STATE ENGINEER'S TWELFTH ANNUAL REPORT TO THE COLORADO GENERAL ASSEMBLY ON DAM SAFETY FOR F.Y. 95-96

November 1, 1996

COLORADO DIVISION OF WATER RESOURCES
OFFICE OF THE STATE ENGINEER

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INTRODUCTION/PURPOSE

Colorado's Dam Safety Program is implemented and managed by the State Engineer in accordance with Title 37, Article 87, of C.R.S. (1996 Supp.), and the Livestock Water Tank Act, Title 35, Article 49, of C.R.S. (1996 Supp.), as amended. The "Rules and Regulations for Dam Safety and Dam Construction" and Standard Specifications for Livestock Water Tanks and Erosion Control Dams establish the procedures and requirements of the State Engineer in the implementation of these statutes.

This report is submitted in compliance with Section 37-87-114.4, C.R.S. (1996 Supp.) concerning the dam safety activities of the State Engineer and the Colorado Division of Water Resources relating to Sections 37-87-105 to 37-87-114, C.R.S. (1996 Supp.)

EFFECTIVENESS OF PROGRAM

As expressed by the goals and objectives of the State Engineer, the program's effectiveness can be measured by the prevention of dam failures. No significant failures occurred during the period, but there were several incidents which are discussed below. The enforcement of the State Engineer's orders is also instrumental in assuring the effectiveness of the program. The combination of the State Engineer's safety inspections, restrictions, Emergency Preparedness Plans, and programs to make dam owners more knowledgeable about the safe operation and maintenance of their dams makes Colorado's Dam Safety Program one of the most effective in the United States. The program receives full credit under the National Flood Insurance Program's Community Rating System, providing reduced premiums for participating entities.

All of the safety inspection and design review goals and objectives were met. The decentralization of the safety inspection activities to the supervision of the Division Engineers is working well. Strategies to implement the regulations in a reasonable time have been partially successful, and in order to fully implement them, new strategies will be devised in the coming year.

At the end of the reporting period, there were 189 dams restricted in storage for various safety problems related to serious leakage, cracking and sliding of embankments, or inadequate spillways. The restrictions provide for the safety of the dams until the problems are remedied. In some cases, the owners are unable to obtain financing for repairing their dams from commercial sources. The Colorado Water Conservation Board's Construction Fund is available to the owners to obtain low cost, long term loans for this purpose. The CWCB created a $2 million emergency infrastructure repair account in their fund in order to provide financing for

structures like dams that are found to be unsafe and in need of repair to protect the public safety. The loans must be beneficial and meet the Board's requirements.

The response to two serious incidents at dams is an indication of the effectiveness of our program. One was wind damage to the riprap at Standley Lake dam near Westminster. The other was a slide on the downstream slope of Sylvan dam near Parshall. In both cases the owners took emergency actions to prevent the failure of the dams, and notified our office of the incidents. John Blair from Division 5 responded to the incident at Sylvan dam to assure that appropriate measures were being taken to protect the public safety. An order to restrict storage was issued. Dennis Miller from Division 1 responded to the incident at Standley Lake dam, and monitored the repairs to the riprap.

Significant progress was made in our extreme precipitation study of the mountainous areas of Colorado. The State Climatologist has assembled historic large storm data that will be used in the modelling of extreme storm rainfall above 7500 feet. A group of meteorologists and modelers who were assembled to discuss the use of models concluded that they have the potential to simulate extreme storms, and can be used to understand the physics of rainfall with elevation. They encouraged us to proceed with our project.

With the passage of the National Dam Safety Program Act, which was sponsored by the Association of State Dam Safety Officials, and signed by the President on October 12, 1996, state programs will benefit by being eligible for matching grants to improve their programs, by taking advantage of research funding, and receive training, and become more effective.

DAM SAFETY PROGRAM

Organization

The Dam Safety Program is accomplished by the State Engineer through the Dam Safety Branch and the Division Engineer's Offices. The branch is partially decentralized, with Dam Safety Engineers working under the supervision of the Division Engineers in the several divisions throughout the state. They are responsible for implementation of the Program, excluding design review, including enforcement of reservoir level restrictions. The Principal Engineer of the Branch, who is located in Denver, has program wide responsibilities such as formulating the goals of the program, recommending policies for implementation of the regulations, preparing procedures for carrying out the policies, and providing technical guidelines for conduct of the work. The position also supervises the Design Review and Construction Inspection Unit and the Design Review Engineers. (See Appendix A for tables and charts of the personnel and organization of the Branch.)

The Dam Safety Engineers' principal duties are to conduct safety inspections of existing dams, review the adequacy of spillways under the rules, enforce the requirement for emergency planning, and assist dam owners in developing their Emergency Preparedness Plans (EPP), do design review and construction inspection of repairs and alterations when necessary, and investigation of complaints on the safety of dams. They investigate the construction of dams in violation of Section 37-87-105(1) and (4), C.R.S. (1996 Supp.), and conduct training on the inspection of dams for division personnel, dam owners, interested agencies, engineers, and the

public. They also review and approve Livestock Watertank and Erosion Control Dam applications, and do other related work as assigned.

The Design Review Engineers' principal duties are to review the plans and specifications for the construction, alteration, modification, repair, and enlargement of reservoirs or dams in accordance with Section 37-87-105, C.R.S. (1996 Supp.). This involves a comprehensive engineering review of the plans and specifications to assure that a safe design has been developed, and to inspect the construction of the dam. The Unit assists the Department of Health in the technical evaluation of tailing impoundments through a Memorandum of Understanding, participates in the state's Joint Review Process with the Department of Natural Resources, provides technical assistance to the Division Engineers' offices on dam safety, and performs other related work as assigned.

Goals and Objectives of the Program

The mission of the program is to prevent loss of life and property damage, and protect the state's water supplies from the failure of dams within the resources available to this office. The program concentrates on "jurisdictional" dams and reservoirs as defined in Section 37-87-105, C.R.S. (1996 Supp.), which are greater than ten feet high at the spillway; or twenty acres in surface area, or 100 acre-feet in capacity at the high water line. Particular focus is placed on inspecting Class 1 dams annually, Class 2 dams every two years, and Class 3 dams are inspected not greater than every six years. Because of their non-hazardous location, Class 4 dams are not inspected regularly, but observed for changes in hazard class periodically. See SAFETY INSPECTIONS AND CONSTRUCTION OBSERVATIONS, page 7 for more information.

The Dam Safety Branch annually identifies specific goals and objectives for the Dam Safety Program. For calendar year 1996, the following goals were adopted. Each of the objectives for the period were either accomplished in whole or in part.

1. **In order to protect the public safety, the Dam Safety Branch shall determine the amount of water which is safe to impound in the several reservoirs in the state.** All of the objectives were accomplished. See page 8 for more details on the number of inspections conducted.

2. **In order to protect the public from the failure of dams, the Dam Safety Branch shall review and recommend approval of plans and specifications for the construction, modification, and repairs of dams, in accordance with the Regulations for Dam Safety and Dam Construction, September 30, 1988.** All of the objectives for this goal were also accomplished, including the Design Review Unit completing the review of plans and specifications within the 180-day limit. See page 6 for more details on the number of plans reviewed and approved.

3. **In order to improve the public safety from the failures of dams, the Dam Safety Branch shall implement the Rules and Regulations for Dam Safety and Dam Construction in a reasonable time.** A long term program for implementing some of the regulations was begun in 1991 in accordance with Goal 3. For example:

A five-year plan was implemented for evaluating the adequacy of existing spillways beginning in 1992. All of the Class 1 dams below 7500 feet have been reviewed. The dams above 7500 feet have been postponed pending completion of an extreme precipitation study. See page 9 for more details. Class 2 dams are being reviewed as the Dam Safety Engineers have time to do them. The dam owners are notified if their spillways are deficient, and are given a reasonable time to upgrade them.

A ten-year program was begun on 1989 to accomplish the internal inspection of outlet works. It is expected that all Class 1 and 2 dams will be inspected by 2000. Each Dam Safety Engineer has developed workplans to accomplish them.

We have made some progress in enforcing owners requirements. These problems are related to owners responsibilities under Rule 15, and Emergency Preparedness Planning under Rule 16. However, due to the emphasis placed on site inspections by the Dam Safety Engineers, and related tasks, and the need to respond to unexpected developments, the enforcement of the owners requirements has been difficult due to shortage of time.

4. **To improve the communications of the Dam Safety Branch, the Principal Engineer of the branch and the Division Engineers shall coordinate their activities closely.** Goal 4 has been fully implemented by scheduling frequent meetings with the Division Engineer offices, an annual meeting in Denver, and developing communications procedures.

5. **In order to improve the functions of the branch, and to meet the public information needs, the Dam Safety Branch shall maintain a data information system.** The maintenance of the DAMS database has been very successful. See page 9 for more information about this and the NATDAM project.

6. **In order to improve the technical proficiency of the branch, the Division of Water Resources shall provide training and professional development of the personnel.** For Goal 6 the Division's Long Range Plan includes objectives for training personnel. In addition, a portion of the Division's training budget is dedicated to paying for training of one Dam Safety Engineer each year. Dam Safety Engineer Sally Lewis attended the ASDSO Dam Safety Conference in Atlanta, GA in September. Administrative leave is also provided for continuing education and participation on task groups and committees.

7. **In order to improve our dam safety program, and to participate in the development of national policies on dam safety, and to take advantage of the continuing education and information available, the State shall be a full voting member of the Association of State Dam Safety Officials (ASDSO).** Under Goal 7, the Principal Engineer of the branch is the designated state representative to ASDSO. He has served on task groups, committees, and the Board of Directors, and is an officer. All of the personnel in the branch have had an opportunity to attend ASDSO conferences and technical seminars over the years. Their Associate Member dues are paid for from operating funds.

Safety of Federal Dams

Safety evaluations are made of U.S. Bureau of Reclamation and U.S. Army Corps of Engineers dams on a cooperative basis with their safety inspections being done in accordance with the "Federal Guidelines for Dam Safety". Arrangements are made with other federal agencies for the safety inspection of their dams by the U.S. Bureau of Reclamation, the Corps of Engineers, their own people, or by consulting engineers. When other than State Engineer's Office personnel conduct the safety inspections, the agency submits the findings/recommendations and follow-up reports to the State Engineer. A Memorandum of Understanding has been executed with the U.S. Bureau of Reclamation relating to dam safety activities in Colorado. It provides for the exchange of safety related information of dams under each agency's jurisdiction. An MOU has also been executed with the U.S. Forest Service, Rocky Mountain Region, to provide coordination of our mutual responsibilities for dam safety.

Tables of Jurisdictional Dams

See pages 13 and 14 for tables showing the distribution of dams by ownership. Table 1 shows the ownership of jurisdictional dams in Colorado by type of owner, and Table 2 shows the distribution of dams in the state by water division and hazard rating.

APPROVAL OF PLANS AND SPECIFICATIONS FOR CONSTRUCTION OF DAMS AND RESERVOIRS

During FY 95-96, the State Engineer's Office received plans for eight new dams and nineteen plans for alteration, modification, repair, or enlargement. Four separate hydrology studies were also submitted for determination of the inflow design flood for spillway design. The estimated cost of construction for the submitted plans was $9,801,381.00. Seventeen thousand six hundred ten dollars ($17,610.00) was collected for the examination and filing of the submitted plans.

Twenty-seven sets of plans and specifications for construction, and three hydrology studies were approved by the State Engineer during FY 95-96. (See Appendix B for lists of dams which were approved.) In order to expedite the approval of repair plans for dams, the Dam Safety Engineers may review them and perform the construction inspections. This enables the owners to repair their dams sooner by shortening the review time.

Upon completion of construction, the owner's engineer submits copies of the "AS-CONSTRUCTED" plans showing any changes made during construction. These plans are reviewed by the engineer who monitored the construction for completeness before being accepted for filing. The superseded plans are disposed of and the "AS-CONSTRUCTED" plans serve as the public record as required by the statutes.

Section 37-87-114.5., C.R.S., (1996 Supp.) exempts certain structures from the State Engineer's approval. They are, structures not designed or operated for the purpose of storing water, mill tailing impoundments permitted under Article 32 or Article 33 of Title 34, C.R.S. (Minerals or Coal Mines), uranium mill tailing and liquid impoundment structures permitted under Article 11 of Title 25, C.R.S., siltation structures permitted under Article 33 of Title 34, C.R.S. (Coal Mines), and structures which only store water below the natural surface of the ground.

In order to prevent administrative problems as a result of the construction of small dams which do not fall under the jurisdiction of the State Engineer's review and approval, Section 37-87-125, C.R.S. (1996 Supp.) requires that a Notice of Intent to Construct a Nonjurisdictional Water Impoundment Structure must be submitted to the State Engineer prior to beginning construction.

SAFETY INSPECTIONS AND CONSTRUCTION OBSERVATIONS

Scope

A safety inspection by the Dam Safety Engineer involves more than a trip to the dam. The site visit is preceded by a review of the file and history of performance, coordination with the owner, Division staff, and other interested parties so they may take part in the inspection. The statute specifies that a safety inspection include the review of previous inspection reports and drawings, site inspection of the dam, spillways, outlet facilities, seepage control and measurement system, and permanent monument or monitoring installations. Construction inspections need to be maintained at a high level. Construction inspections are important because we must assure that the approved plans are being followed and to assure changed conditions during construction don't jeopardize the safety of the design.

The safety inspection must also include an evaluation of the adequacy of the spillway to pass the appropriate sized flood for the dam's size and hazard class, to make an evaluation of the dam's hazard classification and whether it has changed, and to assess the adequacy of the Emergency Preparedness Plan for the dam. The internal inspection of the outlet works and evaluation of instrumentation has also been added to the workload as required by the regulations. The hydrologic evaluation of spillways has been postponed above 7500 foot elevation, pending the completion of a study of extreme precipitation by the State Engineer and the Water Conservation Board.

The findings of the inspection are documented on a report form which rates the conditions observed of the several components of the dam and reservoir. The overall conditions are rated as satisfactory, conditionally satisfactory, or unsatisfactory (unsafe) for full storage, and a recommendation is made for the safe storage level by the Dam Safety Engineer. The report also identifies the several repair and maintenance items which the owner should take care of, and any engineering and monitoring requirements necessary to assure the safety of the dam. A copy of the ENGINEERS INSPECTION REPORT is in Appendix D.

In order to accomplish Goal 1, the Dam Safety Branch makes site inspections of Class 1 (High Hazard) dams annually, Class 2 (Significant Hazard) dams at two-year intervals, and Class 3 (Low Hazard) dams every six years. Since the Lawn Lake dam failure in 1982, emphasis has been placed on more site inspections of dams. This was accomplished by adding personnel in the branch. The increased inspections were beneficial, and served to remedy potential safety problems at several dams, and provided a long term performance record of existing dams. As the workload increased due to the regulations promulgated in 1988, and emergency preparedness became a necessary part of our program, the frequency of inspections needed to be adjusted as shown to allow more time to accomplish the added responsibilities. How the safe storage level of a reservoir is determined is a policy decision which is based upon perceived social values, and application of state-of-the-art principals in dam safety engineering. These should change with time as the need arises and knowledge is gained from participation in the dam safety arena. A valuable resource for this is the Association of State Dam Safety Officials (ASDSO). One of the recommendations made by an ASDSO peer review of our program in 1993 was to employ technician level personnel to assist the engineers with their tasks. ASDSO and other dam safety agencies also recommend that comprehensive reviews of the design of existing dams should be done. This involves comparing the designs to modern dam safety criteria. By

using technicians to do the site inspections, the engineers could begin doing comprehensive reviews of dams.

Procedures have been implemented to begin reporting incidents, and the findings of safety inspections where orders have been issued to make modifications for safety reasons, to the Center for the Performance of Dams at Stanford University, Palo Alto, California. This is a new national program that has been developed by the Association of State Dam Safety Officials and the Federal Emergency Management Agency for accumulating data for the improvement of design and safety evaluations of dams nationwide. Dam incident reports were submitted for 33 dams during the period.

Orders to repair or maintain the dam usually require the reinspection of the dam in order to verify that the work has been done in a workmanlike manner. Re-inspections also occur to assure follow-up of the State Engineer's orders or as requested by the owner. If the safety inspection finds that the overall conditions are unsafe, an order is written by the State Engineer restricting the storage in the reservoir to a safe storage level. If the findings are conditionally satisfactory, full storage is recommended contingent upon appropriate monitoring being provided by the owner. Restriction letters are accompanied by orders to rehabilitate the dam to make it safe for full storage or to breach the dam. In the event the owner fails to comply with an order to make the dam safe, a breach order is issued to remove the hazard created by the dam and reservoir.

Scheduling

The Dam Safety Engineers collectively conduct about 700 to 800 safety inspections each year.. Jurisdictional dams identified for inspection in accordance with the policies of the State Engineer are assigned to the Dam Safety Engineers in each Division. The number of inspections required to be scheduled is related to the number of dams in each division and their hazard class. Included in these numbers has been the annual inspection of all Class 1 dams, one-half of the Class 2 hazard dams, and about one-sixth of the Class 3 hazard dams. Inspection of federal dams are integrated with these schedules. Subsequent follow-up and problem solving results in additional inspections each year.

In order to track potential problems which could develop at Class 3 dams, the Dam Safety Engineers assign dams to be observed to the Division's Water Commissioners, and they file a report. The report is reviewed, and then furnished to the owner for their information, and to implement any recommendations for repair and maintenance. A copy of the WATER COMMISSIONER DAM OBSERVATION REPORT form is in Appendix C.

Number of Inspections

During FY 95-96, a total of 626 safety inspections and 126 construction inspections were conducted for a total of 752. In addition, 149 follow-up inspections were made. The safety inspections included 227 Class 1 hazard dams, 222 Class 2 hazard dams, 173 Class 3 hazard dams, and four inspections of Class 4 dams (includes Federal dams which are inspected at 3 year intervals and which we participated.) For inspections of federally owned dams in which we don't participate, we receive their reports and findings. The objective of inspecting all Class 1 hazard dams on an annual basis, Class 2 on a bi-annual basis, and Class 3 dams on a six-year

basis is an inspection year objective versus a fiscal year objective. This objective was attained for 1995 with the assistance of engineers in some of the Divisions, and is expected to be achieved for 1996.

DAM SAFETY PROJECTS

Extreme Precipitation Study

The State Engineer and the Colorado Water Conservation Board (CWCB) continued the process during the period to study extreme precipitation in the mountainous areas of Colorado. See Proposal for Evaluating Extreme Precipitation for the Mountainous Areas of Colorado in Appendix E. A volunteer committee of meteorologists, hydrologists, engineers, federal and state agencies, and private entities prepared the proposal. The Department of Atmospheric Science, CSU (State Climatologist) was engaged for doing Phase I of the study, which is the collection and verification of data. A workshop was held to provide a forum for professionals in the field to determine which modelling technology should be used during Phase II of the plan. Phase I will be completed by October 31, 1996. It will contain a list of recommended extreme storms that will be used for modelling research, and can be used for site specific analysis of extreme events for project studies.

Emergency Preparedness Plans

Emergency preparedness for incidents at dams that jeopardize the public safety, including the failure of dams, has become an important part of dam safety programs. All the federal dam owning/regulating agencies, and most states require that plans be formulated to detect incidents at dams, give adequate warning, and maintain preparedness, for the eventual failure or misoperation of dams. Colorado has been actively involved in this area since 1981, ultimately requiring that EPPs be prepared for Class I and Class II dams as part of the regulations for dam safety adopted in September 1988. As a result of increased effort, at the end of the period of this report, June 30, 1995, emergency plans have been prepared for all of the Class I dams of record statewide.

The Dam Safety Engineers in the Divisions continue to assist dam owners in the preparation of their EPPs. All Class 2 dam owners have been notified of the requirement to prepare plans for their dams. Approximately 90 percent of the Class 2 dams have plans on file. The others who have not met the deadline, have been notified of the requirement to prepare them. This will be enforced in the following year of inspections.

The Office of Emergency Management is providing training to dam owners on how to exercise their plans. The Dam Safety Branch is participating in the training and providing technical assistance to the OEM. One class has been held in Fort Collins with about 40 dam owners and emergency managers attending. Another class was held in Pueblo with about 12 dam owners and a couple of emergency managers attending. A class is being planned for the West Slope.

Dam Safety Database Management System

The dams database (DAMS) is maintained on a personal computer system (PC) using dBASE IV as the data management program. While the main database is kept on a PC in Denver, the

several dam safety engineers maintain the data for their Divisions on PCs. The main database in Denver is updated from the several Divisions on a periodic basis. The Dam Safety Branch's capability to maintain the database was enhanced by the receipt of computer hardware for the Denver office and the Division offices, from the Association of State Dam Safety Officials (ASDSO), for participation in their National Inventory of Dams Project.

Publications

As a service to dam owners, the Dam Safety Branch makes available, at no charge, a brochure on the construction and operation of dams in Colorado (June, 1994). It contains general information on requirements for approval of plans, water rights, financing, liability, insurance, Emergency Preparedness Plans, statutes, publications, and Division Engineer and Water Court addresses. A "Dam Safety Manual" is also available at a reasonable cost that instructs dam owners on the safety inspection of their dams. Guidelines for preparing EPPs and a Project Review Guide for submitting plans for approval are provided at no cost.

Association of State Dam Safety Officials

All of the engineers in the Dam Safety Branch are members of the Association of State Dam Safety Officials (ASDSO) and actively participate in its programs. Alan Pearson, Principal Engineer of the Dam Safety Branch was re-elected to the Board of Directors, and was elected to the office of President-elect. The purpose of ASDSO is to provide a forum for the exchange of ideas and experiences on dam safety issues, foster interstate cooperation, provide information and assistance to dam safety programs, provide representation of state interests before Congress and Federal agencies for dam safety, and to improve efficiency and effectiveness of state dam safety programs. Alan Pearson also is a member of the Peer Review Committee. The Peer Review Program provides member states with an opportunity to have their dam safety programs reviewed to see if they are accomplishing their objectives, and to receive recommendations for improving their programs. Several of the Dam Safety Engineers have made presentations at ASDSO conferences. James Dubler, a Dam Safety Engineer received training in Emergency Action Plan preparation through ASDSO and the Federal Emergency Management Agency. This will help improve our program on emergency preparedness.

USE OF APPROPRIATED FUNDS

Dam safety personal service expenditures for the FY 95-96 were $920,564.00. Total operating and travel expenditures were approximately $24,000.00. Whenever possible, the members of the Dam Safety Branch are provided training to keep them up to date on current technology and methods being used by professionals in the area of dam safety. Several members of the Branch have attended conferences and meetings of the Association of State Dam Safety Officials, participated in University courses on hydrology, and computer related courses. Funds for these are partially provided from a training fund made up of 2 percent of each Sections/Divisions operating budget, and managed by a training officer and committee. $2,198.00 was expended from this fund for training of personnel in the branch for FY 1995. Training is also paid for with operating funds from the Division Engineer's and the Dam Safety Branch's budgets when available.

RECEIPTS GENERATED FOR COSTS OF FILING PLANS

Fees collected by the State Engineer and deposited in the General Fund for dam safety amounted to $17,610.00 for filing plans and specifications during the period.

ENFORCEMENT ORDERS AND PROCEEDINGS

A complaint was filed by the Attorney General at the request of the State Engineer in Mesa County District Court (Case No. 95CV304) on September 22, 1995 against David Thompson, owner of the G. H. & S. Dam, DAMID 420119, for failing to respond to orders of the State Engineer to repair the dam and restrict storage in the reservoir. These actions were the result of trying to get the owner to fix the dam since 1990. Subsequent to issuing a contempt order, the owner took action to allow the reservoir to be drained in accordance with the restriction order. Repair plans are pending.

LEGISLATION

No legislation affecting dam safety was enacted during the period.

PROGRAM FUNDING NEEDS

One of the alternatives for making the workload more manageable and uniform among the Divisions is to acquire additional FTE, or make use of existing staff to assist in performing certain objectives. We are considering ways to utilize existing technicians to assist the Dam Safety Engineers by performing supporting tasks, which would allow the engineers to concentrate on the high level tasks.

Rapid changes occur in the field of dam safety engineering and related disciplines. New designs for dams (and rehabilitation of dams) are utilizing new materials whose behavior and properties are unknown to the staff. Many conferences are held throughout the country with the objective of sharing knowledge and experience in the field of dam safety. It is still proposed to establish training plans to send our engineers to these training courses to maintain a knowledge of state-of-the-art dam safety. The estimated first year's cost for the program would be about $5,000. The training fund presently provides about $2,000 for training within the branch. This means that we will not be able to provide training to all of our dam safety engineers at one time, but over a period of several years, unless supported by the operating budget.

Another funding area is the acquisition of computer programs, such as DAMBRK, BREACH, STABL, HEC1,and HEC2, that have been developed by companies to make them more "user-friendly," and improve the efficiency of the engineers to apply them to engineering problems. The estimated cost for these programs is about $10,000. Also, replacement computers and printers are needed at an estimated cost of $15,000. We received $5300 from ASDSO this period which was used to upgrade computers in the Divisions.

In order to provide timely communications during incidents at dams, and while at remote locations, and to provide a means for calling for help during emergencies while on the job, radio and/or telephone equipment should be provided for each person in the branch while traveling in the field. Estimated capital costs for cellular telephones is $1200, and annual costs are estimated to be $500.

Photos are an important record of inspections. In order to provide rugged, weather resistant cameras, the type used for snorkeling, etc., is preferred. All of the Dam Safety Engineers, plus the Design Review Unit need cameras or replacement of existing ones that become damaged. Estimated cost for 12 cameras is $3,600.

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TABLE 1

JURISDICTIONAL[1] DAM OWNERSHIP STATUS
IN COLORADO

TYPE OF OWNER

HAZARD RATING	FEDERAL	STATE	OTHER GOVT	PRIVATE	TOTAL
Class 1	51	13	77	145	286
Class 2	14	20	87	200	321[2]
Class 3	60	30	118	813	1021
Class 4	16	1	9	163	189
TOTAL	**141**	**64**	**291**	**1321**	**1817**

Class 1 - Loss of human life is expected in the event of failure of the dam while the reservoir is at the high water line.

Class 2- Significant damage to improved property is expected in the event of failure of the dam while the reservoir is at the high water line, but no loss of life is expected.

Class 3 - Loss of human life is not expected, and damage to improved property is expected to be small in the event of failure of the dam while the reservoir is at the high water line.

Class 4 - Loss of human life is not expected, and damage will occur only to the dam owner's property in the event of failure of the dam while the reservoir is at the high water line.

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[1]Greater than ten feet high to spillway, or twenty acres in surface area at the high water line, or 100 acre-feet in capacity at the high water line.

[2]Includes fourteen Class 2 non-jurisdictional dams.

TABLE 2

DISTRIBUTION OF DAMS BY IRRIGATION DIVISION/CLASS

HAZARD RATING	DIVISION	NONFEDERAL	FEDERAL	TOTAL
Class 1	1	118	14	132
Class 2	1	132	9	141
Class 3	1	417	11	428
Class 4	1	32	9	41
Class 1	2	35	6	41
Class 2	2	50	3	53
Class 3	2	115	12	127
Class 4	2	95	4	99
Class 1	3	9	1	10
Class 2	3	14	0	14
Class 3	3	28	4	32
Class 4	3	15	0	15
Class 1	4	28	10	38
Class 2	4	37	0	37
Class 3	4	145	8	153
Class 4	4	4	3	7
Class 1	5	23	16	39
Class 2	5	41	1	42
Class 3	5	112	15	127
Class 4	5	13	0	13
Class 1	6	12	0	12
Class 2	6	13	0	13
Class 3	6	106	9	115
Class 4	6	9	0	9
Class 1	7	10	4	14
Class 2	7	20	1	21
Class 3	7	38	1	39
Class 4	7	5	0	5
TOTALS		**1676**	**141**	**1817**

Class 1 - Loss of human life is expected in the event of failure of the dam, while the reservoir is at the high water line.

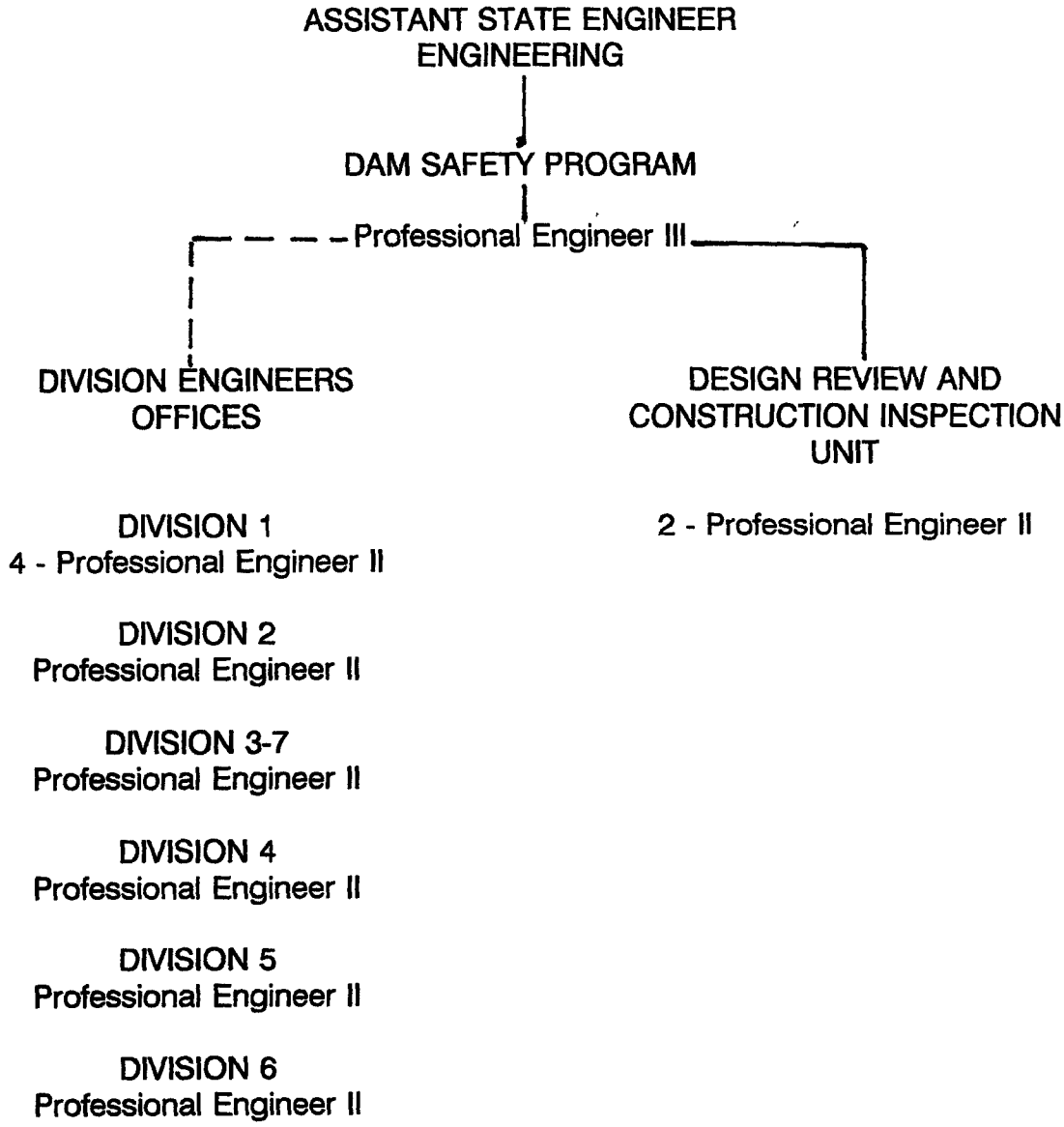
Class 2 - Significant damage to improved property is expected in the event of failure of the dam while the reservoir is at the high water line, but no loss of life is expected.

Class 3 - Loss of human life is not expected, and damage to improved property is expected to be small in the event of failure of the dam while the reservoir is at the high water line.

Class 4 - Loss of human life is not expected, and damage will occur only to the dam owner's property in the event of failure of the dam while the reservoir is at the high water line.

APPENDIX A

DAM SAFETY BRANCH



APPENDIX A

PERSONNEL
DAM SAFETY BRANCH

TITLE	NAME	AREA OF RESPONSIBILITY
	Denver Office	
Professional Engineer III	Alan Pearson	Principal Engineer, Dam Safety Program
Professional Engineer II	Steve Spann	Design Review/Const. Inspection
Professional Engineer II	Mark Haynes	Design Review/Const. Inspection
	Resident, Division Offices	
Professional Engineer II	Dennis Miller	Dam Safety Engineer, Division 1
Professional Engineer II	Michael Cola	Dam Safety Engineer, Division 1
Professional Engineer II	James Dubler	Dam Safety Engineer, Division 1
Professional Engineer II	Gregory Hammer	Dam Safety Engineer, Division 1
Professional Engineer II	Michael Graber	Dam Safety Engineer, Division 2
Professional Engineer II	Frank Kugel	Dam Safety Engineer, Divisions 3&7
Professional Engineer II	James Norfleet	Dam Safety Engineer, Division 4
Professional Engineer II	John Blair	Dam Safety Engineer, Division 5
Professional Engineer II	Sally Lewis	Dam Safety Engineer, Division 6

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APPENDIX B

APPROVED PLANS AND SPECIFICATIONS FOR ALTERATIONS
ENLARGEMENTS, OR REPAIRS OF EXISTING DAMS

NAME	DAMID	C-NO(1)	DATE	USE
CLIMAX MOLY # 4	370103	C-1106B	07/14/95	INDUSTRIAL
KNOX	400330	C-665B	07/14/95	IRRIGATION
HOURGLASS	030209	C-1167B	07/26/95	MUNICIPAL
MILTON LAKE	020304	C-1471C	09/06/95	IRRIGATION
PORTNER (NO. POUDRE #17)	030306	LTR	09/11/95	IRRIGATION
GREAT WESTERN	020212	C-857F	11/20/95	MUNICIPAL
MILTON SEAMAN	030223	C-385C	12/20/95	MUNICIPAL
CLEAR LAKE	070117	C-820B	01/19/96	INDUSTRIAL/HYDRO
BOWLES NO.1	090109	C-1365A	03/04/96	IRRIGATION
D.O.E. ROCKY FLATS A-4	025621	C-1544A	03/06/96	FLOOD CONTROL
WILSON	440212	C-1733A	03/06/96	INDUSTRIAL
OHIO LAKE	020315	LTR	03/06/96	IRRIGATION
BRUSH HOLLOW	120101	C-164A	04/30/96	IRRIGATION
TERRY LAKE	030326	C-1268C	05/09/96	IRRIGATION
BEAVER	400115	C-830B	05/15/96	IRRIGATION
JOE WRIGHT	030402	C-1508A	05/28/96	MUNICIPAL
WADLEY #1	020337	LTR	06/21/96	IRRIGATION
UPPER HIGHLINE	720234	C-1179C	06/24/96	RECREATION
INVERNESS	080334	C-1355A	06/24/96	MUNICIPAL

[1] Filing system for approved plans (C-1106B). Letter at end of number denotes revision/additions to previously approved plans. "LTR" denotes plans and specifications approved by letter in accordance with Rule 6 of the Colorado's "Rules and Regulations for Dam Safety and Dam Construction".

APPROVED PLANS AND SPECIFICATIONS FOR NEW DAMS
OR OLD DAMS NOT PREVIOUSLY APPROVED

NAME	DAMID	C-NO(2)	DATE	USE
ELK WALLOWS	400227	C-1751	07/26/95	IRRIGATION
INTERLOCKEN UPPER	06___	C-1752	08/18/95	RECREATION
EQUALIZER	040231	C-1753	09/06/95	IRRIGATION
LAKE GRANT	590115	C-1754	09/15/95	WATER SUPPLY
VAIL MOUNTAIN SNOW MAKING	37___	C-1755	09/22/95	RECREATION
HANNA RANCH SUPERNATANT	100453	C-1756	10/05/95	MUNICIPAL
REGULATING RESERVOIR	100452	C-1757	12/14/95	MUNICIPAL/HYDRO
FAIRWAY PINES	68___	C-1759	06/24/96	RECREATION

[2] Filing system for approved plans (C-1751). Assigned to plans for new dams and for existing dams that are being altered, enlarged or repaired and were without previously approved plans.

APPENDIX C

WATER COMMISSIONER • DAM OBSERVATION REPORT • OFFICE OF THE STATE ENGINEER

DAM NAME _____ W. DIV. _____ W. DIST. _____ DATE OF INSPECTION ___/___/___

DAM ID _____ FILE NO. C- _____ FOREST I.D. _____ DATE OF LAST INSPECTION ___/___/___

OWNER NAME _____ OWNER PHONE _____

ADDRESS _____ ZIP CODE _____

CONTACT NAME _____ CONTACT PHONE _____

CLASS _____ CAPACITY _____ AF SURFACE AREA _____ AC. HEIGHT _____ FT. CREST LENGTH _____ FT CREST WIDTH _____ FT.

CURRENT RESTRICTION ☐ (NO) ☐ (YES) LEVEL _____ EPP ON FILE ☐ (NO) ☐ (YES) SPWY WIDTH _____ FT. FBD. _____ FT. Z _____

FIELD CONDITIONS OBSERVED

WATER LEVEL: BELOW DAM CREST _____ FT., BELOW SPILLWAY _____ FT., GAGE ROD READING _____

GROUND MOISTURE CONDITION: DRY _____ WET _____ SNOWCOVER _____ OTHER _____

DIRECTIONS: MARK AN X FOR CONDITIONS FOUND AND UNDERLINE WORDS THAT APPLY.

		Conditions Observed			
		GOOD	ACCEPTABLE	POOR	
UPSTREAM SLOPE	**PROBLEMS NOTED:** ☐ (0) NONE ☐ (1) RIPRAP - MISSING, SPARSE, DISPLACED, WEATHERED ☐ (2) WAVE EROSION-WITH SCARPS ☐ (3) CRACKS-WITH DISPLACEMENT ☐ (4) SINKHOLE ☐ (5) APPEARS TOO STEEP ☐ (6) DEPRESSIONS OR BULGES ☐ (7) SLIDES ☐ (8) CONCRETE FACING-HOLES, CRACKS, DISPLACED, UNDERMINED ☐ (9) OTHER _____				UPSTREAM SLOPE
CREST	**PROBLEMS NOTED:** ☐ (10) NONE ☐ (11) RUTS OR PUDDLES ☐ (12) EROSION ☐ (13) CRACKS - WITH DISPLACEMENT ☐ (14) SINKHOLES ☐ (15) NOT WIDE ENOUGH ☐ (16) LOW AREA ☐ (17) MISALIGNMENT ☐ (18) IMPROPER SURFACE DRAINAGE ☐ (19) OTHER _____				CREST
DOWNSTREAM SLOPE	**PROBLEMS NOTED:** ☐ (20) NONE ☐ (21) LIVESTOCK DAMAGE ☐ (22) EROSION OR GULLIES ☐ (23) CRACKS - WITH DISPLACEMENT ☐ (24) SINKHOLE ☐ (25) APPEARS TOO STEEP ☐ (26) DEPRESSION OR BULGES ☐ (27) SLIDE ☐ (28) SOFT AREAS ☐ (29) OTHER _____				DOWNSTREAM SLOPE
SEEPAGE	**PROBLEMS NOTED:** ☐ (30) NONE ☐ (31) SATURATED EMBANKMENT AREA ☐ (32) SEEPAGE EXITS ON EMBANKMENT ☐ (33) SEEPAGE EXITS AT POINT SOURCE ☐ (34) SEEPAGE AREA AT TOE ☐ (35) FLOW ADJACENT TO OUTLET ☐ (36) SEEPAGE INCREASED/MUDDY **DRAIN OUTFALLS SEEN** __No __Yes ☐ (37) FLOW INCREASED/MUDDY ☐ (38) DRAIN DRY/OBSTRUCTED ☐ (39) OTHER _____				SEEPAGE
OUTLET	**PROBLEMS NOTED:** ☐ (40) NONE ☐ (41) NO OUTLET FOUND ☐ (42) POOR OPERATING ACCESS ☐ (43) INOPERABLE ☐ (44) UPSTREAM OR DOWNSTREAM STRUCTURE DETERIORATED ☐ (45) OUTLET NOT OPERATED DURING INSPECTION **INTERIOR INSPECTED** ☐ (120) NO ☐ (121) YES ☐ (46) CONDUIT DETERIORATED OR COLLAPSED ☐ (47) JOINTS DISPLACED ☐ (48) VALVE LEAKAGE ☐ (49) OTHER _____				OUTLET
SPILLWAY	**PROBLEMS NOTED:** ☐ (50) NONE ☐ (51) NO EMERGENCY SPILLWAY FOUND ☐ (52) EROSION-WITH BACKCUTTING ☐ (53) CRACK - WITH DISPLACEMENT ☐ (54) APPEARS TO BE STRUCTURALLY INADEQUATE ☐ (55) APPEARS TOO SMALL ☐ (56) INADEQUATE FREEBOARD ☐ (57) FLOW OBSTRUCTED ☐ (58) CONCRETE DETERIORATED/UNDERMINED ☐ (59) OTHER _____				SPILLWAY
MAINTENANCE	**PROBLEMS NOTED:** ☐ (60) NONE ☐ (61) ACCESS ROAD NEEDS MAINTENANCE ☐ (62) CATTLE DAMAGE ☐ (63) BRUSH ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (64) TREES ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (65) RODENT ACTIVITY ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (66) DETERIORATED CONCRETE-FACING, OUTLET, SPILLWAY ☐ (67) GATE AND OPERATING MECHANISM NEED MAINTENANCE ☐ (68) OTHER _____				MAINTENANCE

See Guidelines on Back of this Sheet

DIRECTIONS: ENTER PROBLEM NUMBER ( ) THEN LOCATION DIMENSIONS, DEGREE, ETC.

LOCATION OF PROBLEMS & COMMENTS: _____

MAINTENANCE – MINOR REPAIR – MONITORING — ACTION REQUIRED OF OWNER TO IMPROVE THE SAFETY OF THE DAM.

- ☐ (80) PROVIDE ADDITIONAL RIPRAP: _____
- ☐ (81) LUBRICATE AND OPERATE OUTLET GATES THROUGH FULL CYCLE _____
- ☐ (82) CLEAR TREES AND/OR BRUSH FROM: _____
- ☐ (83) INITIATE RODENT CONTROL PROGRAM AND PROPERLY BACKFILL EXISTING HOLES _____
- ☐ (84) GRADE CREST TO A UNIFORM ELEVATION WITH DRAINAGE TO THE UPSTREAM SLOPE. _____
- ☐ (85) PROVIDE SURFACE DRAINAGE FOR: _____
- ☐ (86) MONITOR: _____
- ☐ (88) OTHER: _____
- ☐ (89) OTHER: _____

DAM REQUIRES INSPECTION BY A FIELD ENGINEER ☐ ☐ **FIELD DIMENSIONS SHOWN ON BACK**

The State Engineer, by providing this dam safety observation report, does not assume responsibility for any unsafe condition of the subject dam. The sole responsibility for the safety of this dam rests with the reservoir owner or operator, who should take every step necessary to prevent damages caused by leakage or overflow of water from the reservoir or floods resulting from a failure of the dam.

3/86 JTS

OBSERVATION BY WATER COMMISSIONER _____ DATE _____

APPENDIX D

ENGINEERS INSPECTION REPORT

OFFICE OF THE STATE ENGINEER-DIVISION OF WATER RESOURCES - DAM SAFETY BRANCH
1313 Sherman Street, Room 818, Denver, CO 80203, (303) 866-3581

DAM NAME _____ W. DIV. _____ W. DIST. _____ DATE OF INSPECTION ___/___/___

DAM ID _____ FILE NO. C- _____ FOREST I.D. _____ DATE OF LAST INSPECTION ___/___/___

OWNER NAME _____ OWNER PHONE _____

ADDRESS _____ ZIP CODE _____

CONTACT NAME _____ CONTACT PHONE _____

CLASS _____ CAPACITY _____ AF SURFACE AREA _____ AC. HEIGHT _____ FT. CREST LENGTH _____ FT CREST WIDTH _____ FT.

CURRENT RESTRICTION ☐ (NO) ☐ (YES) LEVEL _____ EPP ON FILE ☐ (NO) ☐ (YES) SPWY WIDTH _____ FT. FBD. _____ FT. Z _____

INSPECTION PARTY REPRESENTING _____ _____ _____

DIRECTIONS: MARK AN X FOR CONDITIONS FOUND **AND** UNDERLINE WORDS THAT APPLY. GIVE LOCATION AND EXTENT WITH NUMBER REFERENCE I.E. (25) ALL ALONG SLOPE, OR SHOW IT ON SKETCH.

FIELD CONDITIONS OBSERVED

WATER LEVEL - BELOW DAM CREST _____ FT., BELOW SPILLWAY _____ FT., GAGE ROD _____

GROUND MOISTURE CONDITION: DRY _____ WET _____ SNOWCOVER _____ OTHER _____

Conditions Observed

UPSTREAM SLOPE

PROBLEMS NOTED: ☐ (0) NONE ☐ (1) RIPRAP - MISSING, SPARSE, DISPLACED, WEATHERED ☐ (2) WAVE EROSION-WITH SCARPS
☐ (3) CRACKS-WITH DISPLACEMENT ☐ (4) SINKHOLE ☐ (5) APPEARS TOO STEEP ☐ (6) DEPRESSIONS OR BULGES ☐ (7) SLIDES
☐ (8) CONCRETE FACING-HOLES, CRACKS, DISPLACED, UNDERMINED ☐ (9) OTHER _____
Comments: _____

GOOD | ACCEPTABLE | POOR — UPSTREAM SLOPE

CREST

PROBLEMS NOTED: ☐ (10) NONE ☐ (11) RUTS OR PUDDLES ☐ (12) EROSION ☐ (13) CRACKS - WITH DISPLACEMENT ☐ (14) SINKHOLES
☐ (15) NOT WIDE ENOUGH ☐ (16) LOW AREA ☐ (17) MISALIGNMENT ☐ (18) INADEQUATE SURFACE DRAINAGE
☐ (19) OTHER _____
Comments: _____

GOOD | ACCEPTABLE | POOR — CREST

DOWNSTREAM SLOPE

PROBLEMS NOTED: ☐ (20) NONE ☐ (21) LIVESTOCK DAMAGE ☐ (22) EROSION OR GULLIES ☐ (23) CRACKS - WITH DISPLACEMENT ☐ (24) SINKHOLE
☐ (25) APPEARS TOO STEEP ☐ (26) DEPRESSION OR BULGES ☐ (27) SLIDE ☐ (28) SOFT AREAS ☐ (29) OTHER _____
Comments: _____

GOOD | ACCEPTABLE | POOR — DOWNSTREAM SLOPE

SEEPAGE

PROBLEMS NOTED: ☐ (30) NONE ☐ (31) SATURATED EMBANKMENT AREA ☐ (32) SEEPAGE EXITS ON EMBANKMENT
☐ (33) SEEPAGE EXITS AT POINT SOURCE ☐ (34) SEEPAGE AREA AT TOE ☐ (35) FLOW ADJACENT TO OUTLET ☐ (36) SEEPAGE INCREASED/MUDDY
DRAIN OUTFALLS SEEN ___No ___Yes ☐ (37) FLOW INCREASED/MUDDY ☐ (38) DRAIN DRY/OBSTRUCTED
☐ (39) OTHER _____ Show location of drains on sketch and indicate amount and quality of discharge.
Comments: _____

GOOD | ACCEPTABLE | POOR — SEEPAGE

OUTLET

PROBLEMS NOTED: ☐ (40) NONE ☐ (41) NO OUTLET FOUND ☐ (42) POOR OPERATING ACCESS ☐ (43) INOPERABLE
☐ (44) UPSTREAM OR DOWNSTREAM STRUCTURE DETERIORATED ☐ (45) OUTLET NOT OPERATED DURING INSPECTION
INTERIOR INSPECTED ☐ (120) NO ☐ (121) YES ☐ (46) CONDUIT DETERIORATED OR COLLAPSED ☐ (47) JOINTS DISPLACED ☐ (48) VALVE LEAKAGE
☐ (49) OTHER _____
Comments: _____

GOOD | ACCEPTABLE | POOR — OUTLET

SPILLWAY

PROBLEMS NOTED: ☐ (50) NONE ☐ (51) NO EMERGENCY SPILLWAY FOUND ☐ (52) EROSION-WITH BACKCUTTING ☐ (53) CRACK - WITH DISPLACEMENT
☐ (54) APPEARS TO BE STRUCTURALLY INADEQUATE ☐ (55) APPEARS TOO SMALL ☐ (56) INADEQUATE FREEBOARD ☐ (57) FLOW OBSTRUCTED
☐ (58) CONCRETE DETERIORATED/UNDERMINED ☐ (59) OTHER _____
Comments: _____

GOOD | ACCEPTABLE | POOR — SPILLWAY

See Guidelines on Back of this Sheet

DC185a-85

GUIDELINES FOR DETERMINING CONDITIONS

CONDITIONS OBSERVED - APPLIES TO UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, OUTLET, SPILLWAY

GOOD	ACCEPTABLE	POOR
In general, this part of the structure has a near new appearance, and conditions observed in this area do not appear to threaten the safety of the dam.	Although general cross-section is maintained, surfaces may be irregular, eroded, rutted, spalled; or otherwise not in new condition. Conditions in this area do not currently appear to threaten the safety of the dam.	Conditions observed in this area appear to threaten the safety of the dam.

CONDITIONS OBSERVED - APPLIES TO SEEPAGE

GOOD	ACCEPTABLE	POOR
No evidence of uncontrolled seepage. No unexplained increase in flows from designed drains. All seepage is clear. Seepage conditions do not appear to threaten the safety of the dam.	Some seepage exists at areas other than the drain outfalls, or other designed drains. No unexplained increase in seepage. All seepage is clear. Seepage conditions observed do not currently appear to threaten the safety of the dam.	Seepage conditions observed appear to threaten the safety of the dam. Examples: 1) Designed drain or seepage flows have increased without increase in reservoir level. 2) Drain or seepage flows contain sediment, i.e., muddy water or particles in jar samples. 3) Widespread seepage, concentrated seepage or ponding appears to threaten the safety of the dam.

CONDITIONS OBSERVED - APPLIES TO MONITORING

GOOD	ACCEPTABLE	POOR
Monitoring includes movement surveys and leakage measurements for all dams, and piezometer readings for Class I dams. Instrumentation is in reliable, working condition. A plan for monitoring the instrumentation and analyzing results by the owner's engineer is in effect. Periodic inspections by owner's engineer.	Monitoring includes movement surveys and leakage measurements for Class I & II dams; leakage measurements for Class III dams. Instrumentation is in serviceable condition. A plan for monitoring instrumentation is in effect by owner. Periodic inspections by owner or representative. OR, NO MONITORING REQUIRED.	All instrumentation and monitoring described under "ACCEPTABLE" here for each class of dam, are not provided, or required periodic readings are not being made, or unexplained changes in readings are not reacted to by the owner.

CONDITIONS OBSERVED - APPLIES TO MAINTENANCE AND REPAIR

GOOD	ACCEPTABLE	POOR
Dam appears to receive effective on-going maintenance and repair, and only a few minor items may need to be addressed.	Dam appears to receive maintenance, but some maintenance items need to be addressed. No major repairs are required.	Dam does not appear to receive adequate maintenance. One or more items needing maintenance or repair has begun to threaten the safety of the dam.

OVERALL CONDITIONS

SATISFACTORY	CONDITIONALLY SATISFACTORY	UNSATISFACTORY
The safety inspection indicates no conditions that appear to threaten the safety of the dam, and the dam is expected to perform satisfactorily under all design loading conditions. Most of the required monitoring is being performed.	The safety inspection indicates symptoms of *possible* structural distress (seepage, evidence of minor displacements, etc.), which, if conditions worsen, *could* lead to the failure of the dam. Essential monitoring, inspection, and maintenance must be performed as a requirement for continued full or reduced storage in the reservoir.	The safety inspection indicates *definite* signs of structural distress (excessive seepage, cracks, slides, sinkholes, severe deterioration, etc.), which *could* lead to the failure of the dam if the reservoir is used to full capacity. The dam is judged unsafe for full storage of water.

SAFE STORAGE LEVEL

FULL STORAGE	CONDITIONAL FULL STORAGE	RESTRICTION
Dam may be used to full capacity with no conditions attached.	Dam may be used to full storage if certain monitoring, maintenance, or operational conditions are met.	Dam may not be used to full capacity, but must be operated at some reduced level in the interest of public safety.

CLASSIFICATION OF DAMS

CLASS I	CLASS II	CLASS III
Class I - Loss of human life is expected in the event of failure of the dam, while the reservoir is at the high water line.	Class II - Significant damage to improved property is expected in the event of failure of the dam while the reservoir is at the high water line, but no loss of human life is expected.	Class III - Loss of human life is not expected, and damage to improved property is expected to be small, in the event of failure of the dam while the reservoir is at high water line.

DAM NAME: _____ DAM I.D.: _____ DATE ___/___/___

MONITORING

EXISTING INSTRUMENTATION FOUND ☐ (110) NONE ☐ (111) GAGE ROD ☐ (112) PIEZOMETERS ☐ (113) SEEPAGE WEIRS/FLUMES
☐ (114) SURVEY MONUMENTS ☐ (115) OTHER _____
MONITORING OF INSTRUMENTATION: ☐ (116) NO ☐ (117) YES PERIODIC INSPECTIONS BY: ☐ (118) OWNER ☐ (119) ENGINEER
Comments: _____

GOOD | ACCEPTABLE | POOR — MONITORING

MAINTENANCE AND REPAIR

PROBLEMS NOTED: ☐ (60) NONE ☐ (61) ACCESS ROAD NEEDS MAINTENANCE ☐ (62) CATTLE DAMAGE
☐ (63) BRUSH ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (64) TREES ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE
☐ (65) RODENT ACTIVITY ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (66) DETERIORATED CONCRETE-FACING, OUTLET, SPILLWAY
☐ (67) GATE AND OPERATING MECHANISM NEED MAINTENANCE ☐ (68) OTHER _____
Comments: _____

GOOD | ACCEPTABLE | POOR — MAINTENANCE AND REPAIRS

OVERALL CONDITIONS

REMARKS: _____

Based on this Safety Inspection and recent file review, the overall condition is determined to be:

☐ 71 SATISFACTORY ☐ 72 CONDITIONALLY SATISFACTORY ☐ 73 UNSATISFACTORY

OVERALL CONDITIONS

The State Engineer, by providing this dam safety inspection report, does not assume responsibility for any unsafe condition of the subject dam. The sole responsibility for the safety of this dam rests with the reservoir owner or operator, who should take every step necessary to prevent damages caused by leakage or overflow of waters from the reservoir or floods resulting from a failure of the dam.

ITEMS REQUIRING ACTION BY OWNER TO IMPROVE THE SAFETY OF THE DAM

MAINTENANCE - MINOR REPAIR - MONITORING

☐ (80) PROVIDE ADDITIONAL RIPRAP: _____
☐ (81) LUBRICATE AND OPERATE OUTLET GATES THROUGH FULL CYCLE: _____
☐ (82) CLEAR TREES AND/OR BRUSH FROM: _____
☐ (83) INITIATE RODENT CONTROL PROGRAM AND PROPERLY BACKFILL EXISTING HOLES: _____
☐ (84) GRADE CREST TO A UNIFORM ELEVATION WITH DRAINAGE TO THE UPSTREAM SLOPE: _____
☐ (85) PROVIDE SURFACE DRAINAGE FOR: _____
☐ (86) MONITOR: _____
☐ (87) DEVELOP AND SUBMIT AN EMERGENCY PREPAREDNESS PLAN. _____
☐ (88) OTHER: _____
☐ (89) OTHER: _____

ENGINEERING - EMPLOY AN ENGINEER EXPERIENCED IN DESIGN AND CONSTRUCTION OF DAMS TO: (Plans & Specification must be approved by State Engineer prior to construction.)

☐ (90) PREPARE PLANS AND SPECIFICATIONS FOR THE REHABILITATION OF THE DAM: _____
☐ (91) PREPARE AS-BUILT DRAWINGS OF: _____
☐ (92) PERFORM A GEOTECHNICAL INVESTIGATION TO EVALUATE THE STABILITY OF THE DAM: _____
☐ (93) PERFORM A HYDROLOGIC STUDY TO DETERMINE REQUIRED SPILLWAY SIZE: _____
☐ (94) PREPARE PLANS AND SPECIFICATIONS FOR AN ADEQUATE SPILLWAY: _____
☐ (95) SET UP A MONITORING SYSTEM INCLUDING WORK SHEETS, REDUCED DATA AND GRAPHED RESULTS: _____
☐ (96) PERFORM AN INTERNAL INSPECTION OF THE OUTLET: _____
☐ (97) OTHER: _____
☐ (98) OTHER: _____
☐ (99) OTHER: _____

SAFE STORAGE LEVEL RECOMMENDED AS A RESULT OF THIS INSPECTION

☐ (101) FULL STORAGE
☐ (102) CONDITIONAL FULL STORAGE
☐ (103) RECOMMENDED RESTRICTION → RESTRICTED LEVEL OFFICIAL ORDER TO FOLLOW

- _____ FT. BELOW DAMS CREST
- _____ FT. BELOW SPILLWAY CREST
- _____ FT. GAGE HEIGHT
- _____ NO STORAGE-MAINTAIN OUTLET FULLY OPEN
- _____ _____

REASON FOR RESTRICTION: _____

ACTIONS REQUIRED FOR CONDITIONAL FULL STORAGE OR CONTINUED STORAGE AT THE RESTRICTED LEVEL: _____

Engineer's Signature _____ INSPECTED BY

Owner's Signature _____ OWNER/OWNER'S REPRESENTATIVE DATE ___/___/___

APPENDIX E

PROPOSAL FOR EVALUATING EXTREME PRECIPITATION FOR THE MOUNTAINOUS AREAS OF COLORADO

INTRODUCTION

The state engineer's Regulations for Dam Safety and Dam Construction require that spillways for dams be adequate to handle floods based upon Probable Maximum Precipitation (PMP). PMP is the theoretically greatest depth of precipitation for a given duration, that is physically possible over a drainage basin at any specific time of year. This is essentially a no risk standard that is in accord with the national standards for dam safety, and Colorado case law, where failure of a dam could be catastrophic to the public health and welfare.

PROBLEM

The sources of extreme rainfall (PMP)[1] data for the mountainous areas of Colorado are presently the National Weather Service.[2] Recent studies by the US Geological Survey (Jarrett-Costa), reveal a difference in quantity between the level of flooding predicted by the weather service publications, and runoff observations for areas above 7500 feet in Colorado. Also, studies presently being done (December 1993) by the Denver Water Board for their Williams Fork Dam appear to support that the extreme rainfall for this basin is significantly less than predicted by the weather service. Another study, of the Grizzly Creek watershed near Aspen (1992), provided a conservative reduction of about 20 % in the PMP in relation to the weather service.

PROPOSAL

Because of these apparent differences, and the significant cost associated with designing/constructing spillways to handle floods caused by extreme precipitation (EP), the state engineer is proposing that the Colorado Water Conservation Board fund a study of the extreme precipitation problem in the mountainous areas of Colorado.

# of dams affected.	**81 Class I, 69 Class II**	**Total = 150**
# of owners affected.	**81**	
Volume of storage affected.	**3,379,000 Acre Feet**	

According to a thesis by David Chagnon, Colorado State University, Department of Atmospheric Science (1986), the total economic effect of estimating EP magnitude ranges from $10 -$16 Million per inch of change in rainfall, for about 150 dams in the area affected by HMR 55A. (1996 costs at 3% inflation for 10 years are $13.5 - $22 Million per inch of change in rainfall.) A 20% reduction in estimates of about 3 inches (conservative analysis) could result in a total savings of $40 - $60 million dollars (1996 dollars).

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[1]Hydrometeorological Reports No. 55A (June 1988) for areas east of the continental divide; and No. 49 (1984) for areas west of the divide.

[2]US Department of Commerce, National Oceanic and Atmosphere Administration (NOAA)

PLAN

This proposal was developed by a volunteer committee of meteorologists, hydrologists, and engineers from universities, consulting firms, dam owners, and state and federal agencies. The proposal contains the following components, which will be executed in three phases:

Phase I	1.	Data collection (Extreme precipitation data/studies).
	2.	Development of EP Database (Verification)
	3.	Modeling Workshops (Forum for professionals in field to reach consensus on which technology would be applicable for predicting an EP atmosphere in the mountains of Colorado.)
Phase II	4.	Research/Development of "Model/s" for use.
Phase III	5.	Creation of data for isohyetal maps and depth-duration data of EP. Correlation of data with hydrologic records (including paleo-hydrologic.).
	6.	Peer review and endorsement by other agencies.
	7.	Documentation, development of the procedures for use by practitioners.

Phase I is expected to be accomplished in about one-years time. The State Climatologist's Office (SCO) will do the inventory, and develop the EP database. The SCO will also organize and conduct a workshop on modeling of EP at Colorado State University. Additional workshops may be organized for other components. The estimated cost of these Phase I components are $50,000 - $75,000 for the inventory, and $20,000 - $25,000 for the workshops (primarily for reimbursement of travel expenses of participants). Total cost estimate is $70,000 - $100,000.

The research/development component of Phase II is necessary to understand the physical mechanisms of extreme precipitation with elevation, and to develop a modeling program for analyzing/defining extreme precipitation. (The scope of this component is expected to be defined by the workshops.) The time period could be from 3 to 5 years as presently estimated. The cost shall also be defined by the workshops. After the EP analyses and modeling program are developed, the EP data will be produced and correlated with historic records for verification during Phase III. The generated EP data can then be used to develop (after peer review) procedures for use by practitioners. Geographical Information Systems (GIS) technology is available to do this. The time period for this is estimated to be 1 - 2 years. The cost will be defined by the scope of the project and requests for proposals from the industry.

Total estimated time for completion of all phases is 5 to 8 years. The benefits expected from this proposal are:

Significant reduced costs for the design of new dams, and for upgrading spillways at existing dams, to the standards contained in the regulations.

Increased conservation pools in reservoirs.

Increased head available for power generation.