STATE ENGINEER'S ELEVENTH ANNUAL REPORT TO THE COLORADO GENERAL ASSEMBLY ON DAM SAFETY FOR F.Y. 94-95

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COLORADO DIVISION OF WATER RESOURCES OFFICE OF THE STATE ENGINEER

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1994-1995

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INTRODUCTION

Statutory Provisions

Colorado's Dam Safety Program is implemented and managed by the State Engineer in accordance with Title 37, Article 87, of C.R.S. (1995 Supp.), and the Livestock Water Tank Act, Title 35, Article 49, of C.R.S. (1995 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. (1995 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. (1995 Supp.)

Organization

Implementation of the Dam Safety Program is achieved by the State Engineer through the Dam Safety Branch. The branch is partially decentralized, with the Dam Safety Engineers working out of the Division Engineer's offices, under their supervision. The Principal Engineer of the Branch, who is located in Denver, has program wide responsibilities, and also supervises the Design Review and Construction Inspection Unit. (See Appendix A for tables and charts of the personnel and organization of the Branch.)

The Dam Safety Engineer's 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, 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. (1995 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 and Construction Inspection Unit's 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. (1995 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. (1995 Supp.), which are greater than ten feet high at the spillway, or twenty acres in surface area at the high water line, or 100 acre-feet in capacity at the high water line. Because of their non-hazardous location, Class 4 dams are not inspected regularly, but observed for changes in hazard class periodically. Particular focus is placed on inspecting Class 1 dams annually, Class 2 dams bi-annually, and Class 3 dams are inspected not greater than every six years. The frequency of inspections of Class 2 and 3 dams had been reduced in order to provide more time to implement the requirements of our regulations. See SAFETY INSPECTIONS AND CONSTRUCTION OBSERVATIONS, page 8, for more information.

Safety inspections 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, consulting engineers, or by the State Engineer. When other than State Engineer Office personnel conduct the safety inspections, the agency submits the findings/recommendations and follow-up reports to the State Engineer in order to assure the safety of these dams. 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.

Another objective is the inspection of dams during construction for compliance with approved plans, and to assure that the plans are adequate for the site conditions. Inspections are made of the foundation, outlet works, spillways, and final construction as a minimum. Additional interim inspections are made as necessary. An essential task related to the safety of the public is the goal to have each owner of Class 1 and Class 2 hazard dams prepare an Emergency Preparedness Plan (EPP) to handle any incident which jeopardizes the safety of the dams, and to give warning to appropriate emergency preparedness agencies/officials so they may mobilize their plans for mitigating the consequences of dam-break flooding. An inundation map is required for Class I dams. See EMERGENCY PREPAREDNESS PLANS on page 11 for more discussion.

The Dam Safety Branch annually identifies specific goals and objectives for the Dam Safety Program. For calendar year 1995, the following objectives were adopted:

1. To make annual safety inspections of Class 1 dams, bi-annual inspections of Class 2 dams, and to inspect Class 3 dams not greater than every six years.

2. To make quality reviews of the plans and specifications for the construction of dams within the statutory 180-day limit.

3. To inspect the construction of a dam as often as necessary to assure that the work is being performed in accordance with the approved plans and specifications, and to assure that changed conditions will not jeopardize the approved design.

4. To require that owners of Class 1 and 2 dams prepare, implement, and exercise EPPs in accordance with our regulations.

5. To develop strategies for implementation of the regulations in a reasonable time.

6. To maintain a database of the dam safety program (DAMS), including the update of the National Inventory of Dams (NATDAM).

7. To develop state-of-the-art computer capabilities for engineering analysis of dams, and the Dam Safety Program.

8. To improve the communications of the Dam Safety Branch.

In order to achieve the objectives, the Division Engineer offices prepare workplans (tactics) which are reviewed by the staff before adoption, and used for monitoring progress of the program.

Each of the goals for the period were either accomplished in whole or in part. **Goal 1** to make safety inspections of all classes in accordance with the schedules was accomplished. See page 10 for more details on the number of inspections conducted.

Goal 2 was also accomplished with the Design Review Unit completing the review of plans and specifications within the 180-day limit. See page 7 for more details on the number of plans reviewed and approved.

The construction inspection of dams was accomplished under **Goal 3**, with critical inspections being made in a timely manner on all projects because of the high priority assigned to this important task.

Goal 4 was accomplished with the owners of all Class 1 dams preparing EPPs, and Class 2 dam owners were notified to complete their plans by April 1995. Those owners who have not completed plans will be requested to complete them in a timely manner.

A long term program for implementing some of the regulations was begun in 1991 in accordance with **Goal 5.** For example:

- A five-year plan was implemented for evaluating the adequacy of existing spillways beginning in 1992. This plan was postponed one year however, to prepare an updated hydrologic procedure. Dr. George Sabol, Consulting Hydrologist, was engaged to conduct a peer review of our hydrologic procedures for evaluating the adequacy of spillways. He found them adequate. Reviews began again in August 1992, but the review of spillways above 7500 feet were postponed again, pending the completion of a study of extreme precipitation being conducted by the State Engineer and the Colorado Water Conservation Board. See page 10 for more discussion.

- A ten-year program was begun on 1989 to accomplish the internal inspection of outlet works. In order to economically evaluate the condition of outlet works too small to enter, Mr. James Norfleet, Resident Dam Safety Engineer for Division 4, designed and built a prototype sled and 35mm camera system for photographing the interiors of small outlet pipes. Four working models of the sled have been manufactured, and are being used to inspect outlets. Another one will be obtained when funding is available.

- A strategy meeting between the Dam Safety Branch and the Division Engineers was held in December 1994. A plan was developed encompassing the several divisions identifying the completion dates for the goals and objectives. These will be used to monitor the progress.

Per **Goal 6,** the maintenance of the DAMS database has been very successful. See page 12 for more information about this and the NATDAM project.

Goal 7 was partially successful, primarily due to the acquisition of computers using funds donated to the branch by the Association of State Dam Safety Officials, for participation in the National Inventory of Dams (NATDAM). Each Division office, and the Denver office, have been provided the BOSS DAMBRK program for doing hydrology and hazard classification studies. The Division of Water Resources has made providing software and computers for support of the staff, one of its Long Range Plan goals.

Goal 8 has been fully implemented by scheduling frequent meetings with the Division Engineer offices, an annual meeting in Denver, and developing communications procedures.

Tables of Jurisdictional Dams

The following 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.

TABLE 1

JURISDICTIONAL[1] DAM OWNERSHIP STATUS
IN COLORADO

TYPE OF OWNER

HAZARD RATING	FEDERAL	STATE	OTHER GOVT	PRIVATE	TOTAL
Class 1	50	13	72	140	275
Class 2	14	20	84	206	324[2]
Class 3	61	29	118	816	1025
Class 4	16	1	8	160	185
TOTAL	**141**	**63**	**282**	**1322**	**1809**

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 ten Class 2 non-jurisdictional dams.

TABLE 2

DISTRIBUTION OF DAMS BY IRRIGATION DIVISION/CLASS

HAZARD RATING	DIVISION	NONFEDERAL	FEDERAL	TOTAL
Class 1	1	113	14	127
Class 2	1	134	9	143
Class 3	1	416	11	427
Class 4	1	32	9	41
Class 1	2	34	6	40
Class 2	2	52	3	54
Class 3	2	118	12	130
Class 4	2	93	4	97
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	25	10	35
Class 2	4	38	0	38
Class 3	4	147	8	155
Class 4	4	3	3	6
Class 1	5	22	15	37
Class 2	5	41	1	42
Class 3	5	111	16	127
Class 4	5	12	0	12
Class 1	6	12	0	12
Class 2	6	12	0	12
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		**1668**	**141**	**1809**

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.

APPROVAL OF PLANS AND SPECIFICATIONS FOR CONSTRUCTION OF DAMS AND RESERVOIRS

During FY 94-95, the State Engineer's Office received plans for five new dams and twenty- seven plans for alteration, modification, repair, or enlargement. Six 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 $28,956,862.00. Seventeen thousand three hundred sixty dollars ($17,360.00) was collected for the examination and filing of the submitted plans.

Twenty-four sets of plans and specifications for construction, and nine hydrology studies were approved by the State Engineer during FY 94-95. (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., (1995 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. (1995 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

Scheduling/Workload

Jurisdictional dams identified for inspection in accordance with the policies of the State Engineer are assigned to the Dam Safety Engineers in each Division. Due to the uneven distribution of dams throughout the state, and the differences in travel times to make inspections, the engineers are presently required to each schedule from 75 to 120 dams each "inspection season", which begins around April 1st and ends about November 1st, depending on the weather. Included in these numbers has been the inclusion of all Class 1 and 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. The Dam Safety Engineers collectively conduct about 700 to 800 safety inspections each year.

In order to track potential problems which could develop at Class 3 dams, the Division's Water Commissioners have been assigned these dams to be observed by the Dam Safety Engineers, and they file a report. The report is reviewed and 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.

As indicated in the goals and objectives, the frequency of safety inspections of Class 2 dams was temporarily changed to every two years. This was done to try and provide more time for the engineers to work on implementing the regulations and related tasks required for dam safety. However, it was decided to have the Class 2 dams observed during the interim year by engineer personnel in the Divisions.

Based upon past experience, a 75 (plus or minus) workload appears to be reasonable in order to accomplish the several tasks related to safety inspections and implementing the regulations. Ways to achieve this workload can be realized by 1) reallocating personnel; 2) reducing frequency of safety inspections; 3) allowing use of non-professional staff to make interim observations of Class 2 dams; and 4) additional FTE for the program. One or more of these would be necessary to solve the workload problems. Divisions 2, 4, and 5 presently have workloads exceeding this size. As a result, they are not able to accomplish the objectives of the program. All of the Divisions appear to need additional assistance with their work in order to provide more time for the engineers to concentrate on professional level tasks. A peer review of the program in 1993 recommended that technician level personnel be added to the program for this purpse. Also, the increasing workload of the Water Commissioners is pre-empting their activities in the observation of dams, and their time is limited under the Fair Labor and Standards Act, without paying overtime. See PROGRAM FUNDING for recommendations for additional personnel, and EFFECTIVENESS OF PROGRAM for discussion of strategies for dealing with the workload.

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.

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. See page 10 for more discussion. New procedures have been developed in accordance with the Third Edition, Design of Small Dams, USBR, and the HEC1 program for calculating flood hydrographs, and evaluations have been on-going since August 31, 1992 in the remainder of the state.

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.

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.

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.

The supervision of the Resident Dam Safety Engineers are the responsibility of the Division Engineers in their respective Divisions. The Division Engineers are responsible for

implementation of the Dam Safety Program, exclusive of design review, including enforcement of reservoir level restrictions and performance evaluation of the engineers. The Principal Engineer of the Dam Safety Branch is responsible for development of a comprehensive statewide Dam Safety Program to include planning for training of dam safety personnel, monitoring of the program in the field, and reporting to the State Engineer on the progress and problems related to the program.

Number of Inspections

During FY 94-95, a total of 489 safety inspections and 111 construction inspections were conducted for a total of 600. In addition, 162 follow-up inspections were made. The safety inspections included 197 Class 1 hazard dams, 148 Class 2 hazard dams, 135 Class 3 hazard dams, and nine 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.). Construction inspections were continued at a high level, due to the reorganization of the branch and more emphasis placed on these inspections. 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 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 1994 with the assistance of engineers in some of the Divisions, and is expected to be achieved for 1995.

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 will also be hosted by them to provide a forum for professionals in the field to determine which modelling technology should be used during Phase II of the plan. The CWCB recommended funding of $100,000 for Phase I, and received authorization for this amount for Fiscal Year 1995.

USE OF APPROPRIATED FUNDS

Dam safety personal service expenditures for the FY 94-95 were $922,386.00. Total operating and travel expenditures were approximately $24,245.00. 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% of each Sections/Divisions operating budget, and managed by a training officer and committee. $870.00 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 $17,360.00 for filing plans and specifications during the period.

PROGRAM FUNDING

One of the alternatives for making the workload more manageable and uniform among the Divisions is to acquire additional FTE. It is recommended that three (3) technician level personnel be added to the Dam Safety Program. These personnel would assist the engineers in the conduct of the safety inspection program by performing supporting tasks, which would allow the engineers to concentrate on the high level tasks. The estimated first year cost is $120,000.

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 $3,000 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 $5000 from ASDSO this period which was used to upgrade computers in the Divisions. See Database Management Systems on Page 12 for more information.

The SLED and 35mm camera have been useful for evaluating the condition of small outlets. Presently four SLEDS have been developed for use in Divisions 1 (4 engineers) Division 2, Division 4, and Division 5. Additional push-pipe and carrying cases are needed for Divisions 2 and 5. Due to access problems and opportunity for use, another SLED is needed for Division 3/7. The estimated cost is $1,000.

In order to provide for the safety of personnel during internal inspections of outlets (enclosed spaces), air-testing equipment and emergency oxygen must be provided. We have acquired one set of these in the past, but another set is needed in order for them to be available at reasonable times, and more convenient for the Dam Safety Engineers to share them. The estimated cost for another set plus replacement oxygen sensors is $2,500.

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.

ENFORCEMENT ORDERS AND PROCEEDINGS

There were no enforcement proceedings under Section 37-87-114, C.R.S. (1995 Supp.) during the fiscal year.

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 by April 1995. Approximately 85 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. Other classes will be offered around the state.

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.

In accordance with a Memorandum of Agreement with the Association, the State Engineer participated in the update of the National Inventory of Dams project during the period. The inventory (NATDAM) is produced from the Branch's DAMS database, which also serves the information management needs of the division and provides data and reports for the public. ASDSO will donate $5300 to the branch for its participation, which will be used to upgrade the computers in the branch and purchase of capital equipment.

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.

As noted in the previous discussion on workload, we have some problems which are interfering with our ability to do the job more effectively. Implementation of some of the regulations is not being accomplished in a timely manner. These problems are being addressed by discussions with the Division Engineers, and strategy sessions scheduled to identify appropriate ways and means for solving them, including waiving or delaying the regulations if deemed appropriate, and if public safety will not be unreasonably impaired. We hope to be able to report next time on some progress in dealing with these problems.

At the end of the reporting period, there were 185 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 five incidents at dams during the period is also indicative of the effectiveness of the program. One of these was Lake Henry dam near Ordway which experienced increased leakage again. Another involved the Vincent No. 1 and No. 2 dams owned by the Town of Palisade on the west slope. They were overtopped by snowmelt runoff due to the spillways being plugged with snow. No. 2 washed out. Other incidents were cracking of the embankment at Mesa Park dam in Boulder; natural gas, which had accumulated under the ice at Clinton Gulch dam near Copper Mountain, was accidently ignited by investigators of the odor; and a snow avalanche destroyed the outlet building and damaged controls at Homestake dam near Minturn. The Emergency Preparedness Plans were implemented for each of the incidents. No significant damage occurred to properties downstream.

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.

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-appointed to the Board of Directors, and was elected to the office of Vice President. 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 is also chairing an ASDSO workgroup for developing a guide on environmental and historical preservation regulations that affect dam repairs and construction, and is a member of the Peer Review Committee. Mr. Gregory Hammer, a Dam Safety Engineer, serves on the Subcommittee for Geosynthetics. Several of the Dam Safety Engineers have made presentations at ASDSO conferences.

LEGISLATION

No legislation affecting dam safety was enacted during the period.

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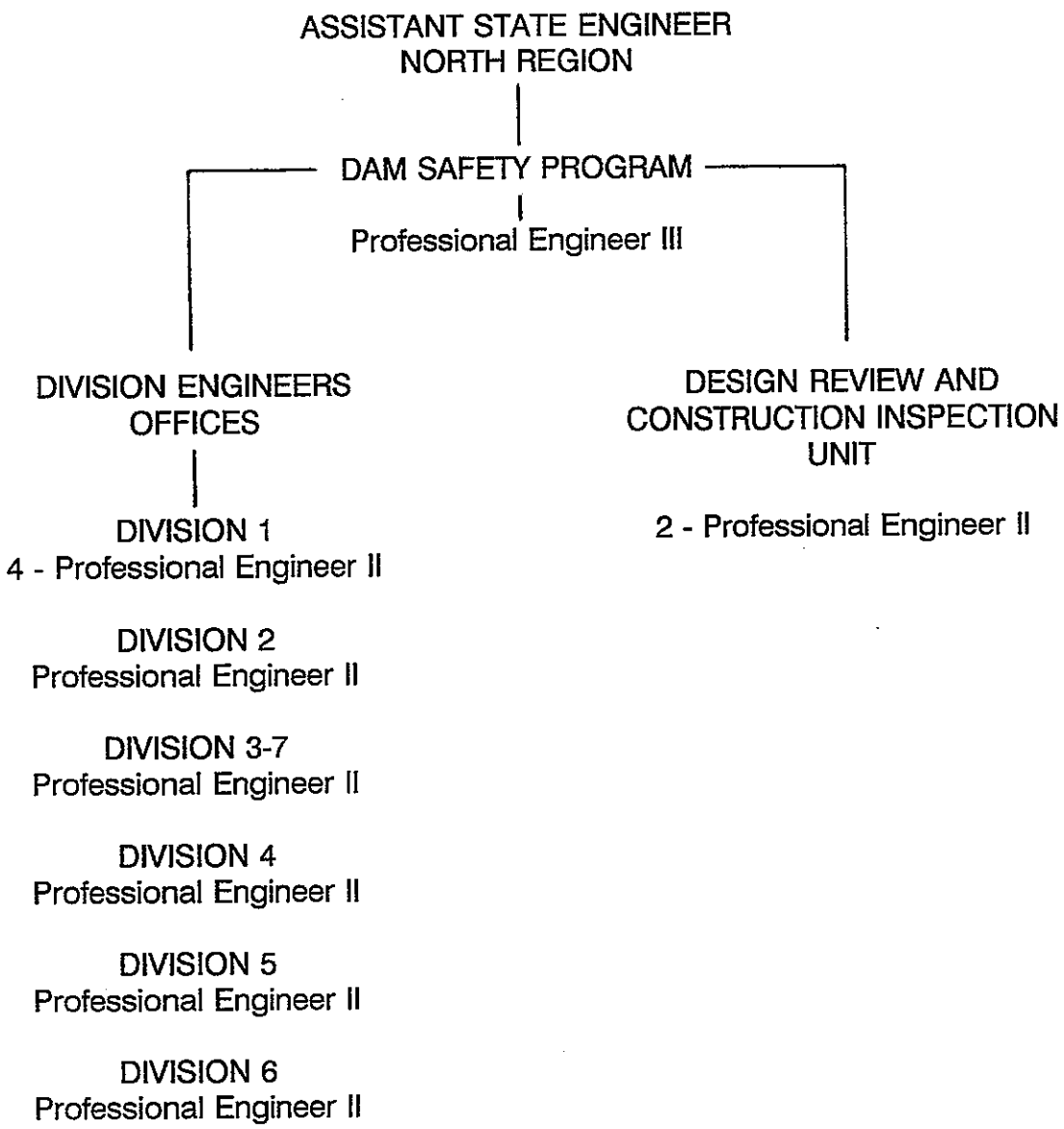
APPENDIX A

DAM SAFETY BRANCH
CHART



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

arper95.aep

APPENDIX B

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

NAME	DAMID	C-NO(1)	DATE	USE
BIG MEADOWS	200103	C-1050C	07/08/94	RECREATION
SCALES #1	420137	C-919A	08/23/94	IRRIGATION
CEDAR MESA	400135	C-1419A	08/23/94	IRRIGATION
SOUTH CATAMOUNT	100111	C-285A	08/26/94	MUNICIPAL
RAMPART	100221	C-1225D	10/11/94	MUNICIPAL/HYDRO
VOUGA	280109	C-739B	10/17/94	IRRIGATION
HALLENBECK #1	420125	C-356C	10/17/94	MUNICIPAL
SNOW MOUNTAIN	510208	C-1718A	03/08/95	DOMESTIC/RECREATION
ALBERTA PARK	200101	C-810A	04/03/95	RECREATION
BIG BEAVER	430103	C-1122B	04/03/95	RECREATION
WORSTER	030401	C-56B	05/25/95	IRRIGATION

[1} Filing system for approved plans (C-1050C). Letter at end of number denotes revision/additions to previously approved plans.

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

NAME	DAMID	C-NO(1)	DATE	USE
TERMINAL	060314	C-1737	08/08/94	DOMESTIC
NO. POUDRE #5	030302	C-1741	10/03/94	IRRIGATION
NO. POUDRE #6	030303	C-1742	10/03/94	IRRIGATION
BEAR CREEK	580311	LTR	10/19/94	STOCKWATER
JIM BAKER	070313	C-1740	10/11/94	MUNICIPAL
CHASE GULCH	070314	C-1743	12/30/94	MUNICIPAL
TODD	400522	C-1744	03/02/95	MUNICIPAL
SANCTUARY #13	080441	C-1745	03/08/95	RECREATION
SANCTUARY #14	080442	C-1746	03/08/95	RECREATION
WOMAN CREEK	02____	C-1747	03/30/95	FLOOD CONTROL
CRYSTAL	050119	C-1748	03/31/95	IRRIGATION
FISH CREEK #1	620122	C-1749	05/01/95	IRRIGATION
FISH CREEK #2	620121	C-1750	05/01/95	IRRIGATION

[1] Filing system for approved plans (C-1741). Assigned to plans for existing dams that are being altered, enlarged, or repaired that were without previously approved plans, and plans for new dams.

APPENDIX C

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

ME _____ W. DIV. _____ W. DIST. _____ DATE OF INSPECTION ___/___/___

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

NAME _____ OWNER PHONE _____

S _____ ZIP CODE _____

T NAME _____ CONTACT PHONE _____

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

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

TIONS RVED

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	
OBLEMS 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
OBLEMS 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
OBLEMS 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
OBLEMS 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 AIN OUTFALLS SEEN ___No ___Yes ☐ (37) FLOW INCREASED/MUDDY ☐ (38) DRAIN DRY/OBSTRUCTED ☐ (39) OTHER _____				SEEPAGE
OBLEMS 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 TERIOR INSPECTED ☐ (120) NO ☐ (121) YES ☐ (46) CONDUIT DETERIORATED OR COLLAPSED ☐ (47) JOINTS DISPLACED ☐ (48) VALVE LEAKAGE (49) OTHER _____				OUTLET
OBLEMS 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
OBLEMS 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**

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.

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

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

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

ER NAME _____ OWNER PHONE _____

RESS _____ ZIP CODE _____

TACT NAME _____ CONTACT PHONE _____

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

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

PECTION
TY
RESENTING _____ _____ _____

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

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

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

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: _____

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: _____

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: _____

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: _____

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: _____

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: _____

Conditions Observed

	GOOD	ACCEPTABLE	POOR
UPSTREAM SLOPE			
CREST			
DOWNSTREAM SLOPE			
SEEPAGE			
OUTLET			
SPILLWAY			

See Guidelines on Back of this Sheet

5a-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.

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

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: _____

MONITORING — ☐ GOOD ☐ ACCEPTABLE ☐ POOR

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: _____

MAINTENANCE AND REPAIRS — ☐ GOOD ☐ ACCEPTABLE ☐ POOR

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

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: _____

The 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.

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
- _____

ON FOR RESTRICTION: _____

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

eer's ture _____ 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.