurtenant structures, and a review of the records of inspections made at and following the last formal inspection. If unusual conditions are observed that are outside the expertise of these inspectors, arrangements should be made for inspections to be conducted by specialists.

(a) Frequency of intermediate inspections. Intermediate inspections should be performed preferably on an annual basis, but at least biennially, where there is a high probability that dam failure could result in loss of life. For other dams, intermediate inspections should be scheduled by responsible engineers on the basis of the dam's size, importance, and potential for damage to property.

(b) Qualifications of personnel for intermediate inspections. Intermediate inspections should be performed by technically qualified engineers, experienced in the operation and maintenance of dams and trained to recognize abnormal conditions. The inspectors should have access to and be familiar with all permanent documentation, especially the operation and maintenance histories for the dam and should be directly responsible for and intimately familiar with the operating characteristics of the dam. The dam tender or operator should be a participant in these inspections.

(3) Formal and Special Inspections. A formal inspection is required periodically to verify the safety and integrity of the dam and appurtenant structures. Formal inspections should include a review to determine if the structures meet current accepted design criteria and practices. The inspection should include a review of all pertinent documents including instrumentation, operation, and maintenance and, to the degree necessary, documentation on investigation, design, and construction. In making the detailed inspection of the dam appurtenant structures and equipment, diving inspections of underwater structures affecting the integrity of the dam should be included. All formal inspections should be conducted by a team of highly trained specialists. To assure that a dam and its appurtenant facilities are thoroughly inspected, checklists should be prepared to cover the condition of structural, electrical, and mechanical features. This inspection should also verify that operating instructions are available and understood, instrumentation is adequate and data is assessed to assure structures are performing as designed, and there are emergency provisions for access to and communication with all project operating facilities.

(a) Frequency of formal inspections. Formal inspections should be made periodically at intervals not to exceed 5 years. Depending on past experience or the project history, some dams may require more frequent formal inspections.

(b) Frequency of special inspections. Special inspections should be performed immediately after the dam has passed unusually large floods and after the occurrence of significant earthquakes, sabotage, or other unusual events reported by operating personnel.

(c) Qualifications of personnel for formal and special inspections. Formal and special inspections should be conducted under the direction of licensed professional engineers experienced in the investigation, design, construction, and operation of dams. The inspection team should be chosen on a site-specific basis considering the nature and type of the dam. The inspection team should comprise individuals having appropriate specialized knowledge in structural, mechanical, electrical, hydraulic, and embankment design; geology; concrete materials; and construction procedures. They must be capable of interpreting structural performance and relating conditions found to current criteria and safety aspects. It is imperative that the inspection team adequately prepare for the inspections by reviewing and discussing all documents relative to the safety of the dam.

c. Instrumentation

Instrumentation or performance observation devices are used to supplement visual inspections in evaluating the performance and safety of dams. Careful examination of instrumentation data on a continuing basis may reveal a possible critical condition. Conversely, instrumentation may be a means of assuring that an observed condition is not serious and does not require immediate remedial measures.

(1) Adequacy of Instrumentation. Instrumentation to monitor structural and functional performance should be installed in dams where complex or unusual site conditions have been encountered or where there is a high probability that failure could result in loss of life or extensive property damage. Instruments should be examined periodically for proper functioning. The adequacy of the installed instrumentation should be assessed from time to

time by specialists to determine if it is sufficient to help evaluate the performance of the dam. When required, additional instrumentation should be installed to confirm suspicious trends or to explore an indicated potential adverse trend.

(2) Observation of Monitoring Devices. The instrumentation data should be collected by personnel trained specifically for the purpose, including training to recognize and immediately report to those responsible for inspections any anomalies in the readings or measurements. Performance observation data should be properly tabulated for record purposes.

(a) Frequency of observations. The frequency of instrument readings should be established at the time the instrumentation system is designed in order to give a timely warning of possible adverse conditions. Whenever necessary, more frequent readings, sometimes as often as hourly, should be taken to monitor a suspected rapidly changing adverse condition. The frequency or number of readings may be reduced after the project has been in operation for an extended time and performance observation data indicates that readings have stabilized.

(3) Data Analysis. It is essential that instrumentation data be processed, reviewed and assessed in a timely manner by specialists familiar with the design, construction, and operation of the project. Operation manuals and design information should be referred to in the evaluation of possible adverse trends. The performance observation data should be periodically analyzed to determine whether project structures are reacting as assumed in the design, and to detect behavior conditions that may indicate the need for corrective action.

d. Correction of Deficiencies

The inspection program could reveal those deficiencies or potential deficiencies which, if uncorrected, could eventually lead to failure of the dam. Deficiencies may vary from emergency type items where immediate action is required, to non-emergency type items which must be corrected in a timely manner but do not present an immediate danger to the safety of the structure. In all cases corrective action should be made under the supervision of qualified personnel. Emergency action plans to be implemented when failure has already occurred or is imminent are discussed in Section III.D.3, Emergency Action Planning.

(1) High Priority Corrective Action. High priority corrective action is required for deficiencies which could result in failure of the dam within a short period of time. Heads of agencies should have authorities, procedures and levels of delegation for transfer of funds and other emergency funding provisions to ensure they are adequate for accomplishing corrective actions in cases where time constraints will not permit allocation through the normal budget process. Procedures for seeking transfer authority beyond that delegated to the agency and/or requests for supplemental appropriations should also be reviewed to ensure such requests can be forwarded quickly and with all necessary supporting documentation to enable expeditious action by the President and/or the Congress.

(2) Non-emergency Corrective Action. Non-emergency corrective action is action taken when there is no immediate threat to the safety or operation of the dam, nor any threat to life or property downstream. The corrective action should be scheduled in advance of the fiscal year in which the work is to be done to allow time for planning, funding through the normal

budgeting process, and arranging for special reservoir operations when required. Some of these deficiencies may be corrected through the regular operation and maintenance program discussed in Section III.D.1, Operation and Maintenance.

(3) Follow-up Action. Periodic inspection reports should continue to list previously identified deficiencies along with any newly discovered deficiencies and show the status of corrective action. Appropriate inspection personnel should make frequent field examinations as long as the problem exists to see all corrective measures are being completed. When deficiencies are not corrected in a reasonable length of time, an investigation should be made to determine the reason for delay and appropriate management personnel should be notified of the findings.

e. Documentation

Proper documentation of the dam's current condition and past performance is necessary to assess the adequacy of operation, maintenance, surveillance, and proposed corrective actions. A complete record or history of the investigation, design, construction, operation, maintenance, surveillance, periodic inspections, modifications, repair, and remedial work should be established and maintained so that relevant data relating to the dam is preserved and readily available for reference. This documentation should commence with the initial site investigation for the dam and continue through the life of the structure.

(1) Instrumentation. All instrumentation observation data and evaluations thereof should be properly tabulated and documented for record purposes. Maintenance of instrumentation systems requires that details of the installation be available for a clear understanding of its functioning. A complete history of past repairs, testing, readings, and analyses should be available as pertinent reference data in the evaluation of current instrumentation data.

(2) Inspections. All inspection observations, especially as related to the safety of the dam, should be documented. The extent and nature of inspection reports required for the informal, intermediate formal, and special inspections will vary in proportion to the intensity of the inspection and the nature of the findings. Informal inspection reports may range from memoranda to supervisors which describe conditions and corrective actions, to detailed accounts of an event or occurrence. Intermediate inspection reports may vary from similar memoranda or trip reports to more formal reports containing substantial records, detail, and recommendations. Formal and special inspections require complete formal technical reports of all findings, corrective actions and recommendations, for permanent record and reference purposes in order to form a basis for major remedial work when required.

All reports should be in a self-explanatory form that permits their retention as permanent records and should carefully document times of inspections, inspection personnel, and findings of the inspection.

(3) Correction of Deficiencies. All deficiencies corrected as a result of the recommendations contained in periodic inspection reports should be fully documented in report form and made a part of the permanent project record. Alterations made to the facility as a result of changes in criteria to meet current practices or changes in dam technology should be fully documented, including as-constructed drawings.

3. Emergency Action Planning

a. General

It is intended that the guidelines for the design, construction, operation and maintenance, and inspection of dams will minimize the risk of future dam failures. Nevertheless, it is recognized that despite the adequacy of those guidelines and their implementation, the possibility of dam failures still exists. Even though the probability of such failures is small, preplanning is required to identify conditions which could lead to failure, in order to initiate emergency measures to prevent such failures as a first priority, and, if this is not possible, to minimize the extent and effects of such failure. These guidelines provide operating and mobilization procedures to be followed upon indication of an impending or possible dam failure or a major flood.

Each Federal agency which owns or is responsible for dams and each public or private owner of a Federally regulated dam (hereinafter, dam agency or owner) should evaluate the possible modes of failure of each dam, indicators or precursors of failure for each mode, possible emergency actions appropriate for each mode, and the effects on downstream areas of failure by each mode. In every case the evaluation should recognize the possibility of sudden failure, and should provide a basis for such "worst case" emergency planning actions in terms of notification and evacuation procedures where failure would pose a significant danger to human life and property. Plans should then be prepared in a degree of detail commensurate with the hazard, and instructions provided to operators and attendants regarding the actions to be taken in an emergency. Planning should be coordinated with local officials, as necessary, to enable those officials to draw up a workable plan for notifying and evacuating local communities when conditions affecting dam safety arise.

b. Evaluation of Emergency Potential

Prior to development of an emergency action plan, consideration must be given to the extent of land areas, and types of development with the areas, that would be inundated as a result of dam failure or flood, and the time available for emergency response.

(1) Determination of Mode of Dam Failure. There are many potential causes and modes of dam failure, depending upon the type of structure and its foundation characteristics. Similarly, there are degrees of "failure" and, often progressive stages of failure. Many dam failures can be prevented from reaching a final catastrophic stage by recognition of early indicators or precursor conditions, and by prompt, effective emergency actions. While emergency planning should emphasize preventive actions, recognition must be given to the catastrophic condition and hazard potential. Analysis should be made to determine the most likely mode of dam failure under the most adverse condition and the resulting peak water outflow following the failure. Where there is a series of dams on the stream, analyses should include consideration of

the potential for progressive "domino" failure of the dams.

(2) Inundation Maps. To evaluate the effects of dam failure, maps should be prepared delineating the area which would be inundated in the event of failure. Land uses and significant development or improvements within the area of inundation should be indicated. The maps should be equivalent to or more detailed than the United States Geological Survey (USGS) quadrangle maps, 7-1/2 minute series, or of sufficient scale and detail to identify clearly the area that should be evacuated if there is evident danger of failure of the dam. Copies of the maps should be distributed to local government officials for use in the development of an evacuation plan.

(3) Classification of Inundation Areas. To assist in the evaluation of hazard potential, areas delineated on inundation maps should be classified in accordance with the degree of occupancy and hazard potential. The potential for loss of life is affected by many factors, including but not limited to the capacity and number of exit roads to higher ground and available transportation. Hazard potential is greatest in urban areas. Since the extent of inundation is usually difficult to delineate precisely because of topographic map limitations, the evaluation of hazard potential should be conservative.

The hazard potential for affected recreation areas varies greatly, depending on the type of recreation offered, intensity of use, communication facilities, and available transportation. The potential for loss of life may be increased where recreationists are widely scattered over the area of potential inundation since they would be difficult to locate on short notice.

Many industries and utilities requiring substantial quantities of water for one or more stages in the manufacture of products or generation of power are located on or near rivers or streams. Flooding of these areas and industries can, in addition to causing the potential for loss of life, damage to machinery, manufactured products, raw materials and materials in process of manufacture, interrupt essential community services.

Rural areas usually have the least hazard potential. However, the potential for loss of life exists, and damage to large areas of intensely cultivated agricultural land can cause high economic loss.

(4) Time Available for Response. Analyses should be made to evaluate the structural, foundation, and other characteristics of the dam and determine those conditions which could be expected to result in slow, rapid or practically instantaneous dam failure.

c. Actions to Prevent Failure or Minimize Effects of Failure

(1) Development of Emergency Action Plan. An emergency action plan should be developed for each dam that constitutes a hazard to life and property, incorporating preplanned emergency measures to be taken prior to and following assumed dam failure. The plan should be coordinated with local governmental and other authorities involved in public safety and be approved by appropriate top level agency or owner management. To the extent possible, the emergency action plan should define emergency situations that require immediate notification of local officials. The emergency action plan should include notification plans, which are

discussed in section (2) below.

Emergency scenarios should be prepared for possible modes of failure for each dam. Periodically these scenarios should be used to test the readiness capabilities of project staff and logistics.

A procedure should be established for review and revision, as necessary, of the emergency action plan, including notification plans and evacuation plans, at least once every 2 years. Such reviews should be coordinated among all organizations responsible for preparation and execution of the plans.

(2) Notification Plans. Plans for notification of key personnel and the public are an integral part of the emergency action plan and should be prepared for slowly developing, rapidly developing, and instantaneous dam failure conditions. Notification plans should include a list of names and position titles, addresses, office and home telephone numbers, and radio communication frequencies and call signals, if available, for agency or owner personnel, public officials, and other personnel and alternates who should be notified as soon as emergency situations develop. A procedure should be developed to keep the list current.

Each type of notification plan should contain the order in which key agency or owner supervisory personnel or alternates should be notified. At least one key supervisory level or job position should be designated to be manned or the responsible person should be immediately available by telephone or radio 24 hours a day. A copy of each notification plan must be posted in a prominent place at the project site near a telephone and/or radio transmitter. All project personnel should be familiar with the plans and the procedures each is to follow in the event of an emergency. Copies of the notification plans should be readily available at the home and the office of each person involved.

Where dams located upstream from the dam for which the plan is being prepared could be operated to reduce inflow or where the operation of downstream dams would be affected by failure of the dam, operators of those dams should be kept informed of the current and expected conditions of the dam as the information becomes available.

Civil defense officials having jurisdiction over all or part of the area subject to inundation should receive early notification. Local law enforcement officials and, when possible, local government officials and public safety officials should receive early notification.

The capabilities of the Defense Civil Preparedness Agency's National Warning System (NAWAS) should be determined for the project and utilized as appropriate. Information can be obtained from State or local civil defense organizations.

Potentially affected industries downstream should be kept informed so that actions to reduce risk of life and economic loss can be taken. Coordination with local government and civil defense officials would determine responsibility for the notification. Normally, this would be a local government responsibility.

When it is determined that a dam may be in danger of failing, the public officials responsible for the decision to implement the evacuation plan should be kept informed of the developing emergency conditions.

The news media, including radio, television, and newspapers, should be utilized to the extent available and appropriate. Notification plans should define emergency situations for which each medium will be utilized and should include an example of a news release that would be the most effective for each possible emergency. Use of news media should be preplanned insofar as is possible by agency and owner personnel and the State and/or local government. Information should be written in clear, concise language. Releases to news media should not be relied upon as the primary means of notification.

Notification of recreation users is frequently difficult because the individuals are often alone and away from any means of ready communication. Consideration should be given to the use of standard emergency warning devices such as sirens at the dam site. Consideration should be given to the use of helicopters with bullhorns for areas further downstream. Vehicles equipped with public address systems and helicopters with bullhorns are capable of covering large areas effectively.

Telephonic communication should not be solely relied on in critical situations. A backup radio communication system should be provided and tested at least once every 3 months. Consideration should be given to the establishment of a radio communication system prior to the beginning of construction and to the maintenance of the system throughout the life of the project.

(3) Evacuation Plans. Evacuation plans should be prepared and implemented by the local jurisdiction controlling inundation areas. This would normally not be the dam agency or owner. Evacuation plans should conform to local needs and vary in complexity in accordance with the type and degree of occupancy of the potentially affected area. The plans may include delineation of area to be evacuated; routes to be used; traffic control measures; shelter, methods of providing emergency transportation; special procedures for the evacuation and care of people from institutions such as hospitals, nursing homes, and prisons; procedures for securing the perimeter and for interior security of the area; procedures for the lifting of the evacuation order and reentry to the area; and details indicating which organizations are responsible for specific functions and for furnishing the materials, equipment, and personnel resources required.

The assistance of local civil defense personnel, if available, should be requested in preparation of the evacuation plan. State and local law enforcement agencies usually will be responsible for the execution of much of the plan and should be represented in the planning effort. State and local laws and ordinances may require that other State, county, and local government agencies have a role in the preparation, review, approval, or execution of the plan. Before finalization, a copy of the plan should be furnished to the dam agency or owner for information and comment.

(4) Stockpiling Repair Materials. Suitable construction materials should be stockpiled for

emergency use. The amounts and types of construction materials needed for emergency repairs should be determined based on the structural, foundation, and other characteristics of the dam; design and construction history; and history of prior problems.

(5) Locating Local Repair Forces. Arrangements should be made with, and a current list maintained of, local entities, including contractors, and Federal, State and local construction departments, for possible emergency use of equipment and labor.

(6) Training Operating Personnel. Technically qualified project personnel should be trained in problem detection, evaluation, and 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 at-site observations. A sufficient number of personnel should be trained to assure adequate coverage at all times. If a dam is operated by remote control, arrangements must be made for dispatching trained personnel to the project at any indication of distress.

(7) Increasing Inspection Frequency. Frequency of appropriate surveillance activities should be increased when the reservoir level exceeds a predetermined elevation. Piezometers, water level gauges, and other instruments should be read frequently and on schedule. The project structures should be inspected as often as necessary to monitor conditions related to known problems and to detect indications of change or new problems that could arise. Hourly or continuous surveillance may be mandated in some instances. Any change in conditions should be reported promptly to the supervisor for further evaluation.

The supervisor should issue additional instructions, as necessary, and alert repair crews and contractors for necessary repair work if developing conditions indicate that emergency repairs or other remedial measures may be required.

d. Actions Upon Discovery of a Potentially Unsafe Condition

Action to be taken will depend on the nature of the problem and the time estimated to be available for remedial or mitigation measures. As time permits, one or more of the following actions will be required.

(1) Notification of Supervisory Personnel. This is essential, if time permits, since development of failure could vary in some or many respects from previous forecasts or assumptions, and advice may be needed.

(2) Initiation of Predetermined Remedial Action. It is imperative that at least one technically qualified individual, previously trained in problem detection, evaluation, and remedial action, be at the project or on call at all times. Depending on the nature and seriousness of the problem and the time available, emergency actions can be initiated, such as lowering the reservoir and holding water in upstream reservoirs. Other actions to be taken include notifying appropriate highway and traffic control officials promptly of any rim slides or other reservoir embankment failures which may endanger public highways.

(3) Determination of Need for Public Notification. To the extent possible, emergency situations

that will require immediate notification of public officials in time to allow evacuation of the potentially affected area should be predefined for the use of management and project personnel. If sufficient time is available, the decision to notify public officials that the dam can be expected to fail will be made at a predetermined supervisory level within the agency or owner organization. If failure is imminent or has already occurred, project personnel at the dam site would be responsible for direct notification of the public official. The urgency of the situation should be made clear so that public officials will take positive action immediately.

APPENDIX A
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Legend
Army-Department of the Army
BIA-Bureau of Indian Affairs
BLM-Bureau of Land Management
BOM-Bureau of Mines
BoR-Bureau of Reclamation
Corps-Corps of Engineers
DOI-Department of the Interior
FERC-Federal Energy Regulatory Commission
FS-Forest Service
FWS-Fish and Wildlife Service
IBWC-International Boundary and Water Commission
MESA-Mining Enforcement and Safety Administration
NRC-Nuclear Regulatory Commission
SCS-Soil Conservation Service
TVA-Tennessee Valley Authority
USDA-Department of Agriculture
USGS-United States Geological Survey

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APPENDIX D
ACKNOWLEDGMENTS

The authority for preparation of the guidelines is given in section I.B. They were prepared by an interagency guidelines task group composed of the Chairmen of the subcommittees identified in Appendix B. Specific sections preparation assignments were:

Section I. SID Chairman, George L. Buchanan, TVA

Section II, CON Chairman, Donald A. Giampaoli, BoR, and O&M Chairman, Gerald R. Wilson, FERC, with the cooperation of L. Douglas James, representative of the Independent Review Panel (Appendix C) to the guidelines task group, and Bruce A. Tschantz, consultant to OSTP and advisor to the task group.

Section III A. and III.B. SID Chairman

Section III.C. CON Chairman

Section III.D. O&M Chairman

The Chairmen were assisted by their subcommittee and task groups members (listed in Appendix B).

Reviews were made by subcommittee members and by representatives of the agencies other than the preparing agency and by L. Douglas James of the Independent Review Panel. Major contributory reviews were made by representatives of the major dam building agencies, BoR, Corps, SCS, and TVA, and the Independent Review Panel member.

Editing and assembly of the final working draft for submittal to FCCSET were handled by the SID Chairman (TVA). Oliver H. Raine of the SID Chairman's engineering staff assisted in the preparation and review of various portions of the guidelines and in the editing and assembly of the working draft.

APPENDIX E
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Tennessee Regulations

Chapter 1200-5-7. Rules and Regulations Applied to the "Safe Dam Act of 1973"
TNR\dp1200\di5\ch1200-5-7

1200-5-7-.02 Definitions.
TNR\dp1200\di5\ch1200-5-7\se1200-5-7-.02
For the purpose of these rules ad regulations, the term:

TNR\dp1200\di5\ch1200-5-7\se1200-5-7-.02(10)
(10) Dam means any artificial barrier, together with appurtenant works, which does or may impound or divert water, and which either (1) is or will be twenty (20) feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the Commissioner, or (2) has or will have an impounding capacity at maximum water storage elevation of thirty (30) acre-feet or more. Provided, however, that any such barrier which is or will be less than six (6) feet in height, regardless of storage capacity, or which has or will have a maximum storage capacity not in excess of fifteen (15) acre-feet, regardless of height, shall not be considered a dam, nor shall any barrier, regardless of size, be considered a dam, if, in the judgment of the Commissioner, such barrier creates an impoundment used only as a farm pond. Diversion weirs, roadbeds, water tanks, and wastewater impoundment barriers as defined in this section are not dams.

TNR\dp1200\di5\ch1200-5-7\se1200-5-7-.02(40)
(40) Wastewater Impoundment Barrier means an artificial barrier impounding a body of wastewater for the purpose of treatment and designed so that no surface runoff from areas adjacent to the barrier is introduced into the impoundment.

Arkansas Regulations

Title VII Rules Governing Design and Operation of Dams
ARR\dpNRC\rgNRRR\tiVII
Subtitle I. General Provisions
ARR\dpNRC\rgNRRR\tiVII\stI
Reg. 701.1. Purpose.
ARR\dpNRC\rgNRRR\tiVII\stI\se701.1

ARR\dpNRC\rgNRRR\tiVII\stI\se701.1(A)
A. Provide for the comprehensive regulation and supervision of dams for the protection of the health, safety, welfare and property of the citizens of Arkansas.

ARR\dpNRC\rgNRRR\tiVII\stI\se701.1(B)
B. Assure proper planning, design, construction, maintenance, monitoring and supervision of dams, including such preventive measures as are necessary to provide an adequate margin of safety.

Attachment 3

Reg. 701.3. Scope of Regulations.
ARR\dpNRC\rgNRRR\tiVII\stI\se701.3
All dams within the State of Arkansas, except those owned by the United States Government or those exempted by Section 701.4, must have a valid construction and operation permit issued under the provisions of this title.

Reg. 701.4. Exemptions.
ARR\dpNRC\rgNRRR\tiVII\stI\se701.4
Dams meeting either of the following criteria are not subject to rules contained in this title, unless Section 701.5 of this title is successfully invoked.

ARR\dpNRC\rgNRRR\tiVII\stI\se701.4(A)
A. Dams with height less than 25 feet.

ARR\dpNRC\rgNRRR\tiVII\stI\se701.4(B)
B. Dams with normal storage less than 50 acre-feet.

ARR\dpNRC\rgNRRR\tiVII\stI\se701.4(C)
C. Dams with crest elevations below the ordinary high water mark of the stream at that location.

Missouri Regulations

Division 22 - Dam and Reservoir Safety Council
MOR\ti10\di22
Chapter 1 - Organization, Definitions and Immunity
MOR\ti10\di22\ch1
10 CSR 22-1.010 General Organization
MOR\ti10\di22\ch1\se10CSR22-1.010
PURPOSE: This rule complies with section 536.023, RSMo which requires each agency to adopt as a rule a description of its operation and the methods where the public may obtain information or make submissions or requests.

MOR\ti10\di22\ch1\se10CSR22-1.020(13)
(13) Dam means any artificial or man-made barrier which does or may impound water and which impoundment has or may have a surface area of fifteen (15) or more acres of water at the water storage elevation or which is thirty-five feet (35') or more in height from the natural bed of the stream or watercourse or lowest point on the toe of the dam (whichever is lower) up to the crest elevation, together with appurtenant works. Sections 236.400 to 236.500 shall not apply to any dam which is not or will not be in excess of thirty-five feet (35') in height or to any dam or reservoir licensed and operated under the Federal Power Act.

MOR\ti10\di22\ch1\se10CSR22-1.020(24)

(24) Height or height of dam means the difference in the elevation of either the natural bed of the stream or watercourse or the lowest point on the toe of the dam (whichever is lower) and the dam crest elevation.

Georgia Regulations

Chapter 391-3-8 Rules for Dam Safety
GAR\dp391\di3\ch391-3-8
391-3-8-.01 Purpose.
GAR\dp391\di3\ch391-3-8\se391-3-8-.01
The purpose of these Rules is to implement the responsibilities assigned to the Environmental Protection Division by the Georgia Safe Dams Act of 1978; Part 3 of Article 5 of O.C.G.A. §§12-5. These Rules are promulgated to provide for the inventory, classification, inspection and permitting of certain dams in order to protect the health, safety and welfare of all the citizens of the State by reducing the risk of failure of such dams to prevent death or injuries to persons.

391-3-8-.02 Definitions.
GAR\dp391\di3\ch391-3-8\se391-3-8-.02
For the purpose of these rules and regulations, the term:

GAR\dp391\di3\ch391-3-8\se391-3-8-.02(e)
(e) "Category II" means the classification where improper operation or dam failure would not expect to result in probable loss of human life.

GAR\dp391\di3\ch391-3-8\se391-3-8-.02(h)
(h) "dam" means, with exception of the exemptions outlined in Rule 391-3-8-.04 herein, the following:

GAR\dp391\di3\ch391-3-8\se391-3-8-.02(h)(1)
1. Any artificial barrier, including appurtenant works, which impounds or diverts water and which the improper operation or failure of such would result in probable loss of human life as determined pursuant to the Act, and which

GAR\dp391\di3\ch391-3-8\se391-3-8-.02(h)(1)(i)
(i) is twenty-five (25) feet or more in height from the natural bed of the stream or water course measured at the downstream toe or the lowest elevation of the outside limit of the barrier (whichever is lower) to the maximum water storage elevation; or

GAR\dp391\di3\ch391-3-8\se391-3-8-.02(h)(1)(ii)
(ii) has an impounding capacity at maximum water storage elevation of one hundred (100) acre-feet or more.

GAR\dp391\di3\ch391-3-8\se391-3-8-.02(h)(2)

2. Any artificial barrier, including appurtenant works, constructed in conjunction with the reclamation of surface mined land, and meeting the requirements of subsection 1., above and when improper operation or failure would result in probable loss of human life.

391-3-8-.04 Scope and Exclusions.
GAR\dp391\di3\ch391-3-8\se391-3-8-.04
These rules and regulations shall apply to any dams or artificial barriers existing or constructed in Georgia except for the following:

GAR\dp391\di3\ch391-3-8\se391-3-8-.04(d)
(d) any dam classified as a Category II Dam;

GAR\dp391\di3\ch391-3-8\se391-3-8-.04(e)
(e) any artificial barrier, except as provided in Rule 391-3-8-.02(h), constructed in connection with and incidental to surface mining, provided that upon completion of mining the impoundment created by the barrier is drained and reclaimed or stabilized as a lake pursuant to a mined land use plan approved by the Director pursuant to the Georgia Surface Mining Act;

GAR\dp391\di3\ch391-3-8\se391-3-8-.04(f)
(f) any artificial barrier which is not in excess of 6 feet in height regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of 15 acre-feet, regardless of height.

Texas Regulations

Chapter 299. Dams and Reservoirs
TXR\ti30\pt1\ch299
Subchapter A. General Provisions
TXR\ti30\pt1\ch299\shA
§299.1. Applicability.
TXR\ti30\pt1\ch299\shA\se299.1

TXR\ti30\pt1\ch299\shA\se299.1(a)
(a) This chapter applies to design, review, and approval of construction plans and specifications; and construction, operation and maintenance, inspection, repair, removal, emergency management, site security, and enforcement of dams that:

TXR\ti30\pt1\ch299\shA\se299.1(a)(1)
(1) have a height greater than or equal to 25 feet and a maximum storage capacity greater than or equal to 15 acre-feet, as described in paragraph (2) of this subsection;

TXR\ti30\pt1\ch299\shA\se299.1(a)(2)
(2) have a height greater than six feet and a maximum storage capacity greater than or equal to 50 acre-feet;

TXR\ti30\pt1\ch299\shA\se299.1(a)(3)
(3) are a high- or significant-hazard dam as defined in §299.14 of this title (relating to Hazard Classification Criteria), regardless of height or maximum storage capacity; or

TXR\ti30\pt1\ch299\shA\se299.1(a)(4)
(4) are used as a pumped storage or terminal storage facility.

TXR\ti30\pt1\ch299\shA\se299.1(b)
(b) This chapter provides the requirements for dams, but does not relieve the owner from meeting the requirements in Texas Water Code (TWC), Chapter 11, and Chapters 213, 295, and 297 of this title (relating to Edwards Aquifer; Water Rights, Procedural; and Water Rights, Substantive; respectively). All applicable requirements in those chapters will still apply.

TXR\ti30\pt1\ch299\shA\se299.1(c)
(c) This chapter does not apply to:

TXR\ti30\pt1\ch299\shA\se299.1(c)(1)
(1) dams designed by, constructed under the supervision of, and owned and maintained by federal agencies such as the Corps of Engineers, International Boundary and Water Commission, and the Bureau of Reclamation;

TXR\ti30\pt1\ch299\shA\se299.1(c)(2)
(2) embankments constructed for roads, highways, and railroads, including low-water crossings, that may temporarily impound floodwater, unless designed to also function as a detention dam;

TXR\ti30\pt1\ch299\shA\se299.1(c)(3)
(3) dikes or levees designed to prevent inundation by floodwater;

TXR\ti30\pt1\ch299\shA\se299.1(c)(4)
(4) off-channel impoundments authorized by the commission under TWC, Chapter 26; and

TXR\ti30\pt1\ch299\shA\se299.1(c)(5)
(5) above-ground water storage tanks (steel, concrete, or plastic).

TXR\ti30\pt1\ch299\shA\se299.1(d)
(d) All dams must meet the requirements in this chapter, including dams that do not require a water right permit, other dams that are exempt from the requirements in Subchapter C of this chapter (relating to Construction Requirements), and dams that are granted an exception as defined in §299.5 of this title (relating to Exception).
33 Tex. Reg. 10465, 12/26/2008.