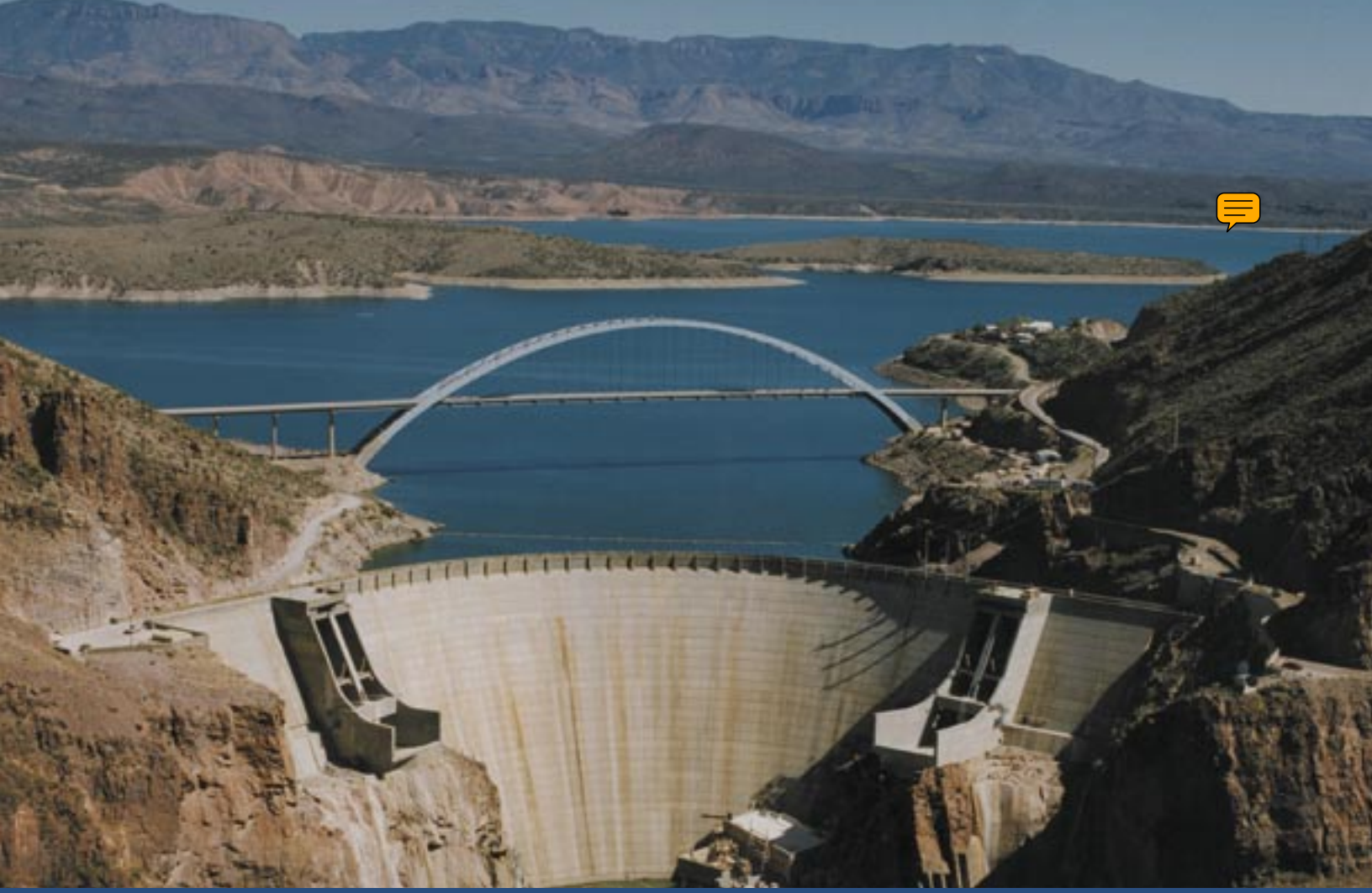

Federal Guidelines for Dam Safety

Hazard Potential Classification System for Dams

April 2004

FEMA

FEDERAL GUIDELINES FOR DAM SAFETY: HAZARD POTENTIAL CLASSIFICATION SYSTEM FOR DAMS

prepared by the
INTERAGENCY COMMITTEE ON DAM SAFETY

U.S. DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY
OCTOBER 1998

Reprinted January 2004

PREFACE

In April 1977, President Carter issued a memorandum directing the review of federal dam safety activities by an *ad hoc* panel of recognized experts. In June 1979, the *ad hoc* interagency committee on dam safety (ICODS) issued its report, which contained the first guidelines for federal agency dam owners. The Federal Guidelines for Dam Safety (Guidelines) encourage strict safety standards in the practices and procedures employed by federal agencies or required of dam owners regulated by the federal agencies. The Guidelines address management practices and procedures but do not attempt to establish technical standards. They provide the most complete and authoritative statement available of the desired management practices for promoting dam safety and the welfare of the public.

To supplement the Guidelines, ICODS prepared and approved federal guidelines in the areas of emergency action planning; earthquake analysis and design of dams; and selecting and accommodating inflow design floods for dams. These publications, based on the most current knowledge and experience available, provided authoritative statements on the state of the art for three important technical areas involving dam safety. In 1994, the ICODS Subcommittee to Review/Update the Federal Guidelines began an update to these guidelines to meet new dam safety challenges and to ensure consistency across agencies and users. In addition, the ICODS Subcommittee on Federal/Non-Federal Dam Safety Coordination developed a new guideline, Hazard Potential Classification System for Dams.

With the passage of the National Dam Safety Program Act of 1996, Public Law 104-303, ICODS and its Subcommittees were reorganized to reflect the objectives and requirements of Public Law 104-303. In 1998, the newly convened Guidelines Development Subcommittee completed work on the update of all of the following guidelines:

- Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners
- Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams
- Federal Guidelines for Dam Safety: Earthquake Analyses and Design of Dams
- Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams
- Federal Guidelines for Dam Safety: Glossary of Terms

The publication of these guidelines marks the final step in the review and update process. In recognition of the continuing need to enhance dam safety through coordination and information exchange among federal and state agencies, the Guidelines Development Subcommittee will be responsible for maintaining these documents and establishing additional guidelines that will help achieve the objectives of the National Dam Safety Program.

The members of all of the Task Groups responsible for the update of the guidelines are to be commended for their diligent and highly professional efforts.

Harold W. Andress, Jr.
Chairman, Interagency Committee on Dam Safety

HAZARD POTENTIAL CLASSIFICATION SYSTEM FOR DAMS
TASK GROUP

Alton P. Davis Jr.**
GEI Consultants, Inc.

David G. Achterberg*
DOI, Bureau of Reclamation

Harold (Bud) W. Andress, Jr.*
Federal Emergency Management Agency

Jerrold W. Gotzmer*
Federal Energy Regulatory Commission

William Irwin*
USDA, Natural Resources Conservation Service

George Mills*
Ohio Department of Natural Resources

James Simons*
North Carolina Department of Environmental
Health and Natural Resources

Constantine G. Tjoumas*
Federal Energy Regulatory Commission

David Bowles
Utah State University

Darian E. Ingram
DOI, Bureau of Reclamation

Charles Karpowicz
DOI, National Park Service

Martin W. McCann, Jr.
Stanford University

Mark A. Riebau
Association of State Flood Plain Managers

Charles Sullivan
U. S. Army Corps of Engineers

**Chair of Task Group that completed final document
*Members of Task Group that completed final document

TABLE OF CONTENTS

I. PURPOSE 1

II. DEFINITIONS 3

III. CLASSIFICATION SYSTEM 5

IV. DISCUSSION 7

APPENDIX A A-1
APPENDIX B B-1

I. PURPOSE

Common practice among federal and state dam safety offices is to classify a dam according to the potential impact a dam failure (breach) or mis-operation (unscheduled release) would have on upstream and/or downstream areas or at locations remote from the dam. The existing classification systems are numerous and vary within and between both the federal and state sectors. Although differences in classification systems exist, they share a common thread: each system attempts to classify dams according to the potential impacts from a dam failure or mis-operation, should it occur. The most significant problem with these various systems is the use of terms that lack clear definition. In addition, the various systems use different terminology to define similar concepts. This precludes consistency between the various federal and state agencies and understanding by the public.

This document sets forth a hazard potential classification system for dams that is simple, clear, concise, and adaptable to any agency's current system. The intent is to provide straightforward definitions that can be applied uniformly by all federal and state dam safety agencies and can be readily understood by the public. It does not establish how the system will be used, such as prescribing specific design criteria or prioritizing inspections. Those responsibilities belong to the responsible regulatory authority.

II. DEFINITIONS

For the purpose of this system, the following terms are defined:

HAZARD POTENTIAL: The possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or mis-operation of the dam or appurtenances.

ADVERSE CONSEQUENCES: Negative impacts that may result from the failure of a dam. The primary concerns are loss of human life, economic loss (including property damage), lifeline disruption, and environmental impact.

INCREMENTAL: Under the same conditions (*e.g.*, flood, earthquake, or other event), the difference in impacts that would occur due to failure or mis-operation of the dam over those that would have occurred without failure or mis-operation of the dam and appurtenances.

PROBABLE: Likely to occur; reasonably expected; realistic.

HAZARD POTENTIAL CLASSIFICATION: A system that categorizes dams according to the degree of adverse incremental consequences of a failure or mis-operation of a dam. The hazard potential classification does not reflect in any way on the current condition of the dam (*e.g.*, safety, structural integrity, flood routing capacity).

III. CLASSIFICATION SYSTEM

Three classification levels are adopted as follows: **LOW**, **SIGNIFICANT**, and **HIGH**, listed in order of increasing adverse incremental consequences. The classification levels build on each other, *i.e.*, the higher order classification levels add to the list of consequences for the lower classification levels, as noted in the table on the following page.

This hazard potential classification system should be utilized with the understanding that the failure of any dam or water-retaining structure, no matter how small, could represent a danger to downstream life and property. Whenever there is an uncontrolled release of stored water, there is the possibility of someone, regardless of how unexpected, being in its path.

A primary purpose of any classification system is to select appropriate design criteria. In other words, design criteria will become more conservative as the potential for loss of life and/or property damage increases. However, postulating every conceivable circumstance that might remotely place a person in the inundation zone whenever a failure may occur should not be the basis for determining the conservatism in dam design criteria.

This hazard potential classification system categorizes dams based on the probable loss of human life and the impacts on economic, environmental, and lifeline interests. Improbable loss of life exists where persons are only temporarily in the potential inundation area. For instance, this hazard potential classification system does not contemplate the improbable loss of life of the occasional recreational user of the river and downstream lands, passer-by, or non-overnight outdoor user of downstream lands. It should be understood that in any classification system, all possibilities cannot be defined. High usage areas of any type should be considered appropriately. Judgment and common sense must ultimately be a part of any decision on classification. Further, no allowances for evacuation or other emergency actions by the population should be considered because emergency procedures should not be a substitute for appropriate design, construction, and maintenance of dam structures.

1. LOW HAZARD POTENTIAL

Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

2. SIGNIFICANT HAZARD POTENTIAL

Dams assigned the significant hazard potential classification are those dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

3. HIGH HAZARD POTENTIAL

Dams assigned the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life.

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

IV. DISCUSSION

This Hazard Potential Classification System for Dams is based on the probable loss of human life and the potential for economic losses, environmental damage, and/or disruption to lifelines caused by failure of mis-operation of a dam or its appurtenances. This Hazard Potential Classification System for Dams recognizes that the failure or mis-operation of any dam or water-retaining structure, no matter how small, represents a potential danger to downstream life and property. Whenever there is an uncontrolled release of stored water, there is always the possibility, regardless of how unexpected, of someone being in the path of the discharge. However, postulating every conceivable circumstance that might remotely place a person in the potential inundation zone should not be the basis for determining the appropriate classification level. This system considers improbable loss of life to exist where persons are only temporarily in the potential inundation area.

The difference between the significant and high hazard potential classification levels is that a high hazard potential dam includes the probable loss of human life. The failure of a dam that is classified as a high hazard potential structure may or may not include adverse incremental consequences that would otherwise justify a significant hazard potential classification.

The hazard potential classification assigned to a dam is based on consideration of the effects of a failure or mis-operation during both normal and flood flow conditions. The classification assigned should be based on the worst-case probable scenario of failure or mis-operation of the dam, *i.e*., the assigned classification should be based on failure consequences that will result in the assignment of the highest hazard potential classification of all probable failure and mis-operation scenarios. Each element of a project must be evaluated to determine the proper hazard potential classification for the project. However, there is only one hazard potential classification assigned to the entire project. Individual elements are not assigned separate classifications.

The probable scenarios considered should be reasonable, justifiable, and consistent with the *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams* (FEMA). For example, assuming reasonable breach parameters and a failure during normal operating conditions ("sunny day" failure) may result in the released water being confined to the river channel and no probable loss of human life, indicating a low hazard potential classification. However, if the dam were assumed to fail in a similar manner during a flood condition, and the result would be probable loss of human life (excluding the occasional passer-by or recreationist) but minor economic losses, a high hazard potential classification would be appropriate. Once a project is placed in the high hazard potential classification, additional probable failure or mis-operation scenarios need only be considered if there is a need to determine if they would likely induce higher adverse incremental impacts.

In most situations, the investigation of the impact of failure or mis-operation of a dam on downstream human life, property damage, lifeline disruption, and environmental concerns is sufficient to determine the appropriate hazard potential classification. However, if failure or mis-operation of a dam contributes to failure of a downstream dam(s), the hazard potential

classification of the dam should be at least as high as the classification of the downstream dam(s) and should consider the adverse incremental consequences of the domino failures.

APPENDIX A - BACKGROUND

CHARTER

On September 12, 1994, a Task Group was chartered to review existing hazard potential classification systems, identify ambiguous terminology, and propose a modified or new system for the hazard potential classification of dams.

METHOD

The Task Group met on five occasions. Minutes of each meeting were recorded. The Task Group assembled copies of various Federal agency hazard potential classification systems, a copy of the Canadian Dam Safety Association Classification System, and a summary of state dam safety agency classification systems. Copies of these documents are included in Appendix B. The Task Group reviewed these documents, considered several options, and developed the Hazard Potential Classification System for Dams. The draft Hazard Potential Classification System for Dams was submitted to the ICODS for review and comment. Comments were received in April 1996 and incorporated in the final Task Group report.

DISCUSSION

An early decision of the Task Group was to limit the work to the classification system and associated definitions. The Task Group would not consider issues related to future uses of the classification system, such as to establish design criteria, remediation schedules, inspection schedules, emergency action plan requirements, and/or spillway inflow design flood criteria. The work would be aimed at developing simple, unambiguous definitions for the proposed classification system.

The Task Group reviewed existing classification systems and the history of their development. The existing systems generally evolved from the U.S. Army Corps of Engineers' Appendix D, "Recommended Guidelines for Safety Inspections of Dams" (ER 1110-2-106), dated September 26, 1979. Although the original 1979 classification system was intended for limited use, *i.e.*, primarily to prioritize inspections for the 1979-1982 inspection program, it had evolved into multiple systems with various nomenclatures and specific design criteria. The resulting hodgepodge of systems has led to confusion in the dam safety community when dealing with multiple agencies and across state boundaries.

The confusion begins with the names of the major classification categories that include: High-Significant-Low Hazard Potential, A-B-C, C-B-A, 1-2-3, and 3-2-1 for the corresponding names. In addition, various High Hazard Potential definitions contain an allowance for zero, few, 1 or more, or up to 10 human lives lost. This variety of terms, systems, and criteria leads to confusion in the dam safety community and, more importantly, to a lack of understanding by the general public.

The Task Group reviewed existing systems for a number of categories. Although a few have up to nine categories, the great majority have three, as in the original 1979 system. In view of the long history of the basic 1979 three-category system, the associated regulatory base, and the

various associated data bases, the Task Group decided to retain the existing three-category system. It was further decided that the original category titles of High, Significant, and Low Hazard Potential would be retained so that the resulting system would be applied uniformly by all regulatory agencies.

The next issue was to discuss the factors to be considered in each category. The Task Group decided that the four key risk factors are loss of human life; economic losses; environmental damage; and lifeline disruption.

Hazard potential categories would consider increasing levels of loss. However, probable loss of human life would designate a High Hazard Potential Structure regardless of the magnitude of other losses. If no loss of life is probable as the result of dam failure or mis-operation, the dam would be classified as Low or Significant Hazard Potential. This is a major change from prior systems. In an effort to clarify ambiguities in prior classification systems, the probable loss of human life is defined to signify one or more lives lost. The term "probable" is specifically included to indicate that the scenario used to predict the loss of human life must be reasonable and realistic, not contrived. In the definition for High Hazard Potential, the probable loss of human life is further clarified to exclude the casual user of the downstream or upstream area in determining the potential for loss of human life. It is also stated that potential public response to the emergency should not be used to reduce the calculated probable loss of human life.

The terms failure and mis-operation of a project are used by the Task Group to define the causes of the hazard to upstream and downstream interests. Failure of a dam is meant to include any cause that breaches the structure to release the stored contents (water, hazardous liquid wastes, slurries, or tailings). Mis-operation is meant to include any cause related to accidental or deliberate unscheduled release of the stored contents, such as a gate being opened more than planned but which does not result in full release of the reservoir contents.

It is the intent of the Task Group that each project would be periodically re-evaluated and reclassified as appropriate. The frequency of review should be each time the project is scheduled for inspection, or at least once each 5 years. This allows for periodic changes in the assigned hazard potential category based on changed reservoir or downstream development.

The Task Group considers it important that the term "Potential" be incorporated in each classification system name. This term helps the public understand the significant difference between hazards that "may" become real and any current actual safety concerns for the dam.

It is the Task Group's conclusion that the classification system should be a universal system for all regulatory agencies. The classification system category names should be adopted in lieu of any existing numerical or alphabetical system for consistency in the dam safety community and to properly educate the public on the need to properly maintain this component of the Nation's infrastructure.

TASK GROUP CONCLUSIONS

1. The proposed Hazard Potential Classification System for Dams provides a clear, simple, concise, and adaptable system to classify the hazard potential for dams.

2. The hazard potential rating does not reflect in any way on the current safety, structural integrity, or flood routing capability of the project water retaining structures.

3. The proposed classification system should be submitted to ICODS with a recommendation for peer review by ASDSO, USCOLD, ASCE, and the Canadian Dam Safety Association.

4. Future task groups should be established to consider design criteria associated with the various hazard classification systems.

5. The proposed Hazard Potential Classification System should be adopted in lieu of existing numerical and alphabetical systems. This is necessary to eliminate confusion in the dam safety community and to educate the public on the importance of dam safety.

APPENDIX B - EXISTING CLASSIFICATION SYSTEM INFORMATION*

Federal Energy Regulatory Commission

USDA, Natural Resources Conservation Service (formerly Soil Conservation Service)

DOI, Bureau of Reclamation

U. S. Army Corps of Engineers

Canadian Dam Safety Association

Summary of State Systems (compiled April 1995)

***Note**: These appendices are available only in the print publication of FEMA 333, which can be ordered through: FEMA Distribution Center, P.O. Box 2012, 8231 Stayton Drive, Jessup, Maryland 20794-2012, Phone Number 1-800-480-2520

FEDERAL ENERGY REGULATORY COMMISSION

USDA, NATURAL RESOURCES CONSERVATION SERVICE
(FORMERLY SOIL CONSERVATION SERVICE)

DOI, BUREAU OF RECLAMATION

U. S. ARMY CORPS OF ENGINEERS

CANADIAN DAM SAFETY ASSOCIATION

SUMMARY OF STATE SYSTEMS (COMPILED APRIL 1995)