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Briefing Report to the Chairman, Subcommittee on Water and Power Resources, Committee on Interior and Insular Affairs, House of Representatives

April 1986

WATER RESOURCES

Implementation of the Bureau of Reclamation's Safety of Dams Program

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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

RESOURCES, COMMUNITY,
AND ECONOMIC DEVELOPMENT
DIVISION

APR 25 1986

B-215782

The Honorable George Miller
Chairman, Subcommittee on
Water and Power Resources,
Committee on Interior and
Insular Affairs
House of Representatives

Dear Mr. Chairman:

In an August 1, 1985, letter and in subsequent discussions with your office, you requested that we provide statistical information about the Safety of Dams program being implemented by the Bureau of Reclamation, Department of the Interior. Our April 7, 1986, letter provided you with information you had also requested on the legislative history of the Reclamation Safety of Dams Act of 1978, and our legal opinion that Safety of Dams funds may not be used in the construction of the proposed Cliff Dam, a part of the Bureau's Central Arizona Project.

This briefing report responds to your specific questions about (1) the number of dams with safety problems the Bureau has identified, (2) the number of dams modified, and (3) the adequacy of funding to correct dams identified as needing safety modifications. In summary, the data show that the Bureau has inspected all of the 275 dams in its safety program. As of September 1985, the Bureau had completed more detailed safety analyses on 125 dams, and advised us that it plans to complete the safety analysis on the remaining dams by fiscal year 1994. As of October 1985, the Bureau had corrected safety deficiencies at 13 dams at a cost of $31 million.

Regarding the question of whether the funding available will be adequate to complete the Safety of Dams program, the Bureau has advised us that on the basis of available data, it has identified 67 dams as needing modification. It is of the opinion that the $750 million authorization should be sufficient to carry out safety modifications. Bureau officials caution, however, that the actual number of dams needing modification and the estimated costs cannot be further refined until all safety analyses have been completed. We would also point out that our opinion that Safety of Dams funds may not be used in the construction of the proposed Cliff Dam would, if followed, require the Bureau to reconsider its plans for and the use of Safety of Dams funds for the Central Arizona Project.

Section 1 of this report discusses the process the Bureau follows to identify dams that need safety modifications and to decide which modifications should be funded under the Safety of Dams Act. The statistical information requested is contained in sections 2 through 4.

To obtain this information, we met with dam safety officials and reviewed documents and records at the Bureau of Reclamation's Engineering and Research Center in Denver, Colorado, the Upper Colorado Regional Office in Salt Lake City, Utah, the Grand Junction Project Office in Colorado, and the Arizona Project Office in Phoenix. We did our work between September 1985 and March 1986. To meet your needs for timely information, we did not verify cost data obtained from the Bureau. We sought the views of responsible dam safety officials during the course of our work and incorporated those views where appropriate.

Unless you publicly announce its contents earlier, we do not plan to distribute this report further until 10 days from its issue date. At that time, copies will be sent to the Secretary of the Interior; the Director, Office of Management and Budget; and other interested parties. If we can be of further assistance, please contact me on (202) 275-7756.

Sincerely,

Michael Gryszkowiec

Michael Gryszkowiec
Associate Director

Contents

ABBREVIATIONS

CAS	Corrective action study
MDA	Modification decision analysis
P.L.	Public Law
SOD	Safety of dams
SEED	Safety evaluation of existing dams

SECTION 1

BACKGROUND ON SAFETY OF DAMS PROGRAM

The Department of the Interior's Bureau of Reclamation is a major designer, builder, and operator of over 300 dams in the western United States. These dams provide water for hydroelectric power generation, irrigated agriculture, and municipal and industrial use, and provide other benefits such as flood control and recreation.

The Bureau is responsible for assuring that the structural safety of these dams is preserved. A dam safety deficiency is a physical condition capable of causing a dam to fail. With partial or complete failure, the sudden, uncontrolled release of reservoir water could cause loss of life and extensive property damage downstream.

RECLAMATION SAFETY OF DAMS ACT OF 1978 AND THE 1984 AMENDMENTS

The Reclamation Safety of Dams Act of 1978 (P.L. 95-578) authorizes $100 million for the Secretary of the Interior to modify federal reclamation dams to preserve their structural safety. The act provides funds for dam modifications to correct safety problems resulting from new hydrologic or seismic data (such as new flood or earthquake studies) or changes in the state-of-the-art design and construction criteria. While modifications to correct safety problems resulting from age, deterioration, or failure to perform reasonable and normal maintenance are fundable under the act, the dams' beneficiaries, such as water and power users, must reimburse the Bureau for these costs, in accordance with reclamation law.

In 1984, the Congress amended the act to add $650 million to the authorization, and authorized the modification of seven non-Bureau dams (through P.L. 98-404). The amendments require that 15 percent of the funds used from this additional authorization to pay for modifications resulting from new hydrologic and seismic data or changes in the state-of-the-art must be allocated to the authorized purposes of the dam, such as power generation, flood control, and recreation. Costs allocated to purposes such as irrigation, municipal and industrial water, and commercial power must be repaid in accordance with reclamation law.

BUREAU PROCEDURES FOR IMPLEMENTING THE ACT

The Bureau's Safety Evaluation of Existing Dams (SEED) Program identifies safety deficiencies that could cause any of its dams to fail.[1] Through systematic evaluations, dams found deficient are placed in the Safety of Dams (SOD) Program, where corrective action alternatives are assessed and modification work is completed.

The SEED program is funded from the Bureau's operation and maintenance appropriations. Funds for the SOD program are provided by the Bureau's construction program appropriations and charged against the Reclamation Safety of Dams Act authorization ceiling.

SEED process

In the SEED process, the Bureau examines the dam and collects, analyzes, and evaluates all available data on the dam's design, construction, operation, and performance, including flood and seismic studies. The Bureau examines the dam site to determine if the dam, related structures, and mechanical equipment are performing as expected. The results are documented in an examination report that includes conclusions and recommendations. The Bureau continually assesses potential safety deficiencies. The frequency of examinations depends on the seriousness of identified problems. According to the Dam Safety Support Branch Chief, Division of Dam Safety, Engineering and Research Center, initial safety examinations and examination reports have been completed on all 275 dams in the SEED program.

On the basis of the completed examination reports, the dams are ranked to reflect the seriousness of dam safety deficiencies and the severity of the hazard posed by the dam. In this way, the dams are prioritized and scheduled for further study according to the critical nature of the identified issues.

The Bureau performs a technical analysis of the dam based on examination reports and other available data to evaluate each recommendation, resolve as many suspected dam safety deficiencies as possible, evaluate the seriousness of the dam's condition, and outline any additional work required to resolve remaining safety issues. The results of this analysis are documented in an

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[1]There are over 300 Bureau dams, of which 275 dams have been selected for the SEED program. The Bureau considers these 275 dams to be of sufficient height or impounding capacity to create a potential hazard should failure occur.

analysis report. A SEED report is then written that documents the results of the SEED process, including examination, structural behavior, and analysis reports, a management summary, and an overall safety classification. As of September 1985, SEED reports on 114 dams were complete.

In most cases, once the SEED report is written, according to the Dam Safety Support Branch Chief, a modification decision analysis (MDA) is performed either to define deficiencies that should be corrected under the SOD program, or to show that all dam safety issues have been resolved. Since the SEED report is based on available data, some dams may require more field data or analysis to perform the MDA. Once any necessary data collection or analysis is completed, the results of the MDA are incorporated into the SEED report.

The SEED program, as described above, represents the Bureau's current process for identifing dam safety deficiencies. According to the Dam Safety Support Branch Chief, the Bureau has bypassed some of the steps in the SEED process on several dams, including not preparing SEED reports, generally because their safety deficiencies had been previously identified by the Bureau. However, according to the official, the Bureau plans to eventually complete the MDAs, in order to uniformly document the condition of the 275 dams.

The Bureau estimates that the SEED process can take from 15 to 49 months to complete, depending on how much analysis is required to substantiate that a SOD deficiency exists. Figure 1.1 illustrates the estimated time frames for the SEED process. For example, one dam may require a flood study, while another dam may already have a recently completed study on record. According to the Dam Safety Support Branch Chief, the Bureau plans to complete safety analysis on all 275 dams by fiscal year 1994. Over the last 5 fiscal years, SEED program costs have averaged $4.3 million annually.

SOD process

Once a safety deficiency has been identified and the need for a modification has been determined under the SEED process, a dam is placed into the SOD program. The purposes of this program are to evaluate alternatives for making the dam safe and to complete necessary modification work.

First, a corrective action study (CAS) considers such measures as remedial construction, revising reservoir operating procedures, installing an early warning system, or breaching the dam. The Bureau must decide what degree of modification would be most appropriate in view of the risks, costs, and public sentiment.

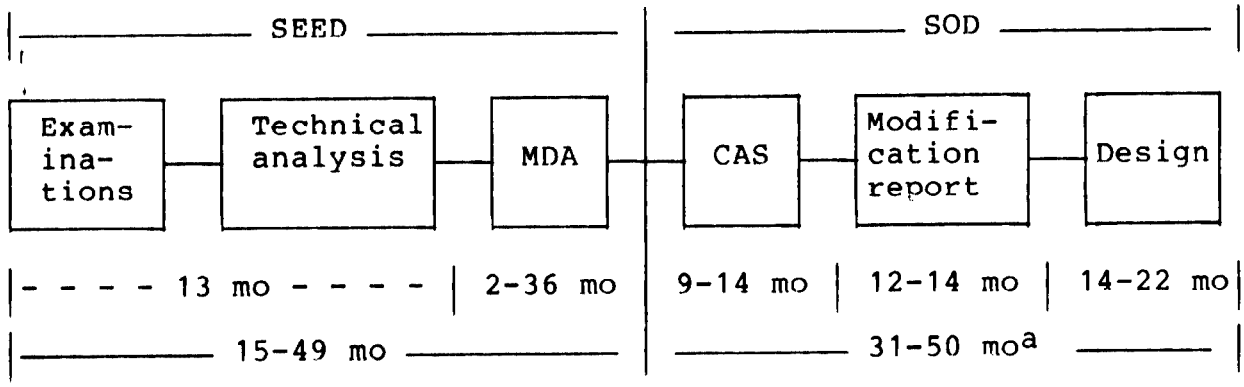
Once a CAS is completed, a modification report is prepared that includes such information as the corrective alternatives considered, as well as the Bureau's preferred alternative. The modification report must demonstrate that the recommended modification is necessary for the safety of the dam. If the modification is estimated to cost more than $750,000, the Office of Management and Budget and the Congress must approve it. The Commissioner of Reclamation approves modifications costing less than $750,000. After approval, final designs are then completed and construction contracts are awarded.

The Bureau estimates that, up to the time the first construction contract is awarded, the SOD process requires 31 to 50 months to complete. Figure 1.1 illustrates the estimated time frames for the SOD process. How quickly a dam progresses through the SOD program, according to the Division of Dam Safety Chief, Engineering and Research Center, depends on how much study and fieldwork is required.

The Bureau separates funding for the various steps in the SOD process. CAS costs are funded under the $100 million authorization of the 1978 act. Modification reports and final design and construction costs are generally funded under the $650 million made available by the 1984 amendments. However, some modification report and corrective action costs will be funded under the $100 million ceiling, generally because these costs were incurred at the time of, or modification work had already begun prior to, the 1984 amendments. As of September 30, 1985, the Bureau has spent about $60.7 million in SOD program funds--$42.7 million on design and construction, and $18.0 million on studies and preconstruction activities.

FIGURE 1.1

SEED AND SOD PROCESS TIME FRAMES



[a]Numbers do not total because some SOD activities may occur concurrently.

SECTION 2

IDENTIFICATION OF DAMS WITH SAFETY PROBLEMS

QUESTION: How many unsafe dams has the Bureau identified? (Include the problem and the date the problem was identified.)

RESPONSE: According to the Dam Safety Support Branch Chief, the Bureau does not use the term "unsafe." Instead, it assigns each dam one of five safety classifications, ranging from satisfactory to unsatisfactory, when the SEED report is written. In addition, some dams have a classification of "none" due to special considerations such as the dam was being modified at the time the SEED report was prepared. Table 2.1 summarizes the classifications the Bureau assigned to the 114 dams with SEED reports, as of September 1985.

We used the publication date of the SEED report to answer the question of when the Bureau identified the safety problem. It is difficult to determine exactly when a dam safety deficiency was documented because of the nature of the SEED process. For example, some dams have problems that can be identified on the basis of available data, while other problems may require additional field data collection or analysis to substantiate that a problem exists. The problem of identification is further complicated when deficiencies are documented at different points in the SEED process.

In addition to the 114 dams with completed SEED reports, the Bureau identified 11 other dams with potential safety problems. According to the Dam Safety Support Branch Chief, SEED reports will not be prepared because the Bureau had previously identified the problems at these 11 dams.

Most of the dam safety problems the Bureau has identified are hydrologic (such as the dam would not be able to pass the probable maximum flood),[1] seismic (such as the dam would not be able to withstand the maximum credible earthquake,[2] and seepage-related. According to the Division of Dam and Waterway Design Chief, Engineering and Research Center, many of these are potential problems that could lead to failure of the dam only in the remote event of such a flood or earthquake.

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[1]The Bureau defines the probable maximum flood as a hypothetical flood at a selected location on a given stream, whose magnitude is such that there is virtually no chance of its being exceeded.

[2]The Bureau defines the maximum credible earthquake as the largest hypothetical earthquake that may be reasonably expected to occur along a given fault or in a particular source area.

Table 2.1

Safety Classification of Dams
With Completed SEED Reports

	Satisfactory[a]	Fair[b]	Conditionally poor[c]	Poor[d]	Unsatisfactory[e]	None[f]	Total
Number of dams	12	35	29	24	7	7	114

[a]Satisfactory. No existing or potential dam safety deficiencies are recognized. Safe performance is expected under all anticipated loading conditions, including such events as the maximum credible earthquake and the probable maximum flood.

[b]Fair. No existing dam safety deficiencies are recognized for normal loading conditions. Infrequent hydrologic and/or seismic events would probably result in a dam safety deficiency.

[c]Conditionally Poor. A potential dam safety deficiency is recognized for unusual loading conditions which may realistically occur during the expected life of the structure. Conditionally Poor may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency; further investigations and studies are necessary.

[d]Poor. A potential dam safety deficiency is clearly recognized for normal loading conditions. Immediate actions to resolve the deficiency are recommended; reservoir restrictions may be necessary until problem resolution.

[e]Unsatisfactory. A dam safety deficiency exists for normal conditions. Immediate remedial action is required for problem resolution.

[f]None. This classification is made for dams which require special analysis before a safety classification can be assigned.

Table 2.2

Dams With SEED Reports and Safety Classification of Satisfactory (12 dams)
(as of September 1985)

Dam	State	SEED report date
Angostura[a]	S. Dak.	10/81
Blue Mesa	Colo.	10/81
Bonham	Colo.	9/82
Caballo	N. Mex.	2/82
Contra Loma	Calif.	12/82
Deerfield[b]	S. Dak.	10/82
Elephant Butte	N. Mex.	10/81
Martinez	Calif.	6/84
Minidoka	Idaho	11/82
Pueblo	Colo.	9/85
Shasta	Calif.	10/84
Sly Park	Calif.	4/83

[a]The SEED report for Angostura Dam classified it as "satisfactory;" however, the report also recommended various items be completed. A subsequent MDA found that SOD modifications were needed to correct deficiences regarding overtopping and instrumentation.

[b]Deerfield Dam was originally classified as "fair;" however, its safety classification was changed to "satisfactory" after work to modify the inadequate spillway was completed.

Table 2.3

Dams With SEED Reports and
Safety Classification of Fair (35 dams)
(as of September 1985)

Dam	State	Potential safety deficiency[a]	SEED report date
Alcova	Wyo.	Foundation liquefaction/seepage	6/83
Altus	Okla.	Overtopping, inadequate spillway	8/82
Anderson Ranch	Idaho	Liquefaction	5/82
Arrowrock	Idaho	Inadequate spillway	11/83
Belle Fourche	S. Dak.	Overtopping/evacuation of appurtenant structure	9/84
Black Canyon	Idaho	Overtopping[b]	6/83
Boca	Calif.	Overtopping/foundation liquefaction	2/84
Buffalo Bill	Wyo.	Overtopping	6/82
Bully Creek	Oreg.	Inadequate freeboard/foundation liquefaction	9/82
Clark Canyon	Mont.	Seepage	8/83
Currant Creek	Utah	Overtopping/foundation liquefaction/ seepage	6/84
El Vado	N. Mex.	Water barrier may rupture	6/83
Friant	Calif.	Spillway gate control/dynamic stability of concrete/seepage	7/84
Guernsey	Wyo.	Inadequate spillway/liquefaction potential	10/81
Heart Butte	N. Dak.	Overtopping	12/82
Helena Valley	Mont.	Overstressing of isolated areas of appurtenant structures	8/84
Horsetooth	Colo.	Overtopping	12/83
Huntington North	Utah	Dynamic stability/seepage	3/83
Hyrum	Utah	Inadequate spillway/dynamic stability	8/82
Keswick	Calif.	Overtopping	9/85
Lake Alice 1	Nebr.	Overtopping	6/82
Lake Alice 1 1/2	Nebr.	Overtopping	6/82
Lauro	Calif.	Dynamic stability	1/83
Los Banos	Calif.	Overtopping	2/83
McKay	Oreg.	Embankment stability/seepage	6/82
Merritt	Nebr.	Inadequate freeboard/seepage	6/82
Newton	Utah	Overtopping	9/82
Olympus	Colo.	Inadequate spillway	2/82
Pactola	S. Dak.	Overtopping, inadequate spillway	9/82
Palisades	Idaho	Embankment stability, foundation liquefaction, rock slides	10/82
Prosser Creek	Calif.	Inadequate freeboard/foundation liquefaction	4/84
Sherman	Nebr.	Overtopping	2/83
Soldiers Meadow	Idaho	Inadequate spillway capacity/ seepage	10/82
Stony Gorge	Calif.	Overtopping	11/82
Wickiup	Oreg.	Liquefaction	11/81

[a]See Glossary for description of the deficiencies.

[b]The subsequent MDA found no safety deficiency.

Table 2.4

Dams With SEED Reports and Safety Classification
of Conditionally Poor (29 dams)
(as of September 1985)

Dam	State	Potential safety deficiency[a]	SEED report date
Arbuckle	Okla.	Overtopping/foundation liquefaction/ piping	7/85
Avalon	N. Mex.	Overtopping/unstable spillway	3/85
Bumping Lake	Wash.	Overtopping/seepage-piping, reservoir evacuation	7/85
Casitas	Calif.	Overtopping/foundation liquefaction	10/82
Clear Lake	Calif.	Inadequate outlet works/seepage, cracking along crest	5/85
Cold Springs	Oreg.	Foundation liquefaction/seepage	7/82
Deer Flat	Idaho	Overtopping/seismic stability/ piping	9/84
Fish Lake	Oreg.	Overtopping/volcanic hazard, conduit corrosion, dynamic stability	9/85
Fort Cobb	Okla.	Overtopping/foundation liquefaction	7/85
Glen Anne	Calif.	Static & dynamic stability	8/84
Jamestown	N. Dak.	Overtopping, inadequate spillway capacity/seepage	9/84
Lemon	Colo.	Inadequate spillway capacity/ foundation & abutment solutioning/ landsliding	9/85
Meeks Cabin	Wyo.	Piping, landsliding	11/82
Ortega	Wash.	Foundation liquefaction	3/85
O'Sullivan	Calif.	Inadequate freeboard/foundation liquefaction	3/85
Paonia	Colo.	Overtopping/embankment stability & deformation, foundation liquefaction	9/85
Rye Patch	Nev.	Inadequate freeboard/dynamic & static stability	4/84
Scofield	Utah	Foundation liquefaction/seepage	4/84
Soldier Creek	Utah	Potential cavitation damage to outlet works/abutment seepage	6/84
Spring Creek	Calif.	Potential cavitation damage to outlet works/foundation liquefaction	9/85
Stampede	Calif.	Inadequate freeboard/embankment displacement	8/82
Steinaker	Utah	Inadequate freeboard/foundation liquefaction/high pore pressures at toe of dam	9/84

[a]See Glossary for description of the deficiencies.

Dam	State	Potential safety deficiency[a]	SEED report date
Tieton	Wash.	Embankment and/or foundation liquefaction	9/85
Trenton	Nebr.	Overtopping/foundation & embankment stability	7/85
Trinity	Calif.	Overtopping, evacuation/landsliding	9/85
Twitchell	Calif.	Foundation liquefaction	2/83
Warm Springs	Oreg.	Overtopping/overstressing	2/85
Whiskeytown	Calif.	Overtopping/stability & liquefaction potential	9/85
Willow Creek	Mont.	Erodable spillway/static & seismic stability, liquefaction/seepage	6/85

[a]See Glossary for description of the deficiencies.

Table 2.5

Dams With SEED Reports and Safety Classification of Poor (24 dams)
(as of September 1985)

Dam	State	Potential safety deficiency[a]	SEED report date
Atkinson	Colo.	Inadequate freeboard/substandard embankment, seepage	9/82
Big Creek	Colo.	Inadequate freeboard/substandard embankment, seepage	9/82
Big Sandy	Wyo.	Deteriorated spillway	11/81
Box Butte	Nebr.	Overtopping	6/83
Bradbury	Calif.	Overtopping/spillway gate control	7/84
Causey	Utah	Overtopping/foundation liquefaction/ seepage	8/85
Cottonwood 1	Colo.	Seepage	9/82
Cottonwood 2	Colo.	Seepage	9/82
Cottonwood 4	Colo.	Inadequate freeboard/substandard embankment & outlet works	9/82
Decamp	Colo.	Substandard embankment, seepage	9/82
Fontenelle	Wyo.	Seepage	1/83
Forty Acre	Colo.	Substandard embankment	9/82
Foss	Okla.	Overtopping/seepage	1/83
Fruitgrowers	Colo.	Inadequate spillway & freeboard/ embankment stability	11/81
Joes Valley	Utah	Overtopping/deformation & foundation liquefaction	11/82
Lake Alice 2	Colo.	Outlet works deterioration/trees on embankment	6/82
Lake Tahoe	Calif.	Inadequate freeboard, spillway deterioration/deformation potential, foundation liquefaction/ piping	8/82
Little Meadows	Colo.	Inadequate freeboard/embankment deterioration	9/82
Little Panoche	Calif.	Overtopping	4/83
McMillan	N. Mex.	Overtopping (dam to be breached)	5/85
Minatare	Nebr.	Obstructed spillway channel/slope stability, foundation liquefaction	5/82
Neversweat	Colo.	Inadequate freeboard	9/82
Ochoco	Oreg.	Inadequate freeboard/outlet work tunnel damaged, seepage, erosion	5/83
Senator Wash	Calif.	Overtopping/foundation liquefaction/ piping	9/84

[a]See Glossary for description of the deficiencies.

Table 2.6

Dams With SEED Reports and Classification of Unsatisfactory (7 dams)
(as of September 1985)

Dam	State	Potential safety deficiency[a]	SEED report date
Big Meadows	Colo.	Inadequate freeboard and slope protection, static stability, seepage-piping	9/82
Blackman	Colo.	Inadequate freeboard/substandard embankment (dam has been breached)	9/82
Currier	Colo.	Seepage, substandard embankment (dam has been breached)	9/82
Kitson	Colo.	Inadequate freeboard/substandard embankment, seepage	9/82
Lahontan	Nev.	Spillway deterioration/foundation liquefaction & embankment stability	9/82
Lambert	Colo.	Inadequate freeboard/embankment deterioration	9/82
Silver Lake	Colo.	Inadequate freeboard/embankment deterioration, seepage	9/82

[a]See Glossary for description of the deficiencies.

Table 2.7

Dams With SEED Reports and Safety Classification of None (7 dams)
(as of September 1985)

Dam	State	Potential safety deficiency[a]	SEED report date
Cottonwood 5	Colo.	Dam has been breached & reconstructed	9/82
Folsom	Calif.	Overtopping/seepage	6/84
Gibson	Mont.	Overtopping/seismic stability	7/85
Glen Canyon	Ariz.	Dynamic stability/seepage, rock mass contraction	8/83
Lake Sherburne	Mont.	Overtopping/landslides	4/82
Navajo[b]	N. Mex.	Seepage	5/83
Twin Buttes	Tex.	Overtopping/seepage	9/82

[a]See Glossary for description of the deficiencies.

[b]Although the SEED report classified Navajo Dam as "none," a subsequent MDA, CAS, and modification report justified the need for a SOD modification. According to the Dam Safety Support Branch Chief, the safety classification for Navajo Dam should probably be changed to "unsatisfactory" until the dam is modified.

Table 2.8

Bureau-Identified Dams With Potential Problems and No SEED Report (11 dams)
(as of September 1985)

Dam	State	Potential safety deficiency[a]
Bartlett[b]	Ariz.	Overtopping/foundation stability
East Park[c]	Calif.	Inadequate spillway
Horse Mesa[b]	Ariz.	Overtopping/foundation stability
Horseshoe[b]	Ariz.	Overtopping/cracks on crest
Island Park[c]	Idaho	Deteriorated spillway & conduits, inadequate freeboard/foundation liquefaction
Jackson Lake[c]	Wyo.	Foundation, embankment, & spillway stability
Mormon Flat[b]	Ariz.	Overtopping/foundation stability
O'Neill[d]	Calif.	Overtopping/liquefaction potential/ pressure at toe of dam
San Luis[d]	Calif.	Static & dynamic stability
Stewart Mountain[b/c]	Ariz.	Overtopping/disbonding of construction joints, foundation stability
T. Roosevelt[b/c]	Ariz.	Overtopping/foundation stability

[a]See Glossary for description of the deficiencies.

[b]These dams are part of the Salt River Project, and the Bureau studied all six dams together as a system.

[c]These dams were included in Interior's justification for the 1978 Safety of Dams Act authorization ceiling.

[d]According to the Dam Safety Support Branch Chief, the Bureau had previously identified the potential safety problems and decided to bypass some of the SEED process steps.

SECTION 3

DAMS MODIFIED

QUESTION: Of the unsafe dams identified, how many have been corrected? (List the nature of the safety deficiency and the corrective action taken as well as the cost. Also, identify if the costs were reimbursable.)

RESPONSE: As of October 1985, the Bureau corrected safety deficiencies at seven dams with SOD funds at a cost of $30 million. The corrective action generally was to modify the spillways and to increase storage capacity to accommodate major floods, and the Bureau paid for these costs without reimbursement. The $30 million represents 4 percent of the $750 million authorization. Table 3.1 shows the seven dams, the corrective action, the cost, and the completion date.

The Bureau also modifies dams with other than SOD funds. Through the SEED process, the Bureau identified 1 dam in the Eden Project in Wyoming and 17 dams in the Collbran Project in Colorado that had safety deficiencies due to normal wear and tear or lack of reasonable maintenance. Modifications for these types of deficiencies are addressed in the 1978 act. However, instead of using SOD funds, the Bureau's policy is to fund these modifications under some other authority, such as its rehabilitation and betterment or operation and maintenance program. The costs are reimbursable by the dams' beneficiaries.

The Eden Project dam was modified at a cost of $2.7 million. Of the 17 Collbran Project dams, corrective actions on 6 were completed as of September 30, 1985, at a cost of $756,000, and modifications on 7 are scheduled to be completed by 1997. According to the Operations Branch Chief, Division of Water and Land Operations at the Grand Junction Project Office, the Bureau does not plan to modify the remaining four dams at this time; however, these dams will continue to undergo routine operation and maintenance. The Bureau estimates that it will cost $5.1 million to repair the 14 dams. Table 3.2 lists these dams, the corrective action, the cost, and the expected completion date.

Table 3.1

Completed Corrective Actions Under SOD Program (7 dams)

Dam	State	Corrective action taken	Cost (millions)	Completion date
Deerfield[a]	S. Dak.	Raise dam crest & modify spillway & outlet works	$ 6.9	9/84
Gibson[b/h]	Mont.	Construct aeration piers on dam crest and provide abutment protection to accommodate overtopping	3.3	1/82
Guernsey[c]	Wyo.	Replace & protect deteriorated concrete in spillway	0.6	4/84
Island Park[d]	Idaho	Raise dam crest; reinforce spillway; replace materials in abutment; construct auxiliary spillway	6.3	7/85
Lahontan[e/f/h]	Nev.	Repair spillway & outlet works	6.2	4/85
Lake Sherburne[b/g]	Mont.	Raise dam crest	3.7	6/84
Stony Gorge[c/f]	Calif.	Structural strengthening of dam to accomodate overtopping	3.0	10/85
Total			$30.0	

[a]See Table 2.2 for the description of safety deficiencies.

[b]See Table 2.7 for the description of safety deficiencies.

[c]See Table 2.3 for the description of safety deficiencies.

[d]See Table 2.8 for the description of safety deficiencies.

[e]See Table 2.6 for the description of safety deficiencies.

[f]According to the Dam Safety Support Branch Chief, costs for these dams differ from estimated costs shown on Table 4.1 because, although modification is complete, not all of the funds had been expended as of September 30, 1985.

[g]Cost for this dam is more than the estimated cost shown on Table 4.1 because of the inclusion of study/preconstruction activity costs.

[h]Corrective action taken at these dams addressed hydrologic deficiencies; however, the Bureau is continuing study of potential seismic problems.

Table 3.2

Dams With Corrective Actions
Outside of SOD Program (18 dams)
(as of September 30, 1985)

Dam	Corrective action	Estimated cost	Expected completion date
Eden Project, Wyoming			
Big Sandy	Modify spillway	$2,729,715	Completed
Collbran Project, Colo.			
Atkinson[a]	Add riprap to outlet channel & dam face; cut & remove trees on embankment; blanket upstream face to stop leaks	200,000	1993
Big Creek[a]	Remove trees & rodent holes; blanket embankment; repair spillway; widen crest	190,000	1991
Big Meadows[b]	Replace dam structure on left end; plug old outlet works; raise crest; construct new spillway	341,000	1988
Blackman[b]	Dam has been breached	- [e]	Completed
Bonham[c]	Repair beaching area & spillway	18,343	Completed
Cottonwood 1[a]	No major modification work planned	-	
Cottonwood 2[a]	Widen crest; construct spillway; blanket seep areas; flatten downstream face	200,000	1995
Cottonwood 4[a]	Breach & replace dam	163,777	Completed
Cottonwood 5[d]	Breach & replace dam	405,929	Completed
Currier[b]	Dam has been breached	125,091[e]	Completed
Decamp[a]	Reshape dam; flatten downstream face	200,000	1997
Forty Acre[a]	No major modification work planned	-	
Kitson[b]	Breach part of left end; replace outlet works; raise crest; flatten downstream face; install toe drains & concrete weir on spillway	267,871	1986
Lambert[b]	Add riprap to face; raise & widen crest; repair embankment	225,000	1990
Little Meadows[a]	No major modification work planned	-	
Neversweat[a]	No major modification work planned	-	
Silver Lake[b]	Repair sink hole; raise crest; flatten downstream face; repair spillway	43,180	Completed
Subtotal- Collbran Project		$2,380,191	
Total		$5,109,906	

[a]See Table 2.5 for the description of safety deficiencies.

[b]See Table 2.6 for the description of safety deficiencies.

[c]See Table 2.2 for the description of safety deficiencies.

[d]See Table 2.7 for the description of safety deficiencies.

[e]Corrective action costs for Blackman Dam are included with Currier Dam. Separate costs were not readily available.

SECTION 4

ADEQUACY OF FUNDS

QUESTION: Will the $750 million authorization ceiling be sufficient to accomplish the remaining dam safety program needs? (List those dams which the Bureau intends to modify using the authority in P. L. 95-578 and P. L. 98-404. List the estimated cost to complete these modifications.) Have certain modifications required a much greater portion of the $750 million authorization, leaving a relatively smaller share for work at other facilities?

RESPONSE: According to Dam Safety officials, the $750 million authorization ceiling should be sufficient to accomplish the remaining SOD program needs through 1995, although overall program needs have not been formally updated since the 1984 amendments. The officials told us the Bureau identified 67 dams as needing modification during the process of obtaining the increased authorization ceiling. That list, according to the Dam Safety Division Chief, represents the Bureau's best estimate based on available data. The actual number of dams and their estimated modification costs, the Dam Safety officials told us, cannot be further refined until the dam studies progress through the SEED and SOD processes.

The cost estimates provided in the Bureau's 1984 list of 67 dams, with more recent estimates on individual dams where available, show that the Bureau plans to modify these dams at a total estimated cost of $704.7 million. Table 4.1 lists the 67 dams and the estimated costs available at the time of our review.

The single largest safety of dams modification planned by the Bureau concerns dams in the Salt River Project in Arizona (modification of Bartlett, Horse Mesa, Horseshore, Morman Flat, Stewart Mountain, and T. Roosevelt dams, and construction of Cliff Dam). The Bureau plans to spend $287.7 million on these dams. The second and third largest modifications are at Jackson Lake Dam ($82 million) and at Fontenelle Dam ($52 million), respectively. According to the Bureau, these modifications and construction will total $421.7 million, or 56 percent of the $750 million authorized ceiling. It should be noted, however, that because of our opinion that Safety of Dams funds may not be used in the construction of Cliff Dam, the Bureau will have to reconsider its plans for and the use of Safety of Dam funds for the Salt River Project, if it follows our opinion.

Table 4.1

Potential Modifications Under P.L. 95-578 and P.L. 98-404
(September 30, 1985, 67 dams)

Dam	State	Modification or deficiency[a]	Estimated costs P.L.95-578	Estimated costs P.L.98-404
			----- millions -----	
Altus[b]	Okla.	Overtopping, inadequate spillway	$ 2.7	$ -
Angostura[b]	S. Dak.	Overtopping/instrumentation	-	5.0
Arbuckle	Okla.	Overtopping/foundation liquefaction/ piping	-	2.5
Bartlett[b]	Ariz.	Overtopping/foundation stability	-	6.5
Belle Fourche	S. Dak.	Overtopping/evacuation of appurtenant structure	-	3.0
Black Canyon[b]	Idaho	Studies complete-no deficiencies	0.4	-
Boca	Calif.	Overtopping/foundation liquefaction	-	5.0
Box Butte[b]	Nebr.	Overtopping	-	2.0
Bradbury[b]	Calif.	Overtopping/spillway gate control	-	5.0
Bumping Lake	Wash.	Overtopping/seepage-piping, reservoir evacuation	-	3.0
Casitas[b]	Calif.	Overtopping/foundation liquefaction	-	3.0
Clear Lake	Calif.	Inadequate outlet works/seepage, cracking along crest	-	1.0
Cold Springs	Oreg.	Foundation liquefaction/seepage	-	3.5
Como[c]	Mont.	Structural stability	-	1.0
Deerfield[b]	S. Dak.	Raise dam crest/modify spillway & outlet works - modification completed	6.9	-
East Park[b]	Calif.	Inadequate spillway	0.1	-
El Vado	N. Mex.	Water barrier may rupture	-	3.0
Fish Lake	Oreg.	Overtopping/volcanic hazard, conduit corrosion, dynamic stability	-	1.0
Folsom	Calif.	Overtopping/seepage	-	20.0
Fontenelle[b]	Wyo.	Seepage	-	52.0
Foss[b]	Okla.	Overtopping/seepage	-	3.0
Fourmile Lake[c]	Oreg.	Structural stability	-	1.0
Friant	Calif.	Spillway gate control/dynamic stability of concrete/seepage	-	2.5
Fruitgrowers[b]	Colo.	Inadequate spillway and freeboard/embankment stability	2.0	-
Gibson[b]	Mont.	Overtopping/modification completed	3.3	-
Glen Anne	Calif.	Static & dynamic stability	-	1.5
Guernsey[b]	Wyo.	Replace & protect deteriorated concrete in spillway	0.6	-

[a]See Glossary for description of the deficiencies.

[b]Dams included in SOD program at the time of our review.

[c]These are non-Bureau dams which were authorized for SOD modification in the 1984 amendments. According to the Dam Safety Support Branch Chief, SEED reports will be prepared for these dams by fiscal year 1990.

Dam	State	Modification or deficiency[a]	Estimated costs P.L.95-578	Estimated costs P.L.98-404
			----- millions -----	
Heart Butte[b]	N. Dak.	Overtopping	$ 4.5	$ -
Horse Mesa[b]	Ariz.	Overtopping/foundation stability	-	5.5
Horseshoe/Cliff[b]	Ariz.	Breach Horseshore and construct cliff	(See T. Roosevelt)	
Horsetooth	Colo.	Overtopping	-	3.7
Hyrum[b]	Utah	Inadequate spillway/dynamic stability	0.7	-
Island Park[b]	Idaho	Raise dam crest; reinforce spillways; replace materials in abutment; a construct auxiliary spillway - modification completed	6.3	-
Jackson Lake[b]	Wyo.	Foundation, embankment & spillway stability	4.0	78.0
Jamestown	N. Dak.	Overtopping, inadequate spillway capacity/seepage	-	10.0
Joes Valley	Utah	Overtopping/deformation & foundation liquefaction potential	-	8.0
Lahontan[b]	Nev.	Repair spillway & outlet works - modification completed	6.4	-
Lake Sherburne[b]	Mont.	Raise dam crest - modification completed	3.5	-
Lake Tahoe[b]	Calif.	Inadequate freeboard, spillway deterioration/deformation potential, foundation liquefaction/piping	-	0.6
Little Panoche[b]	Calif.	Overtopping	-	0.4
Little Wood River[c]	Idaho	Structural stability	-	1.0
Los Banos[b]	Calif.	Overtopping	-	0.4
Meeks Cabin	Wyo.	Piping, landsliding potential	-	5.0
Merritt[b]	Nebr.	Inadequate freeboard/seepage	-	2.0
Mormon Flat[b]	Ariz.	Overtopping/foundation stability	-	5.5
Navajo[b]	N. Mex.	Seepage	-	12.3
Newton[b]	Utah	Overtopping	3.0	-
Ochoco	Oreg.	Inadequate freeboard/outlet work tunnel damaged, seepage, erosion	-	5.0
Olympus[b]	Colo.	Inadequate spillway	-	10.0
O'Neill[b]	Calif.	Overtopping/liquefaction potential/ pressure at toe of dam	-	1.4
Owyhee[d]	Oreg.	Repair top 75 ft. of arch	-	10.0
Pactola[b]	S. Dak.	Overtopping, inadequate spillway	9.4	-
Palisades	Idaho	Embankment & foundation stability	-	10.0
Prosser Creek	Calif.	Inadequate freeboard/foundation liquefaction	-	5.0

[a]See Glossary for description of the deficiencies.

[b]Dams included in SOD program at the time of our review.

[c]These are non-Bureau dams which were authorized for SOD modification in the 1984 amendments. According to the Dam Safety Support Branch Chief, SEED reports have not yet been prepared for these dams but will be in the near future.

[d]Owyhee Dam does not appear in the lists of dams identified as having potential deficiencies in Section 2. According to the Dam Safety Support Branch Chief, a SEED report is being prepared.

Dam	State	Modification or deficiency[a]	Estimated costs P.L.95-578	Estimated costs P.L.98-404
			----- millions -----	
Rye Patch	Nev.	Inadequate freeboard/dynamic & static stability	$ -	$ 5.0
Savage Rapids[c]	Oreg.	Structural stability	-	1.0
Shasta	Calif.	Grout contraction joints in dam	-	0.5
Sherman[b]	Nebr.	Overtopping	-	2.0
Soldiers Meadow[b]	Idaho	Inadequate spillway capacity/seepage	-	1.1
Stewart Mountain[b]	Ariz.	Overtopping/disbonding of construction joints, foundation stability	0.4	43.8
Stony Gorge[b]	Calif.	Overtopping - modification completed	3.2	-
T. Roosevelt[b]	Ariz.	Overtopping/foundation stability	-	226.0
Trinity	Calif.	Overtopping, evacuation/landsliding	-	1.0
Twitchell	Calif.	Foundation liquefaction	-	5.0
Twin Buttes[b]	Tex.	Overtopping/seepage	-	5.5
Warm Springs	Oreg.	Overtopping/overstressing	-	1.0
Willow Creek[b]	Mont.	Erodable spillway/static & seismic stability, liquefaction/seepage	0.2	-
Modification reports and preconstruction activity			25.7	31.2
		Subtotal	$ 83.3	$ 621.4
		Total		$704.7

[a]See Glossary for description of the deficiencies.

[b]Dams included in SOD program at the time of our review.

[c]These are non-Bureau dams which were authorized for SOD modification in the 1984 amendments. According to the Dam Safety Support Branch Chief, SEED reports have not yet been prepared for these dams, but will be in the near future.

Glossary

Breach -- the act of destroying an existing dam or related structure.

Conduit Corrosion -- the corrosion of any channel or pipe that conducts the flow of water.

Cracking -- the presence of relatively large cracks extending into the interior of a structure, usually produced by over-stressing the structural material.

Dynamic Stability -- the characteristic of the dam or related structure to gradually restore its original condition after being disturbed by a seismic event. On an embankment, dynamic instability may lead to deformations and displacements under earthquake loadings.

Inadequate Freeboard -- freeboard is the vertical distance between a stated water level and the top of the dam. Inadequate freeboard means that the vertical distance does not meet established standards for the dam under inflow design or probable maximum flood conditions.

Inadequate Spillway -- a spillway is a structure over or through which water or floodflows are discharged. An inadequate spillway may not have sufficient capacity to pass an inflow design or probable maximum flood without overtopping the dam, or has inoperable spillway gates.

Liquefaction -- the sudden large decrease of the stress resistance of a cohesionless soil, which is temporarily changed into a fluid mass. It is caused by a collapse of the soil structure by shock or other type of strain, such as ground motion. Foundation liquefaction could lead to instability under maximum credible earthquake conditions.

Overstressing -- the excessive force that an earthquake can exert on a solid material in resisting separation, compacting, or sliding.

Overtopping -- in a hydrologic event or flood, the water rises over the top of the dam. Inadequate spillway capacity could cause the dam to overtop. Overtopping could cause an embankment to erode and fail.

Piping -- the movement or erosion of material caused by seepage through the embankment, foundation or other conduits.

Reservoir Evacuation -- the removal or evacuation of water from a reservoir or other structure related to a dam. A deficiency may exist if the evacuation capability does not meet Bureau criteria.

Seepage -- the movement of water through close spaces that may take place through a dam, its foundation, or abutments.

Slope Stability -- the ability of the inclined face of an embankment structure to maintain its position or to resist displacement and, if displaced, to develop forces tending to restore the original condition.

Static Stability -- the static stability of a dam or related structure refers to its stability under steady-state water levels or flows, and sudden reservoir loading or drawdown conditions.

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