§ 222.6 National Program for Inspection of Non-Federal Dams.

(a) *Purpose*. This regulation states objectives, assigns responsibilities and prescribes procedures for implementation of a National Program for Inspection of Non-Federal Dams.

(b) *Applicability*. This regulation is applicable to all Divisions and Districts having Civil Works functions.

(c) *References*. (1) The National Dam Inspection Act, Pub. L. 92–367, 8 August 1972.

(2) Freedom of Information Act, Pub. L. 87–487, 4 July 1967.

(3) ER 500–1–1.

(d) *Authority*. The National Dam Inspection Act, Public Law 92–367, 8 August 1972 authorizes the Secretary of the Army, acting through the Chief of Engineers, to carry out a national program of inspection of non-Federal dams for the purpose of protecting human life and property.

(e) *Scope*. The program provides for:

(1) An update of the National Inventory of Dams.

(2) Inspection of the following non-Federal dams (the indicated hazard potential categories are based upon the location of the dams relative to developed areas):

(i) Dams which are in the high hazard potential category (located on Federal and non-Federal lands).

(ii) Dams in the significant hazard potential category believed by the State to represent an immediate danger to the public safety due to the actual condition of the dam.

(iii) Dams in the significant hazard potential category located on Federal lands.

(iv) Specifically excluded from the national inspection program are:

(A) Dams under the jurisdiction of the Bureau of Reclamation, the Tennessee Valley Authority, the International Boundary and Water Commission and the Corps of Engineers and

(B) Dams which have been constructed pursuant to licenses issued under the authority of the Federal Power Act, and

(C) Dams which have been inspected within the 12-month period immediately prior to the enactment of this act by a State agency and which the Governor of such State requests be excluded from inspection.

(f) *Objectives*. The objectives of the program are:

(1) To update the National Inventory of Dams by 30 September 1980.

(2) To perform the initial technical inspection and evaluation of the non-Federal dams described in paragraph 222.8(e) of this section to identify conditions which constitute a danger to human life or property as a means of expediting the correction of hazardous conditions by non-Federal interests. The inspection and evaluation is to be completed by 30 September 1981.

(3) To obtain additional information and experience that may be useful in determining if further Federal actions are necessary to assure national dam safety.

(4) Encourage the States to establish effective dam safety programs for non-Federal dams by 30 September 1981 and assist the States in the development of the technical capability to carry out such a program.

(g) *Program execution*—(1) *Responsibilities*. (i) The owner has the basic legal responsibility for potential hazards created by their dam(s). Phase II studies, as described in Chapter 4, Appendix D, and remedial actions are the owner's responsibility.

(ii) The State has the basic responsibility for the protection of the life and property of its citizens. Once a dam has been determined to be unsafe, it is the State's responsibility to see that timely remedial actions are taken.

(iii) The Corps of Engineers has the responsibility for executing the national program. The Federal program for inspection of dams does not modify the basic responsibilities of the States or dam owners. The Engineering Division of the Civil Works Directorate is responsible for overall program goals, guidance, technical criteria for inspections and inventory and headquarters level coordination with other agencies. The Water Resources Support Center (WRSC) located at Kingman Building, Fort Belvoir, Virginia 22060 is responsible for:

(A) Program Coordination of both the inventory and inspection programs.

(B) Developing and defining functional tasks to achieve program objectives.

(C) Determining resource requirements. (Budget)

(D) Compiling and disseminating progress reports.

(E) Monitoring and evaluating program progress and recommending corrective measures as needed.

(F) Collecting and evaluating data pertaining to inspection reports, dam owners' responses to inspection report recommendations, attitudes and capabilities of State officials, State dam safety legislation, Architect-Engineer performance, etc., for defining a comprehensive national dam safety program.

(G) Responding to Congressional, media, scientific and engineering organization and general public inquiries.

Division and District offices are responsible for executing the program at the State level. Assignment of Division reponsibilities for States is shown in Appendix A.

(2) *State participation.* Where State capability exists, every effort should be made to encourage the State to execute the inspection program either with State personnel or with Architect-Engineer (A-E) contracts under State supervision. If the State does not have the capability to carry out the inspection program, the program will be managed by the Corps of Engineers utilizing Corps employees or contracts with A-E firm.

(h) *Update of National Inventory of Dams.* (RCS-DAEN-CWE-17/OMB No. 49–RO421)

(1) The National Inventory of Dams should be updated and verified to include all Federal and non-Federal dams covered by the Act. Those dams are defined as all artificial barriers together with appurtenant works which impound or divert water and which: (1) Are twenty-five feet or more in height or (2) have an impounding capacity of fifty acre-feet or more. Barriers which are six feet or less in height, regardless of storage capacity or barriers which have a storage capacity at maximum water storage elevation of fifteen acre-feet or less regardless of height are not included.

(2) Inventory data for all dams shall be provided in accordance with Appendix B.

(3) The hazard potential classification shall be in accordance with paragraph 2.1.2 *Hazard Potential* of the Recommended Guideline for Safety Inspection of Dams (Appendix D to this section).

TABLE 2—HAZARD POTENTIAL CLASSIFICATION

Category	Urban development	Economic loss
Low	No permanent structure for human habitation	Minimal (Undeveloped to occasional structures or agriculture).
Significant	No urban development and no more than a small number of habitable structures.	Appreciable (Notable agriculture, industry or structures).
High	Urban development with more than a small number of habitable structures.	Excessive (Extensive community, industry or agriculture).

(4) As in the original development of the inventory, the States should be encouraged to participate in the work of completing, verifying and updating the inventory. Also, when available, personnel of other appropriate Federal agencies should be utilized for the inventory work on a reimbursable basis. Work in any State may be accomplished:

(i) Under State supervision utilizing State personnel or Architect-Engineers contracts.

(ii) Under Corps supervision utilizing Corps employees, employees of other Federal agencies or Architect-Engineer contracts.

(5) A minimum staff should be assigned in Districts and Divisions to administer and monitor the inventory activities. Generally, the work should be accomplished by architect-engineers or other Federal agency personnel under State or Corps supervision. Corps personnel should participate in the inventory only to the extent needed to assure that accurate data are collected.

(6) The National Inventory of Dams computerized data base in stored on the Boeing Computer Services (BCS) EKS computer system in Seattle, Washington. The data base uses Data Base Management System 2000 and is accessible for query by all Corps offices.

(7) Appendix B indicates details on accessing and updating inventory data.

(8) Appendix I describes the procedure for using NASA Land Satellite (LANDSAT) Multispectral Scanner data along with NASA's Surface Water Detection and Mapping (DAM) computer program to assist in updating and verifying and National Inventory of Dams.

(9) All inventory data for dams will be completed and verified utilizing all available sources of information (including LANDSAT overlay maps) and will include site visitation if required. It is the responsibility of the District Engineer to insure that the inventory of each State within his area of responsibility is accurate and contains the information required by the General Instructions for completing the forms for each Federal and non-Federal dam.

(i) [Reserved]

(j) *Inspection Program.* (RCS-DAEN-CWE-17 and OMB No. 49–RO421)

(1) *Scheduling of inspections.* The Governor of each State or his designee will continue to be involved in the selection and scheduling of the dams to be inspected. Priority will be given to inspection of those dams considered to offer the greatest potential threat to public safety.

(i) No inspection of a dam should be initiated until the hazard potential classification of the dam has been verified to the satisfaction of the Corps. Dams in the significant hazard category should be inspected only if requested by the State and only then if the State can provide information to show that the dam has deficiencies that pose an immediate danger to the public safety. Guidance for the selection of significant category non-Federal dams on Federal lands will be given in the near future.

(ii) Selection for inspection of non-Federal dams located on Federal lands or non-Federal dams designed and constructed under the jurisdiction of some Federal agency, should be coordinated with the responsible Federal agency. The appropriate State or regional representative of the Federal agency also should be contacted to obtain all available data on the dam. Representatives of the agency may participate in the inspection if they desire and should be given the opportunity to review and comment on the findings and recommendations in the inspection report prior to submission to the Governor and the dam owner. Examples of such dams are: non-Federal dams built on lands managed by National Forest Service, Bureau of Land Management, Fish and Wildlife Service, etc.; non-Federal dams designed and constructed by the Soil Conservation Service of the U.S. Department of Agriculture; high hazard mine tailings and coal mine waste dams under the jurisdiction of the Mine Safety and Health Administration, Department of Labor.

(iii) Indian-owned dams on trust lands are considered to be non-Federal dams. All dams in the high hazard potential category will be inspected. Privately-owned dams located on Indian lands are to be included in the program, however BIA-owned dams on Indian lands are Federal dams and are exempt.

(2) *Procedures.* The Division Engineer is responsible for the quality of inspections and reports prepared by the District Engineer. Close liaison between the District Engineer and the State agency or A-E firm responsible for the inspections will be required in order to obtain a dependable result. To avoid undesirable delays in the evaluation of safety of individual dams, contracts with A-E's or agreements with States which are managing the program will provide that reports be completed and furnished to the District Engineer within a specified time after completion of the on-site inspection of the dam.

(i) *Inspection guidelines.* The inspection should be conducted in accordance with the Recommended Guidelines for Safety Inspection of Dams (Appendix D to this section). Expanded Guidance for Hydrologic and Hydraulic Assessment of Dams is provided in Appendix C. The criteria in the recommended guidelines are screening criteria to be used only

for initial determinations of the adequacy of the dam. Conditions found during the investigation which do not meet the guideline recommendations should be assessed as to their importance from the standpoint of the degree of risk involved.

(ii) *Coordinators.* Experience has shown that coordination and communications among technical disciplines, Public Affairs Office, emergency officials, training officers, operations personnel, State representatives and A-E firms has been best in those districts where one person was delegated the responsiblity for coordinating the actions of all involved elements. Each district should evaluate its overall coordination procedures to insure that all involved elements have the best possible access to necessary data.

(iii) Field investigations should be carried out in a systematic manner. A detailed checklist or inspection form should be developed and used for each dam inspection and appended to the inspection report. The size of the field inspection team should be as small as practicable, generally consisting of only one representative of each required discipline in order to control the costs of the inspection without sacrificing the quality of the inspection. The inspection team for the smaller less complex dams should be limited to two or three representatives from appropriate technical areas with additional specialists used only as special conditions warrant. The larger more complex projects may require inspection teams of three or four specialists. Performance of overly detailed and precise surveys and mapping should be avoided. Necessary measurement of spillway, dam slopes, etc. can generally be made with measuring tapes and hand levels.

(iv) *Additional engineering studies.* Dam inspections should be limited to Phase I investigations as outlined in Chapter 3 of Appendix D. However, if recommended by the investigating engineer and approved by the District Engineer, some additional inexpensive investigations may be performed when a reasonable judgment on the safety of the dam cannot be made without additional investigation. Any further Phase II investigation needed to prove or disprove the findings of the District Engineer or to devise remedial measures to correct deficiencies are the responsibility of the owner and will not be undertaken by the Corps of Engineers.

(v) *Assessment of the investigation.* (A) The findings of the visual inspection and review of existing engineering data for a dam shall be assessed to determine its general condition. Dams assessed to be in generally good condition should be so described in the inspection report. Deficiencies found in a dam should be described and assessed as to the degree of risk they present. The degree of risk should consider only loss of life and/or property damage resulting from flooding due to dam failure. Loss of project benefits *i.e.*, municipal water supply, etc., should not be considered. If deficiencies are assessed to be of such a nature that, if not corrected, they could result in the failure of the dam with subsequent loss of life and/or substantial property damage, the dam should be assessed as ''Unsafe.'' If the probable failure of an ''Unsafe'' dam is judged to be imminent and immediate action is required to reduce or eliminate the hazard, the ''unsafe'' condition of the dam should be considered an ''emergency.'' If the probable failure is judged not to be imminent, the ''unsafe'' condition should be considered a ''non-emergency.''

(B) Adequacy of spillway. The ''Recommended Guidelines for Safety Inspection of Dams,'' Appendix D, provide current, acceptable inspection standards for spillway capacity. Any spillway capacity that does not meet the criteria in the ''Guidelines'' is considered inadequate. When a spillway's capacity is so deficient that it is seriously inadequate, the project must be considered *unsafe*. If all of the following conditions prevail, the Governor of the State shall be informed that such project is unsafe:

(*1*) There is high hazard to loss of life from large flows downstream of the dam.

(*2*) Dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam over that which would exist just before overtopping failure.

(*3*) The spillway is not capable of passing one-half of the probable maximum flood without overtopping the dam and causing failure.

Classification of dams with seriously inadequate spillways as ''unsafe, nonemergency'' is generally a proper designation of the urgency of the unsafe condition. However, there may be cases where the spillway capacity is unusually small and the consequences of dam overtopping and failure would be catastrophic. In such cases, the unsafe dam should be classified as an emergency situation.

(vi) All inspection reports will receive one level of independent review by the Corps. If the reports are prepared by the Corps, the independent review may be performed internally within the district office. However, in cases which involve significant economic, social or political impacts and technical uncertainties in evaluating the dams, advice may be obtained from the staffs of the Division Engineer and the Office, Chief of Engineers.

(3) *Reports*—(i) *Preparation*. A written report on the condition of each dam should be prepared as soon as possible after the completion of the field inspection and assessment. A suggested report format is attached as Appendix E. It is important that the inspection report be completed in a timely manner. For inspections being done by Corps employees, it is suggested that once an inspection team has been assigned to a dam inspection it be allowed to complete the inspection and report without interruption by other work.

(ii) *Review and approval*. The coordinating engineer should determine which disciplines should review the report and establish a procedure to accomplish the review in a timely manner. A review panel, made up of the appropriate Division and Branch Chiefs has worked well in some districts. Use of a review panel should be seriously considered by all districts. All inspection reports shall be approved by the District Engineer who will maintain a complete file of final approved reports. Any State or Federal agency having jurisdiction over the dam or the land on which the dam is built should be given the opportunity to review and comment on the report prior to submission to the Governor or dam owner. The District Engineer will transmit final approved reports to the Governor of the State and the dam owner (or the Governor only, when requested in writing by State officials). If the report is initially furnished to the Governor only, a period of up to ten days may be allowed before the report is furnished to the dam owner. If the Governor or the owner indicates additional technical information is available that might affect the assessment of the dam's condition, the District Engineer will furnish the proposed final report to the Governor and the owner and establish a definite time period for comments to be furnished to the District Engineer prior to report approval.

(iii) In general the Governor will be responsible for public release of an inspection report and for initiating any public Statements. However, an approved report must be treated as any other document subject to release upon request under the Freedom of Information Act. The letters of transmittal to the Governor and owner should indicate that under the provisions of the Freedom of Information Act, the documents will be subject to release upon request after receipt by the Governor. Proposed final reports will be considered as internal working papers not subject to release under the Freedom of Information Act. Corps personnel, A-E contractor personnel and others working under supervision of the Corps will be cautioned to avoid public statements about the condition of the dam until after the District Engineer has approved the report. The Corps will respond fully to inquiries after the Governor has received the approved report or been notified of an unsafe dam. An information copy of the report should be sent to the District office normally having jurisdiction if other than the District responsible for the inspection.

(iv) *Follow-up action*. A Federal investment of the magnitude anticipated for this inspection program makes it desirable that a reporting system be established to keep the District Engineer abreast of the implementation of the recommendations in the inspection reports. The letters of transmittal to the Governor and owner will request that

the District Engineer be informed of the actions taken on the recommendations in the inspection reports. However, the National Dam Inspection Act only authorizes the initial inspection of certain dams; therefore, once a report is completed no reinspection will be undertaken.

(4) *Unsafe dams.* The investigating engineer will be required to immediately notify the District Engineer when a dam is assessed as being unsafe. He will also indicate if probable failure of the unsafe dam is judged to be imminent and immediate action is required to reduce or eliminate the threat. The District Engineer will evaluate the findings of the investigating team and will immediately notify the Governor and the owner if the findings are Unsafe Non-Emergency or Unsafe-Emergency. The appropriate State agency and the Corps of Engineers officials having emergency operation responsibility for the area in which the dam is located will also be notified. The information provided in the unsafe dam notice shall be as indicated in Appendix F. Any emergency procedures or remedial actions deemed necessary by the District Engineer will be recommended to the Governor who has the responsibility for any corrective actions. As provided in ER 500–1–1, Corps assistance under Pub. L. 84–99 ''Advance Measures,'' may be made available to complement the owner's and Governor's action under certain conditions and subject to the approval of the Director of Civil Works. The District Engineer's Emergency Operation Officer will coordinate the advance measures request in accordance with existing procedures. Coordination will be maintained between the District responsible for emergency action under Pub. L. 84–90 and the District responsible for the inspection.

(5) *Emergency action plans.* An emergency action plan should be available for every dam in the high and significant hazard category. Such plans should outline actions to be taken by the operator to minimize downstream effects of an emergency and should include an effective warning system. If an emergency action plan has not been developed, the inspection report should recommend that the owner develop such an action plan. However, the Corps has no authority to require an emergency action plan.

(k) *Progress reports.* Progress reports should be submitted monthly by the Division Engineer to WRSC. The reports shall include progress through the last Saturday of the month and should be mailed by the following Monday. The reports shall contain the information and be typewritten in the format shown in Appendix G. Copies of Unsafe Dam Data Sheets will be submitted with the progress report. Copies of the completed inspection report for Dams in the Unsafe-Emergency category will be submitted also. (RCS-DAEN-CWE-19)

(l) *Contracts*—(1) *Corps of Engineers supervision.* Contracts for performing inventory and inspection activities under supervision of the Corps of Engineers shall be Fixed-Price Architect Engineer Contracts for Services. A sample scope of work setting forth requirements is provided in Appendix H. Experience has shown that costs for individual dam inspection have been lower when multiple inspections are included in one contract. Therefore, each A-E contract should include multiple dam inspections where practicable. Corps participation in A-E inspections should be held to a minimum. Corps representatives should participate in only enough A-E inspections to assure the equality of the inspections.

(2) *State supervision.* Contracts with States for performing inventory and inspection activities under State supervision may be either a Cost-Reimbursement type A-E Contract for Services or a Fixed-Price type contract. The selection of Architect-Engineers by the State should require approval of the Corps of Engineers Contracting Officer. The negotiated price for A-E services under cost-reimbursement type contracts with States will also require approval by the Contracting Officer. Contracts with States should require *timely* submission of the inspection reports to the District Engineer for review and approval. The contract provisions should also prevent public release of or public comment on the inspection report until the District Engineer has reviewed and approved the report. Corps

of Engineers participation in State inspections should be limited to occasional selected inspections to assure the quality of the State program.

(m) *Training*. As indicated in paragraph (f) of this section, one objective of the inspection program for non-Federal Dams is to prepare the States to provide effective dam safety programs. In many States this will require training of personnel of State agencies in the technical aspects of dam inspections. The Office, Chief of Engineers is studying the need for and content of a comprehensive Corps-sponsored training program in dam inspection technology. Pending the possible adoption of such a comprehensive plan, division and district Engineers are encouraged to take advantage of suitable opportunities to provide needed training in dam safety activities to qualified employees of State agencies and, when appropriate, to employees of architect-engineer firms engaged in the program. The following general considerations should be observed in providing such training:

(1) Priority must be placed on inspection of dams and updating the national dam inventory; hence, diversion of resources to training activities should not deter or delay these principle program functions.

(2) Salaries, per diem and travel expenses relating to training activities of State employees will be a State expense. There will be no tuition charge for State employees.

(3) Architect-Engineer firms will be required to pay expenses and tuition costs for their employees participating in Corps-sponsored training activities.

(4) Corps-sponsored training will require that each trainee is a qualified engineer or geologist and will concentrate on engineering technology related directly to dam safety. (This may require screening of proposed candidates for training.)

(5) Under this program, the Corps will not sponsor training that is intended primarily to satisfy requirements for a degree.

(6) Training by participation in actual dam inspections and/or management of the inspection program should be encouraged.

APPENDIX A TO § 222.6—DIVISION ASSIGNMENTS

To facilitate better coordination with the States, the Division Engineers are responsible for the dam inspection program by States as follows:

New England Division: Maine, Rhode Island, Connecticut, Vermont, New Hampshire, Massachusetts

North Atlantic Division: New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, District of Columbia

Ohio River Division: West Virginia, Ohio, Kentucky, Tennessee, Indiana

South Atlantic Division: North Carolina, South Carolina, Georgia, Florida, Alabama, Puerto Rico, Virgin Islands

Lower Mississippi Valley Division: Mississippi, Louisiana, Missouri

North Central Division: Michigan, Wisconsin, Illinois, Minnesota, Iowa

Southwestern Division: Arkansas, Oklahoma, Texas, New Mexico

Missouri River Division: Kansas, Nebraska, South Dakota, North Dakota, Wyoming, Colorado

North Pacific Division: Oregon, Idaho, Montana, Washington, Alaska

South Pacific Division: Utah, California, Arizona, Nevada

Pacific Ocean Division: Hawaii, Trust Territories, American Samoa

APPENDIX B TO § 222.6—INVENTORY OF DAMS

(RCS-DAEN-CWE-17 and OMB No. 49–RO421)

1. The updating of the inventory will include the completion of all items of data for all dams now included in the inventory, verification of the data now included in the inventory, and inclusion of complete data for all appropriate existing dams not previously listed. Data completion, verification and updating will be scheduled over a three year period.

2. The inventory data will be recorded on Engineering Form 4474 and 4474A (Exhibit 2). The general instructions for completing the forms are printed on the back of the forms. Parts I and II of the forms are to be fully completed. The instruction for completing Item 29, Line 5, Para. II (Engr Form 4474A) is revised to conform identically with the hazard potential classification contained in the recommended guidelines for safety inspection of dams. Additional data has been added to designate Corps districts in which the dam is located, Federal agency owned dams, Corps owned dams, Federal agency regulated dams, dams constructed with technical or financial assistance of the U.S. Soil Conservation Service, and privately owned dams located on Federal property.

3. All inventory data will be verified utilizing all available sources of information and will include site visitation if required.

4. The Inventory Data Base is stored on the Boeing Computer Services (BCS) EKS System in Seattle, Washington. The data is available to all Corps offices for queries using Data Base Management System 2000 (S2K).

a. To access the National Data Base log on BCS and type the following:

GET,DAMS/UN=CECELB

CALL,DAMS

b. For current information and changes to the National Inventory Data Base, type:

OLD,HOTDAM/UN=CEC1AT

LIST

5. The inventory update data will be furnished and the National Data Base will be updated on a monthly basis. The monthly submission will cover all dams whose inventory data were completed since the last report. The update data will be loaded directly onto the Boeing Computer by the field office.

a. The procedure for loading the data on the Boeing Computer can be printed by accessing the Boeing Computer and listing the information file ''HOTDAM.'' (See paragraph 4b. above.)

b. It is the responsibility of the submitting office to edit the data prior to furnishing it for the update. Editing will be accomplished by processing the data using the Inventory Edit Computer program developed by the Kansas City District. This procedure is described in the ''HOTDAM'' file.

6. Federal agencies will be uniformly designated by major and minor abbreviations according to the following list whenever applicable to Items 46 through 53. Abbreviations are to be left justified within the field with one blank separating major and minor abbreviations.

	Major	Minor
a. International Boundary and Water Commission.	IBWC	
b. U.S. Department of Agriculture:		
(1) Soil Conservation Service	USDA	SCS
(2) Forest Service	USDA	FS
c. U.S. Department of Energy Federal Energy Regulatory Commission.	DOE	FERC
d. Tennessee Valley Authority	TVA	
e. U.S. Department of Interior:		
(1) Bureau of Sport Fisheries and Wildlife.	DOI	BSFW
(2) Geological Survey	DOI	GS
(3) Bureau of Land Management	DOI	BLM
(4) Bureau of Reclamation	DOI	USBR
(5) Bureau of Indian Affairs	DOI	BIA
f. U.S. Department of Labor: (1) Mine Safety and Health Administration.	DOL	MSHA
g. Corps of Engineers:		
(1) Lower Mississippi Valley Division:		
(a) Memphis District	DAEN	LMM
(b) New Orleans District	DAEN	LMN
(c) St. Louis District	DAEN	LMS
(d) Vicksburg District	DAEN	LMK
(2) Missouri River Division:		
(a) Kansas City District	DAEN	MRK
(b) Omaha District	DAEN	MRO
(3) New England Division	DAEN	NED
(4) North Atlantic Division:.		
(a) Baltimore District	DAEN	NAB
(b) New York District	DAEN	NAN
(c) Norfolk District	DAEN	NAO
(d) Philadelphia District	DAEN	NAP
(5) North Central Division:		
(a) Buffalo District	DAEN	NCB
(b) Chicago District	DAEN	NCC
(c) Detroit District	DAEN	NCE
(d) Rock Island District	DAEN	NCR
(e) St. Paul District	DAEN	NCS
(6) North Pacific Division:		
(a) Alaska District	DAEN	NPA
(b) Portland District	DAEN	NPP
(c) Seattle District	DAEN	NPS
(d) Walla Walla District	DAEN	NPW
(7) Ohio River Division:		
(a) Huntington District	DAEN	ORH
(b) Louisville District	DAEN	ORL
(c) Nashville District	DAEN	ORN
(d) Pittsburgh District	DAEN	ORP
(8) Pacific Ocean Division	DAEN	POD
(9) South Atlantic Division:		
(a) Charleston District	DAEN	SAC
(b) Jacksonville District	DAEN	SAJ
(c) Mobile District	DAEN	SAM
(d) Savannah District	DAEN	SAS
(e) Wilmington District	DAEN	SAW
(10) South Pacific Division:		
(a) Los Angeles District	DAEN	SPL
(b) Sacramento District	DAEN	SPK
(c) San Franciso District	DAEN	SPN
(11) Southwestern Division:		
(a) Albuquerque District	DAEN	SWA
(b) Fort Worth District	DAEN	SWF
(c) Galveston District	DAEN	SWG
(d) Little Rock District	DAEN	SWL
(e) Tulsa District	DAEN	SWT

7. *Procedures for Revising and Updating the Inventory of Dams Master File.*

a. *To Change Correct or Add an Item.* Submit a change card that contains the identification assigned to the dams (Columns 1 thru 7), the proper card code (Column 80) and only the item or items changed, corrected or added. Data on the master file is added or replaced on an item for item basis.

b. *To Delete an Item.* Submit a change card that contains the identification assigned to the dam, (Columns 1 thru 7), the proper card code (Column 80), and an asterisk (*) in the left most column of the item or items to be deleted. More than one item can be changed, corrected, added on or deleted from the same card.

c. *To Delete the Entire Data for a Dam from the Master File.* Submit a zero (0) card punched as follows:

Columns 1 thru 7—Item 1 identification assigned to the dam
Columns 8 thru 10—Item 2, Division Code
Columns 11 thru 16—The word DELETE
Columns 17 thru 79—Blank Spaces
Column 80—A zero

8. *Keypunch Instructions and Punched Card Formats.*

a. Table 1 describes the character set to be used for keypunch cards of Engr. Forms 4474 and 4474A.

b. Exhibit 1 is the EDPC keypunch instructions and punch card formats defining the data fields (Items) and card columns to be used in preparing punched cards in compliance with the requirements of this regulation.

c. Exhibit 2 are prints of Engr. Forms 4474 and 4474A which are laid out in punch card format to facilitate punching cards directly from the completed forms.

Table 1

STANDARD CHARACTER SET AND CARD CODES

A	12-1		0	0
B	12-2		1	1
C	12-3		2	2
D	12-4		3	3
E	12-5		4	4
F	12-6		5	5
G	12-7		6	6
H	12-8		7	7
I	12-9		8	8
J	11-1		9	9
K	11-2	space	blank	
L	11-3		,	0-3-8
M	11-4		.	12-3-8
N	11-5		-	11
O	11-6		*	11-4-8
P	11-7		/	0-1
Q	11-8		$	11-3-8
R	11-9			
S	0-2			
T	0-3			
U	0-4			
V	0-5			
W	0-6			
X	0-7			
Y	0-8			
Z	0-9			

NON-STANDARD CHARACTER SET

(	12-5-8	0-8-4
)	11-5-8	12-8-4
"	8-4	
'	11-8-5	
+	12	
%	8-6	
;	12-8-7	11-8-6
:	8-2	
#	0-8-6	
@	8-5	
=	8-3	8-6

EDPC KEYPUNCH INSTRUCTIONS (Continued)

ER 1110-2-106
26 Sept 79

JOB TITLE: INVENTORY OF UNITED STATES DAMS

JOB NO.:

CARD IDENTIFICATION: CARDS 0&1

SOURCE: ENG FORM 4474

SOURCE BLOCK	NAME OF FIELD	COLUMNS FROM	COLUMNS TO	NO. COLS.	TYPE DATA *	JUSTIFY **	REMARKS-INSTRUCTIONS
1	Card Number 0 Identity (State)	1	2	2	A	L	
1	Identity (Number)	3	7	5	N	R	
2	Div	8	10	3	A	L	
3	State	11	12	2	A	L	
4	County	13	15	3	N	R	
5	Congr Dist	16	17	2	N	R	
6	State	18	19	2	A	L	
7	County	20	22	3	N	R	
8	Congr. Dist	23	24	2	N	R	
9	Name	25	61	39	A	L	
10	Latitude	62	66	5	N	R	No decimal point is punched.
11	Longitude	67	72	6	N	R	No decimal point is punched.
12	Report Data (Day)	73	74	2	N	R	
12	Report Data (Mo)	75	77	3	A	L	
12	Report Data (Yr)	78	79	2	N	R	
	Card Number	80	80	1	N		Punch a 0
1	CARD NUMBER 1 Identity	1	7				Repeat Item 1 card 0
13	Popular Name	8	43	36	A	L	
14	Name of Impoundment	44	79	36	A	L	
	Card Number	80	80	1	N		Punch a 1

* A = ALPHA, N = NUMERIC ** L = LEFT, R = RIGHT

ENG FORM 1 OCT 66 0-1817B

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SHEET OF SHEETS

Exhibit 1

ER 1110-2-106
26 Sept 79

EDPC KEYPUNCH INSTRUCTIONS (Continued)

JOB TITLE: INVENTORY OF UNITED STATES DAMS

JOB NO.:

CARD IDENTIFICATION: CARD 2

SOURCE: ENG FORM 4474

SOURCE BLOCK	NAME OF FIELD	COLUMNS FROM	COLUMNS TO	NO. COLS.	TYPE DATA *	JUSTIFY **	REMARKS-INSTRUCTIONS
1	CARD NUMBER 2 Identity	1	7				Repeat Item 1 card 0
15	Region	8	9	2	N	R	
16	Basin	10	11	2	N	R	
17	River or Stream	12	40	29	A	L	
18	City-Town-Village	41	68	28	A	L	
19	Distance from Dam	69	71	3	N	R	
20	Population	72	79	8	N	R	
	Card Number	80	80	1	N		Punch a 2

* A = ALPHA, N = NUMERIC ** L = LEFT, R = RIGHT

ENG FORM 1 OCT 66 0-1817B

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SHEET OF SHEETS

Exhibit 1

EDPC KEYPUNCH INSTRUCTIONS (Continued)

ER 1110-2-106
26 Sept 79

JOB TITLE: INVENTORY OF UNITED STATES DAMS

JOB NO.:

CARD IDENTIFICATION: CARD 3 & 4

SOURCE: ENG FORM 4474A

SOURCE BLOCK	NAME OF FIELD	COLUMNS FROM	COLUMNS TO	NO. COLS.	TYPE DATA *	JUSTIFY **	REMARKS-INSTRUCTIONS
	CARD NUMBER 3						
1	Identity	1	7				Repeat Item 1 card 0
21	Type of Dam	8	19	14	A	L	
22	Year Completed	20	23	4	N	R	
23	Purposes	24	33	10	A	L	
24	Structural Height	34	37	4	N	R	
25	Hydraulic Height	38	41	4	N	R	
26	Impounding Maximum	42	49	8	N	R	
27	Impounding Normal	50	57	8	N	R	
27A	C. E. District	58	60	3	A	L	
27B	Ownership	61	61	1	A		
27C	Fed. Regulated	62	62	1	A		
27D	Prv't Dams/Fed Land	63	63	1	A		
27E	Soil Con. Ser. Ass't.	64	64	1	A		
27F	Verif. Date (Day)	65	66	2	N	R	
27F	Verif. Date (Mo)	67	69	3	A	L	
27F	Verif Date (Yr)	70	71	2	N	R	
	Card Number	80	80	1	N		Punch a 3
	CARD NUMBER 4						
1	Identity	1	7				Repeat Item 1 card 0
28	Remarks	8	79	72	A	L	
	Card Number	80	80	1	N		Punch a 4

* A = ALPHA, N = NUMERIC ** L = LEFT, R = RIGHT

ENG FORM 1 OCT 66 0-1817B

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SHEET OF SHEETS

Exhibit 1

ER 1110-2-106
26 Sept 79

EDPC KEYPUNCH INSTRUCTIONS (Continued)

JOB TITLE: INVENTORY OF UNITED STATES DAMS

JOB NO.:

CARD IDENTIFICATION: CARD 5

SOURCE: ENG FORM 4474A

SOURCE BLOCK	NAME OF FIELD	COLUMNS FROM	COLUMNS TO	NO. COLS.	TYPE DATA *	JUSTIFY **	REMARKS-INSTRUCTIONS
1	CARD NUMBER 5 Identity	1	7				Punch from Part II Item 1
29	D/S Has	8	8	1	N		
30	Crest Length	9	13	5	N	R	
31	Spillway Type	14	14	1	A		
32	Spillway Width	15	18	4	N	R	
33	Maximum Discharge	19	25	7	N	R	
34	Volume of Dam	26	34	9	N	R	
35	Power-Installed	35	40	6	N	R	
36	Power-Proposed	41	46	6	N	R	
37	N.L. Number	47	47	1	N		
38	N.L. Length	48	51	4	N	R	
39	N.L. Width	52	54	3	N	R	
40	N.L. Length	55	58	4	N	R	
41	N.L. Width	59	61	3	N	R	
42	N.L. Length	62	65	4	N	R	
43	N.L. Width	66	68	3	N	R	
44	N.L. Length	69	72	4	N	R	
45	N.L. Width	73	75	3	N	R	
	Card Number	80	80	1	N		Punch a 5

* A = ALPHA, N = NUMERIC ** L = LEFT, R = RIGHT

ENG FORM 1 OCT 66 0-1817B

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SHEET Exhibit 1 OF SHEETS

EDPC KEYPUNCH INSTRUCTIONS (Continued)

ER 1110-2-106
26 Sept 79

JOB TITLE: INVENTORY OF UNITED STATES DAMS

JOB NO.:

CARD IDENTIFICATION: CARD 6.7,8, & 9

SOURCE: ENG FORM 4474A

SOURCE BLOCK	NAME OF FIELD	COLUMNS FROM	COLUMNS TO	NO. COLS.	TYPE DATA *	JUSTIFY **	REMARKS-INSTRUCTIONS
1	CARD NUMBER 6 Identity	1	7				Repeat Item 1 card 5
46	Owner	8	31	24	A	L	
47	Engineering By	32	55	24	A	L	
48	Construction By	56	79	24	A	L	
	Card Number	80	80	1	N		Punch a 6
1	CARD NUMBER 7 Identity	1	7				Repeat Item 1 card 5
49	Design	8	25	18	A	L	
50	Construction	26	43	18	A	L	
51	Operation	44	61	18	A	L	
52	Maintenance	62	79	18	A	L	
	Card Number	80	80	1	N		Punch a 7
1	CARD NUMBER 8 Identity	1	7				Repeat Item 1 card 5
53	Inspection By	8	40	33	A	L	
54	Inspection (Day)	41	42	2	N	R	
54	Inspection (Mo)	43	45	3	N	R	
54	Inspection (Yr)	46	47	2	N	R	
55	Authority	48	79	32	A	L	
	Card Number	80	80	1	N		Punch a 8
1	CARD NUMBER 9 Identity	1	7				Repeat Item 1 card 5
56	Remarks	8	79	72	A	L	
	CARD NUMBER	80	80	1	N		Punch a 9

* A = ALPHA, N = NUMERIC ** L = LEFT, R = RIGHT

ENG FORM 1 OCT 66 0-1817B

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SHEET OF SHEETS

Exhibit 1

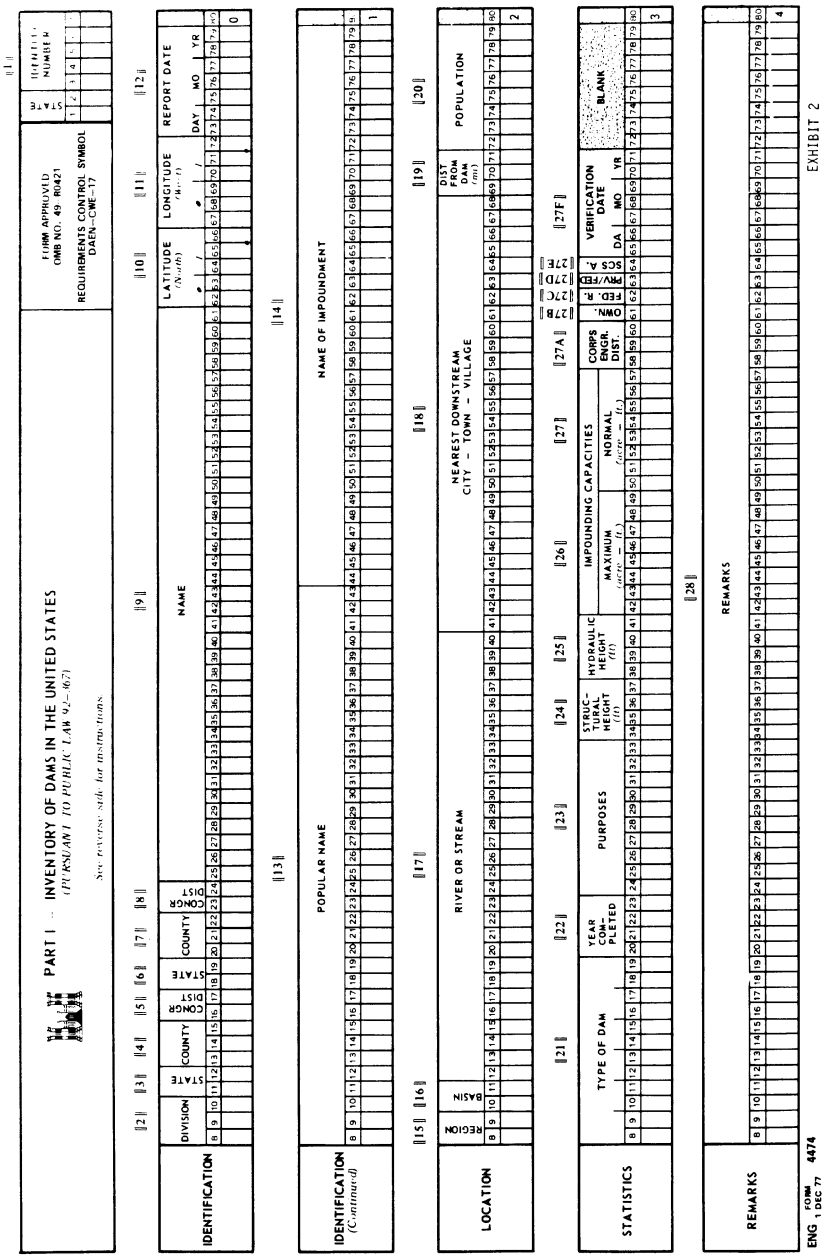
PART I — INVENTORY OF DAMS IN THE UNITED STATES
(PUBLIC LAW 92-367)
See reverse side for instructions.
FORM APPROVED
OMB NO. 49-R0421
REQUIREMENTS CONTROL SYMBOL
DAEN-CWE-17
STATE
INVENTORY NUMBER
IDENTIFICATION
DIVISION
STATE
COUNTY
CONGR DIST
STATE
COUNTY
CONGR DIST
NAME
LATITUDE (North)
LONGITUDE (West)
REPORT DATE
DAY
MO
YR
IDENTIFICATION (Continued)
POPULAR NAME
NAME OF IMPOUNDMENT
LOCATION
REGION
BASIN
RIVER OR STREAM
NEAREST DOWNSTREAM CITY - TOWN - VILLAGE
DIST FROM DAM (mi)
POPULATION
STATISTICS
TYPE OF DAM
YEAR COM-PLETED
PURPOSES
STRUC-TURAL HEIGHT (ft)
HYDRAULIC HEIGHT (ft)
IMPOUNDING CAPACITIES
MAXIMUM (acre-ft)
NORMAL (acre-ft)
CORPS ENGRS. DIST.
OWN.
FED. P.
PRV/FED
SCS A.
VERIFICATION DATE
DA
MO
YR
BLANK
REMARKS
ENG FORM 1 DEC 77 4474

EXHIBIT 2

GENERAL INSTRUCTIONS

This form is for use in preparing the inventory of dams in the United States under the requirements of the National Program for the Inspection of Dams, P.L. 92-367. All items of Part I and Part II (Lines 0-9) must be completed as instructed below. Print entries distinctly in ink or pencil. For letters o, z, and i, write Ø, Z , and I.

Write only one letter or numeral in each space; do not use more letters than blocks allowed for an item. Do not abbreviate on Part I. Leave one space between words and no space between code letters.

For all letter codes or word entries place first letters in left block of field. In word fields any alphabetic, numeric or special character may be entered. For all numerical entries, use only numerals placing the last digit of number in the right block of field, including trailing zeros. Do not include a decimal point! In fields where decimals are required values are to be placed around the decimal point printed on the form.

Leave blank those spaces where item does not apply, e.g., do not write "N/A", "–", "None", etc., unless instructed to do so by specific instructions. Use the remarks line when additional space is needed for an item, or to clarify an entry. Preface each remark with the item number. (See Item ‖28‖ or ‖56‖ instructions)

PART I

Item ‖ 1 ‖ IDENTITY: The Division Engineer will assign and control the identity for dams in the states for which he is responsible. The first two characters of the identity will be the two-letter state abbreviation in accordance with Federal Information Processing Standards Publication, June 15, 1970 (FIPS PUB 6-1). In cases where a dam is physically located in two or more states, one state will be designated as the principal state for the identity. The last five (5) characters of the identity will be a sequential number assigned to identify dams within a state.

LINE 0:

Item ‖ 2 ‖ DIVISION: Enter the three (3) letter office symbol for the division making the report in accordance with ABBR Report Code, Appendix B, ER 18-2-1, Civil Works Information System; e.g., NAD, ORD, SWD, etc.

Location:

Item ‖ 3 ‖ STATE: Enter two (2) letter principal state abbreviation in accordance with FIPS PUB 6-1.
Item ‖ 4 ‖ COUNTY: Enter three (3) digit county identification in accordance with FIPS PUB 6-1.
Item ‖ 5 ‖ CONG DIST: Enter one (1) or two (2) digit number for congressional districts in which dam is located.
Item ‖ 6 ‖, ‖ 7 ‖, and ‖ 8 ‖ (Use second location for structures situated in more than one state.)

Item ‖ 9 ‖ DAM NAME: Enter official name of dam. Do not abbreviate unless the abbreviation is a part of the official name. For dams that do not have a name, create a name by combining the two (2) letter state abbreviation plus "NO NAME" plus a sequential number. Example: if two dams in the State of Alabama do not have names, they would be named as ALNONAME1 and ALNONAME2.
Item ‖10‖ & ‖11‖ LATITUDE AND LONGITUDE: Enter the latitude and longitude in degrees, minutes and tenths of a minute. All geographical location items pertain to dam as its maximum section.
Item ‖12‖ REPORT DATE: Enter the one (1) or two (2) digits for day, the first three (3) letters of the month and a two (2) digit year (e.g., 12 JAN74) in which the data has been revised, updated or otherwise changed.

LINE 1:

Item ‖13‖ POPULAR NAME OF DAM: If (other than the official name of the dam) in common use, enter the name in this space. Leave blank if not applicable.
Item ‖14‖ NAME OF IMPOUNDMENT: Enter official name of lake or reservoir. Leave blank if reservoir does not have a name.

LINE 2

Item ‖15‖ & ‖16‖ REGION AND BASIN: Enter two (2) digit numbers for Region and Basin in accordance with Appendix C ER 18-2-1, Civil Works Information System.
Item ‖17‖ RIVER OR STREAM: Enter official name of river or stream on which the dam is built. If stream is without name indicate as tributary to river named, e.g., TR-COLORADO. If off stream, enter name of river plus "OFFSTREAM".
Item ‖18‖ NEAREST DOWNSTREAM CITY-TOWN-VILLAGE: Enter the nearest downstream city-town-village of such size which can be located on a general map.
Item ‖19‖ DISTANCE FROM DAM: Enter distance from dam to nearest downstream city-town-village to the nearest mile.
Item ‖20‖ POPULATION: Enter population of city-town-village given in Item ‖18‖.

LINE 3:

Item ‖21‖ TYPE OF DAM: Enter two (2) letter codes, in any order, to describe type of dam.

EARTH	RE	BUTTRESS	CB	OTHER – OT
ROCKFILL	ER	ARCH	VA	(Describe "other" in remarks)
GRAVITY	PG	MULTI-ARCH	MV	

Item ‖22‖ YEAR COMPLETED: Enter year when the main dam structure was completed and ready for use. If only approximate year can be determined, note this in remarks.
Item ‖23‖ PURPOSES: Enter one (1) letter codes that describe the purposes for which the reservoir is used. The order entered should indicate the relative decreasing importance of the project purposes.

IRRIGATION – I	WATER SUPPLY – S	DEBRIS CONTROL – D
HYDROELECTRIC – H	RECREATION – R	OTHER – O
FLOOD CONTROL – C	STOCK OR SMALL	(Describe "other" in remarks)
NAVIGATION – N	FARM POND – P	

Item ‖24‖ STRUCTURAL HEIGHT: Enter, to the nearest foot, the structural height of the dam which is defined as: the overall vertical distance from the lowest point of foundation surface to the top of the dam.
Item ‖25‖ HYDRAULIC HEIGHT: Enter, to the nearest foot, the hydraulic height of the dam which is defined as; the effective height of the dam with respect to the maximum storage capacity, measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier to the maximum storage elevation.

Impounding Capabilities:

Item ‖26‖ MAXIMUM: Enter the acre feet for maximum storage which is defined as: the total storage space in a reservoir below the maximum attainable water surface elevation, including any surcharge storage.
Item ‖27‖ NORMAL: Enter the acre feet for normal storage which is defined as; the total storage space in a reservoir below the normal retention level, including dead and inactive storage and excluding any flood control or surcharge storage.

Item ‖27A‖ CORPS OF ENGINEERS DISTRICT: Enter the three character Corps of Engineers ABBR report code in which the dam is geographically located, in accordance with Appendix B, ER 19-2-1, Civil Works Information System, e.g., NAN, ORH, SWF, etc.
Item ‖27B‖ OWNERSHIP: Enter N, for Non-Federal; G, for Federal Gov't. Agencies other than the Corps of Engineers; C for Corps of Engineers.
Item ‖27C‖ FEDERALLY REGULATED: Enter N for No; Enter Y for Yes.
Item ‖27D‖ PRIVATE DAMS ON FEDERAL LAND: Enter N for No; Enter Y for Yes.
Item ‖27E‖ ASSISTANCE BY SOIL CONSERVATION SERVICE: Enter N for None; T for Technical Assistance; F for Financial Assistance; B for Both Technical and Financial Assistance.
Item ‖27F‖ VERIFICATION: Date the data was verified as being complete and correct. Enter date as described in Item ‖12‖.

LINE 4:

Item ‖28‖ REMARKS: Preface remarks with the item number to which it pertains, e.g., 22-ORIGINALLY CONSTRUCTED IN 1928, 23-SETTLING BASIN. Only one remark line should be used for PART I remarks.

EXHIBIT 2

PART II - INVENTORY OF DAMS IN THE UNITED STATES
(PURSUANT TO PUBLIC LAW 92–367)

See reverse side for instructions.

FORM APPROVED
OMB NO. 49–R0421

REQUIREMENTS CONTROL SYMBOL
DAEN–CWE–17

‖1‖ STATE (1 2) IDENTITY NUMBER (3 4 5 6 7)

STATISTICS

‖29‖ D S HAZ | ‖30‖ CREST LENGTH (ft) | ‖31‖ SPILLWAY TYPE | ‖32‖ SPILLWAY WIDTH (ft) | ‖33‖ SPILLWAY MAXIMUM DISCHARGE (cfs) | ‖34‖ VOLUME OF DAM (CY) | ‖35‖ POWER CAPACITY INSTALLED (MW) | ‖36‖ POWER CAPACITY PROPOSED (MW) | ‖37‖ NAVIGATION LOCKS NO. | ‖38‖ LENGTH (ft) | ‖39‖ WIDTH (ft) | ‖40‖ LENGTH (ft) | ‖41‖ WIDTH (ft) | ‖42‖ LENGTH (ft) | ‖43‖ WIDTH (ft) | ‖44‖ LENGTH (ft) | ‖45‖ WIDTH (ft) | BLANK

MISC DATA

‖46‖ OWNER | ‖47‖ ENGINEERING BY | ‖48‖ CONSTRUCTION BY

MISC. DATA *(Continued)*

‖49‖ REGULATORY AGENCY: DESIGN | ‖50‖ CONSTRUCTION | ‖51‖ OPERATION | ‖52‖ MAINTENANCE

MISC. DATA *(Continued)*

‖53‖ INSPECTION BY | ‖54‖ INSPECTION DATE (DAY | MO | YR) | ‖55‖ AUTHORITY FOR INSPECTION

REMARKS

‖56‖ REMARKS

ENG FORM 1 DEC 77 4474A

EXHIBIT 2

PART II:

Item 1 IDENTITY: Enter Identity per GENERAL INSTRUCTIONS on PART I.

LINE 5:

Item [29] D/S HAZ: Enter the digit that most closely represents the hazard potential that could occur to the downstream (D/S) area resulting from failure or mis-operation of the dam or facilities.

HAZARD POTENTIAL

CATEGORY	LOSS OF LIFE (Extent of Development)	ECONOMIC LOSS (Extent of Development)
3 = Low	None expected (No permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agriculture)
2 = Significant	Few (No urban developments and no more than a small number of inhabitable structures)	Appreciable (Notable agriculture, industry or structures)
1 = High	More than few	Excessive (Extensive community, industry or agriculture)

Item [30] CREST LENGTH: Enter, to the nearest foot, the crest length of the dam which is defined as; the total horizontal distance measured along the axis at the elevation of the top of dam between abutments or ends of dam. Note that this includes spillway width, powerhouse sections, and navigation locks where they form a continuous part of the dam water retaining structure. Detached spillways, locks, and powerhouses shall not be included.

Spillway:

Item [31] TYPE: Enter the one letter code that applies.

CONTROLLED = C UNCONTROLLED = U NONE = N

Item [32] WIDTH: Enter to the nearest foot, the width of the spillway available for discharge when the reservoir is at its maximum designed water surface elevation.
Item [33] MAXIMUM DISCHARGE: Enter the number of cubic feet per second which the spillway is capable of discharging when the reservoir is at its maximum designed water surface elevation.

Volume of Dam:

Item [34] VOLUME OF DAM: Enter the total number of cubic yards occupied by the materials used in the dam structure. If volume of separate materials is known, enter in remarks. Include portions of powerhouses, locks and spillways only if integral with the dam and required for structural stability.

Power Capacity:

Item [35] INSTALLED: Enter installed capacity to one tenth (1/10) Megawatt as of the report date.
Item [36] PROPOSED: Enter the future additional capacity proposed to one tenth (1/10) Megawatt.

Navigation Locks:

Item ‖37‖ NUMBER: Enter the number of existing navigation locks for the project.

Item ‖38‖ LENGTH: Enter to the nearest foot the length of the navigation lock.

Item ‖39‖ WIDTH: Enter to the nearest foot the width of the navigation lock.

Item ‖40‖ thru ‖45‖ Enter the lengths and widths of additional locks.

LINE 6:

Item ‖46‖ OWNER: Enter name of owner. Abbreviate as necessary.
Item ‖47‖ ENGINEERING BY: Enter name of organization that engineered the main dam structure. Abbreviate as required.
Item ‖48‖ CONSTRUCTION BY: Enter name of construction agency responsible for construction of main structure. Abbreviate as required.

LINE 7:

Regulatory Agency:

Item ‖49‖ DESIGN: Enter the name of the organization other than the owner having regulatory or approval authority over the design of the dam. If no organization other than the owner has regulatory or approval authority over the design of the dam indicate NONE.
Item ‖50‖ CONSTRUCTION: Enter the name of the organization other than the owner having regulatory authority or inspection responsibilities over the construction of the dam. If no organization other than the owner has regulatory authority or inspection responsibilities over the construction of the dam indicate NONE.
Item ‖51‖ OPERATION: Enter the name of the organization other than the owner having regulatory authority, operational control, or surveillance responsibilities over the operation of the dam. If no organization other than the owner has regulatory authority, operational control or surveillance responsibilities over the operation of the dam indicate NONE.
Item ‖52‖ MAINTENANCE: Enter the name of the organization other than the owner having regulatory authority or inspection or surveillance responsibilities over the maintenance of the dam. If no organization other than the owner has regulatory authority or inspection or surveillance responsibilities over the maintenance of the dam indicate NONE.

LINE 8:

Inspection:

Item ‖53‖ BY: Enter the name of the organization that performed the last safety inspection. Abbreviate as required. If no inspection has been performed enter NONE.
Item ‖54‖ DATE: Enter the one (1) or two (2) digits for day, the first three (3) letters of the month and a two (2) digit year when the inspection was performed. If not applicable, leave blank.
Item ‖55‖ AUTHORITY FOR INSPECTION: Enter the legislative or regulatory authority for performing the inspection indicated in item 53, e.g., P.L. 92-367; Div 3, Water Code, State of Calif; ER 1110-2-100; etc.

LINE 9:

Item ‖56‖ REMARKS: Preface remarks with the item number to which it pertains. e.g., 34.2, 500,000 c.y. conc. 475,000 c.y. earthfill. Only one Remarks line should be used for PART II remarks.

EXHIBIT 2

APPENDIX C TO § 222.6—HYDROLOGIC AND HYDRAULIC ASSESSMENT OF DAMS

1. Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses of dam and reservoir capabilities. However, when such analyses are available, they should be evaluated for reliability and completeness. If a project's ability to pass the appropriate flood (see Table 3, page D–12 of Recommended Guidelines) can be determined from available information of a brief study, such an assessment should be made. It should be noted that hydrologic and hydraulic analyses connected with the Phase I inspections should be based on approximate methods or systematized computer programs that take minimal effort. The Hydrologic Engineering Center (HEC) has developed a special computer program for hydrologic and hydraulic analyses to be used with the Phase I inspection program. Other Field Operating Agencies have developed similar computer programs or generalized procedures which are acceptable for use. All such efforts should be completed with minimum resources.

2. A finding that a dam will not safely pass the flood indicated in the Recommended Guidelines does not necessarily indicate that the dam should be classified as unsafe. The degree of inadequacy of the spillway to pass the appropriate flood and the probable adverse impacts of dam failure because of overtopping must be considered in making such classification. The following criteria have

been selected which indicate when spillway capacity is so seriously inadequate that a project must be classified as unsafe. All of the following conditions must prevail before designating a dam unsafe:

a. There is high hazard to loss of life from large flows downstream of the dam.

b. Dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure.

c. The spillway is not capable of passing one-half of the probable maximum flood without overtopping the dam and causing failure.

3. The above criteria are generally adequate for evaluating most non-Federal dams. However, in a few cases the increased hazard potential from overtopping and failure is so great as to result in catastrophic consequences. In such cases, the evaluation of condition 2c should utilize a flood more closely approximating the full probable maximum flood rather than one-half the flood. An example of such a situation would be a large dam immediately above a highly populated flood plain, with little likelihood of time for evacuation in the event of an emergency.

4. Conditions 2a and 2b require an approximation of housing location in relation to flooded areas. Resources available in Phase I inspections do not permit detailed surveys or time-consuming studies to develop such relationships. Therefore, rough estimates will generally be made from data obtained during the inspection and from readily available maps and drawings. Brief computer routings such as the HEC–1 dam break analysis, using available data, are recommended in marginal cases. The HEC–1, dam break version, is available on the Boeing Computer Services or may be obtained from the Hydrologic Engineering Center, Davis, California. Available resources do not permit detailed studies or investigations to establish the amount of overtopping that would cause a dam to fail, as designated in condition 2c. Professional judgment and available information will have to be used in these determinations. When detailed investigations and studies are required to make a reasonable judgment of the conditions which designate an unsafe dam, the inspection report should recommend that such studies be the responsibility of the dam owner.

5. During the inspection of a dam, consideration should be given to impacts on other dams located downstream from the project being inspected. When failure of a dam would be likely to cause failure of another dam(s) downstream, its designation as an unsafe dam could result in multiple impacts. Therefore, the information should be explicitly described in the inspection report. Such information may be vital to the priorities established by State Governors for dam improvements. Similarly, when the failure of an upstream dam (classified as unsafe) could cause failure of the dam being inspected, this information should be prominently displayed in the inspection report.

6. The criteria established in paragraph 2 for designating unsafe dams because of seriously inadequate spillways are considered reasonable and prudent. They provide a consistent bases for declaring unsafe dams and also serve as an effective compromise between the Recommended Guidelines and unduly low standards suggested by special interests and individuals unfamiliar with flood hazard potential.

7. The Hydrometeorological Branch (HMB) of the National Weather Service has reviewed some 500 experienced large storms in the United States. The purpose of the review was to ascertain the relative magnitude of experienced large storms to probable maximum precipitation (PMP) and their distribution throughout the country. Their review reveals that about 25 percent of the major storms have exceeded 50 percent of the probable maximum precipitation for one or more combinations of area and duration. In fact some storms have very closely approximated the PMP values. Exhibits C–1 thru C–5 indicate locations where experienced storms have exceeded 50 percent of the PMP.

8. There are several options to consider when selecting mitigation measures to avoid severe consequences of a dam failure from overtopping. The following measures may be required by a Governor when sufficient legal authority is available under State laws and a dam presents a serious threat to loss of life.

a. Remove the dam.

b. Increase the height of dam and/or spillway size to pass the probable maximum flood without overtopping the dam.

c. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

d. Enhance the stability of the dam to permit overtopping by the probable maximum flood without failure.

e. Provide a highly reliable flood warning system (generally does not prevent damage but avoids loss of life).

TABLE 1—STORMS WITH RAINFALL ≥150% OF PMP, U.S. EAST OF THE 105TH MERIDIAN (FOR 10 MI², 6 HOURS; 200 MI², 24 HOURS AND/OR 1,000 MI², 48 HOURS)

Storm date	Index No.	Corps assignment No. (if available)	Storm center		Latitude	Longitude
			Town	State		
July 26, 1819	1		Catskill	NY	42°12′	73°53′
Aug. 5, 1843	2		Concordville	PA	39°53′	75°32′
Sept. 10–13, 1878	3	OR 9–19	Jefferson	OH	41°45′	80°46′
Sept. 20–24, 1882	4	NA 1–3	Paterson	NJ	40°55′	74°10′
June 13–17, 1886	5	LMV 4–27	Alexandria	LA	31°19′	92°33′
June 27–July 11, 1899	6	GM 3–4	Turnersville	TX	30°52′	96°32′
Aug. 24–28, 1903	7	MR 1–10	Woodburn	IA	40°57′	93°35′
Oct. 7–11, 1903	8	GL 4–9	Paterson	NJ	40°55′	74°10′
July 18–23, 1909	9	UMV 1–11B	Ironwood	MI	46°27′	90°11′
July 18–23, 1909	10	UMV 1–11A	Beaulieu	MN	47°21′	95°48′
July 22–23, 1911	11		Swede Home	NB	40°22′	96°54′
July 19–24, 1912	12	GL 2–29	Merrill	WI	45°11′	89°41′
July 13–17, 1916	13	SA 2–9	Altapass	NC	35°33′	82°01′
Sept. 8–10, 1921	14	GM 4–12	Taylor	TX	30°35′	97°18′
Oct. 4–11, 1924	15	SA 4–20	New Smyrna	FL	29°07′	80°55′
Sept. 17–19, 1926	16	MR 4–24	Boyden	IA	43°12′	96°00′
Mar. 11–16, 1929	17	UMV 2–20	Elba	AL	31°25′	86°04′
June 30–July 2, 1932	18	GM 5–1	State Fish Hatchery	TX	30°01′	99°07′
Sept. 16–17, 1932	19		Ripogenus Dam	ME	45°53′	69°09′
July 22–27, 193	20	LMV 2–26	Logansport	LA	31°58′	94°00′
Apr. 3–4 1934	21	SW 2–11	Cheyenne	OK	35°37′	99°40′
May 30–31, 1935	22	MR 3–28A	Cherry Creek	CO	39°13′	104°32′
May 31, 1935	23	GM 5–20	Woodward	TX	29°20′	99°28′
July 6–10, 1935	24	NA 1–27	Hector	NY	42°30′	76°53′
Sept. 2–6, 1935	25	SA 1–26	Easton	MD	38°46′	76°01′
Sept. 14–18, 1936	26	GM 5–7	Broome	TX	31°47′	100°50′
June 19–20, 1939	27		Snyder	TX	32°44′	100°55′
July 4–5, 1939	28		Simpson	KY	38°13′	83°22′
Aug. 19, 1939	29	NA 2–3	Manahawkin	NJ	39°42′	74°16′
June 3–4, 1940	30	MR 4–5	Grant Township	NB	42°01′	96°53′
Aug. 6–9, 1940	31	LMV 4–24	Miller Isl	LA	29°45′	92°10′
Aug. 10–17, 1940	32	SA 5–19A	Keysville	VA	37°03′	78°30′
Sept. 1, 1940	33	NA 2–4	Ewan	NJ	39°42′	75°12′
Sept. 2–6, 1940	34	SW 2–18	Hallet	OK	36°15′	96°36′
Aug. 28–31, 1941	35	UMV 1–22	Haywood	WI	46°00′	91°28′
Oct. 17–22, 1941	36	SA 5–6	Trenton	FL	29°48′	82°57′
July 17–18, 1942	37	OR 9–23	Smethport	PA	41°50′	78°25′
Oct. 11–17, 1942	38	SA 1–28A	Big Meadows	VA	38°31′	78°26′
May 6–12, 1943	39	SW 2–20	Warner	OK	35°29′	95°18′
May 12–20, 1943	40	SW 2–21	Nr. Mounds	OK	35°52′	96°04′
July 27–29, 1943	41	GM 5–21	Devers	TX	30°02′	94°35′
Aug. 4–5, 1943	42	OR 3–30	Nr. Glenville	WV	38°56′	80°50′
June 10–13, 1944	43	MR 6–15	Nr. Stanton	NB	41°52′	97°03′
Aug. 12–15, 1946	44	MR 7–2A	Cole Camp	MO	38°40′	93°13′
Aug. 12–16, 1946	45	MR 7–2B	Nr. Collinsville	IL	38°40′	89°59′
Sept. 26–27, 1946	46	GM 5–24	Nr. San Antonio	TX	29°20′	98°29′
June 23–24, 1948	47		Nr. Del Rio	TX	29°22′	100°37′
Sept. 3–7, 1950	48	SA 5–8	Yankeetown	FL	29°03′	82°42′
June 23–28, 1954	49	SW 3–22	Vic Pierce	TX	30°22′	101°23′
Aug. 17–20, 1955	50	NA 2–22A	Westfield	MA	42°07′	72°45′
May 15–16, 1957	51		Hennessey	OK	36°02′	97°56′
June 14–15, 1957	52		Nr. E. St. Louis	IL	38°37′	90°24′
June 23–24, 1963	53		David City	NB	41°14′	97°05′
June 13–20, 1965	54		Holly	CO	37°43′	102°23′
June 24, 1966	55		Glenullin	ND	47°21′	101°19′
Aug. 12–13, 1966	56		Nr. Greely	NB	41°33′	98°32′
Sept. 19–24, 1967	57	SW 3–24	Falfurrias	TX	27°16′	98°12′
July 16–17, 1968	58		Waterloo	IA	42°30′	92°19′
July 4–5, 1969	59		Nr. Wooster	OH	40°50′	82°00′
Aug. 19–20, 1969	60	NA 2–3	Nr. Tyro	VA	37°49′	79°00′
June 9, 1972	61		Rapid City	SD	44°12′	103°31′
June 19–23, 1972	62		Zerbe	PA	40°37′	76°31′
July 21–22, 1972	63		Nr. Cushing	MN	46°10′	94°30′
Sept. 10–12, 1972	64		Harlan	IA	41°43′	95°15′
Oct. 10–11, 1973	65		Enid	OK	36°25′	97°52′

TABLE 2—STORMS WITH RAINFALL ≥50% OF PMP, U.S. WEST OF CONTINENTAL DIVIDE (FOR 10 MI^2 6 HOURS OR 1,000 MI^2 FOR ONE DURATION BETWEEN 6 AND 72 HOURS)

Storm date	Index No.	Storm center		Latitude	Longitude	Duration for 1,000 mi^2
		Town	State			
Aug. 11, 1890	1	Palmetto	NV	37°27′	117°42′	.....
Aug. 12, 1891	2	Campo	CA	32°36′	116°28′	.....
Aug. 28, 1898	3	Ft. Mohave	AZ	35°03′	114°36′	.....
Oct. 4–6, 1911	4	Gladstone	CO	37°53′	107°39′	.....
Dec. 29, 1913–Jan. 3, 1914	5	.....	CA	39°55′	121°25′	.....
Feb. 17–22, 1914	6	Colby Ranch	CA	34°18′	118°07′	.....
Feb. 20–25, 1917	7	.....	CA	37°35′	119°36′	.....
Sept. 13, 1918	8	Red Bluff	CA	40°10′	122°14′	.....
Feb. 26–Mar 4, 1938	9	.....	CA	34°14′	117°11′	.....
Mar. 30–Apr. 2, 1931	10	.....	ID	46°30′	114°50′	24
Feb. 26, 1932	11	Big Four	WA	48°05′	121°30′	.....
Nov. 21, 1933	12	Tatoosh Is	WA	48°23′	124°44′	.....
Jan. 20–25, 1935	13	.....	WA	47°30′	123°30′	6
Jan. 20–25, 1935	14	.....	WA	47°00′	122°00′	72
Feb. 4–8, 1937	15	Cyamaca Dam	CA	33°00′	116°35′	.....
Dec. 9–12, 1937	16	.....	CA	38°51′	122°43′	.....
Feb. 27–Mar. 4, 1938	17	.....	AZ	34°57′	111°44′	12
Jan. 19–24, 1943	18	.....	CA	37°35′	119°25′	18
Jan. 19–24, 1943	19	Hoegee's Camp	CA	34°13′	118°02′	.....
Jan. 30–Feb. 3, 1945	20	.....	CA	37°35′	119°30′	.....
Dec. 27, 1945	21	Mt. Tamalpias	CA	37°54′	122°34′	.....
Nov. 13–21, 1950	22	.....	CA	36°30′	118°30′	24
Aug. 25–30, 1951	23	.....	AZ	34°07′	112°21′	72
July 19, 1955	24	Chiatovich Flat	CA	37°44′	118°15′	.....
Aug. 16, 1958	25	Morgan	UT	41°03′	111°38′	.....
Sept. 18, 1959	26	Newton	CA	40°22′	122°12′	.....
June 7–8, 1964	27	Nyack Ck	MT	48°30′	113°38′	12
Sept. 3–7, 1970	28	.....	UT	37°38′	109°04′	6
Sept. 3–7, 1970	29	.....	AZ	33°49′	110°56′	6
June 7, 1972	30	Bakersfield	CA	35°25′	119°03′	.....
Dec. 9–12, 1937	31	.....	CA	39°45′	121°30′	48

ER 1110-2-106
26 Sept 79

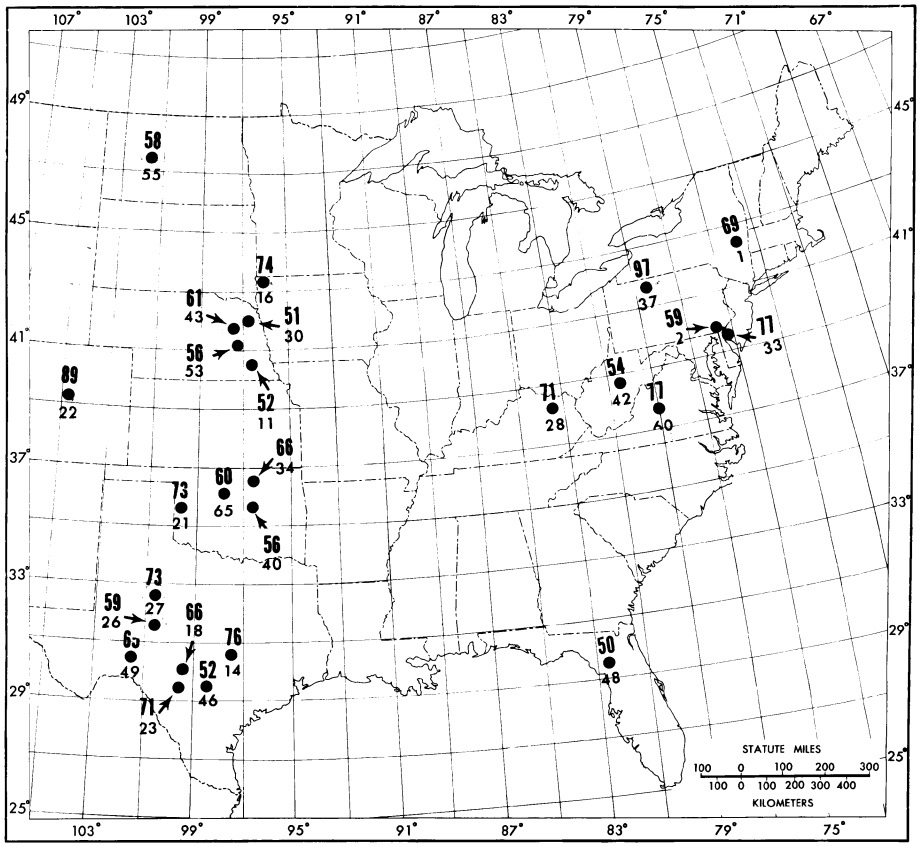

Plate 1: Observed point rainfalls ≥ 50% of all-season PMP, U.S. east of 105th meridian for 10 mi^2 6 hours. (Large number is % of PMP, small number is storm index, see table 1.)

Exhibit C-1

ER 1110-2-106
26 Sept 79

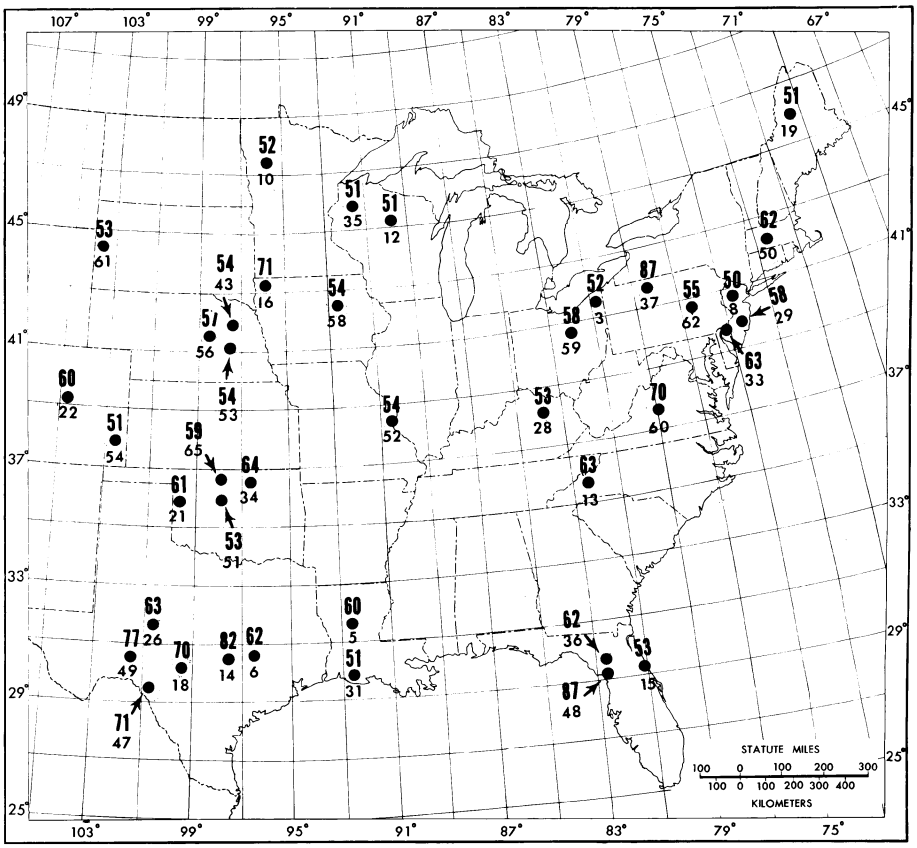

Plate 2: Observed rainfalls ≥ 50% of all-season PMP, U.S. east of 105th meridian for 200 mi^2 24 hours. (Large number is % of PMP, small number is storm index, see table 1.)

Exhibit C-2

ER 1110-2-106
26 Sept 79

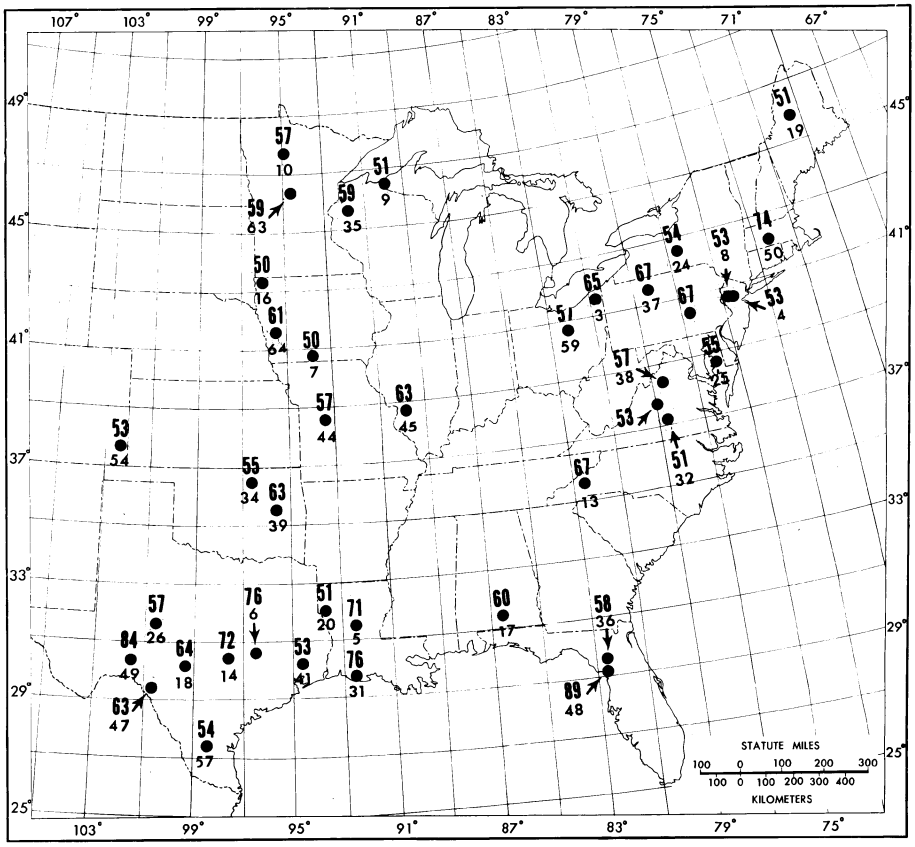

Plate 3: Observed rainfalls ≥ 50% of all-season PMP, U.S. east of the 105th meridian for 1000 mi^2 48 hours. (Large number is % of PMP, small number is storm index, see table 1.)

Exhibit C-3

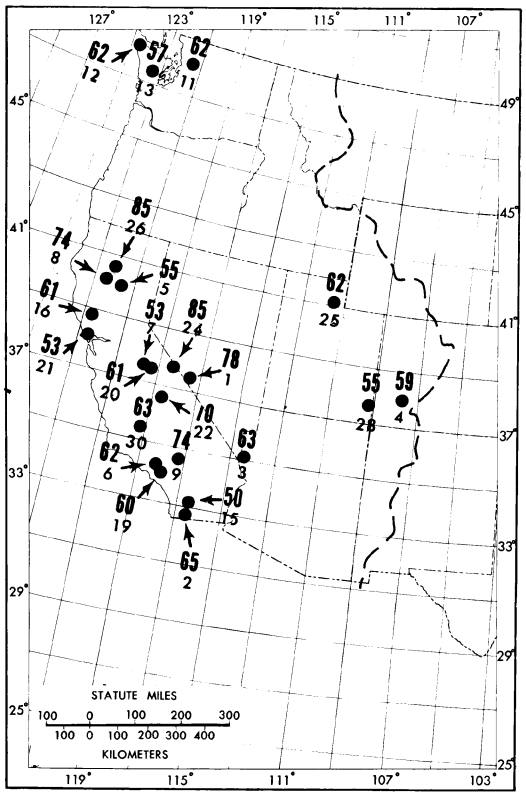

Plate 4: Observed point rainfalls ≥ 50% of all-season PMP, U.S. west of the Continental Divide for 10 mi^2 for 6 hours. (Large number is % of PMP. Small number is storm index, see table 2.)

Exhibit C-4

ER 1110-2-106
20 Sept 79

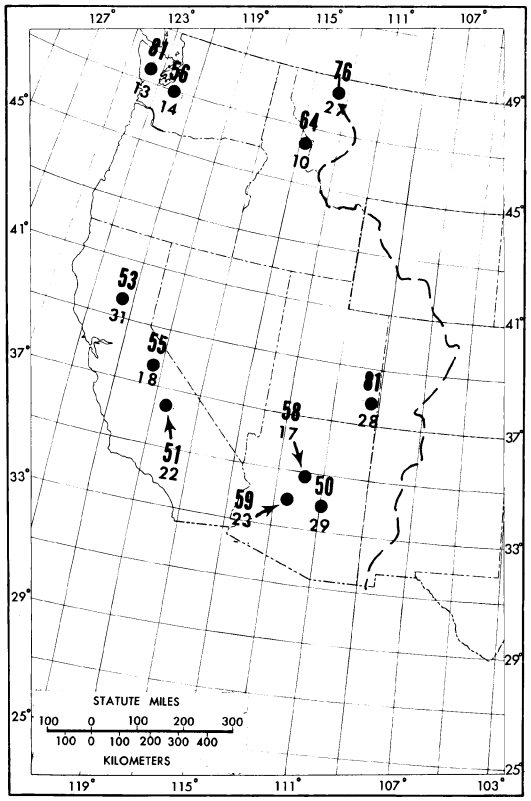

Plate 5: Observed rainfalls ≥ 50% of all-season PMP, U.S. west of the Continental Divide for 1000 mi^2 for one duration between 6 and 72 hours. (Large number is % of PMP. Small number is storm index, see table 2.)

Exhibit C-5

APPENDIX D TO § 222.6—RECOMMENDED GUIDELINES FOR SAFETY INSPECTION OF DAMS

Department of the Army—Office of the Chief of Engineers

Preface

The recommended guidelines for the safety inspection of dams were prepared to outline principal factors to be weighed in the determination of existing or potential hazards and to define the scope of activities to be undertaken in the safety inspection of dams. The establishment of rigid criteria or standards is not intended. Safety must be evaluated in the light of peculiarities and local conditions at a particular dam and in recognition of the many factors involved, some of which may not be precisely known. This can only be done by competent, experienced engineering judgment, which the guidelines are intended to supplement and not supplant. The guidelines are intended to be flexible, and the proper flexibility must be achieved through the employment of experienced engineering personnel.

Conditions found during the investigation which do not meet guideline recommendations should be assessed by the investigator as to their import from the standpoint of the involved degree of risk. Many deviations will not compromise project safety and the investigator is expected to identify them in this manner if that is the case. Others will involve various degrees of risk, the proper evaluation of which will afford a basis for priority of subsequent attention and possible remedial action.

The guidelines present procedures for investigating and evaluating existing conditions for the purpose of identifying deficiencies and hazardous conditions. The two phases of investigation outlined in the guidelines are expected to accomplish only this and do not encompass in scope the engineering which will be required to perform the design studies for corrective modification work.

It is recognized that some States may have established or will adopt inspection criteria incongruous in some respects with these guidelines. In such instances assessments of project safety should recognize the State's requirements as well as guideline recommendations.

The guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers. In reviewing two drafts of the guidelines they have contributed many helpful suggestions. Their contributions are deeply appreciated and have made it possible to evolve a document representing a consensus of the engineering fraternity. As experience is gained with use of the guidelines, suggestions for future revisions will be generated. All such suggestions should be directed to the Chief of Engineers, U.S. Army, DAEN-CWE-D, Washington, D.C. 20314.

RECOMMENDED GUIDELINES FOR SAFETY INSPECTION OF DAMS

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CHAPTER 1—INTRODUCTION

1.1. *Purpose*. This document provides recommended guidelines for the inspection and evaluation of dams to determine if they constitute hazards to human life or property.

1.2. *Applicability*. The procedures and guidelines outlined in this document apply to the inspection and evaluation of all dams as defined in the National Dam Inspection Act, Public Law 92–367. Included in this program are all artificial barriers together with appurtenant works which impound or divert water and which (1) are twenty-five feet or more in height or (2) have an impounding capacity of fifty acre-feet or more. Not included are barriers which are six feet or less in height, regardless of storage capacity, or barriers which have a storage capacity at maximum water storage elevation of fifteen acre-feet or less regardless of height.

1.3. *Authority*. The Dam Inspection Act, Public Law 92–367 (Appendix III), authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. The Chief of Engineers issues these guidelines pursuant to that authority.

CHAPTER 2—GENERAL REQUIREMENTS

2.1. *Classification of dams*. Dams should be classified in accordance with size and hazard potential in order to formulate a priority basis for selecting dams to be included in the inspection program and also to provide compatibility between guideline requirements and involved risks. When possible the initial classifications should be based upon information listed in the National Inventory of Dams with respect to size, impoundment capacity and hazard potential. It may be necessary to reclassify dams when additional information becomes available.

2.1.1. *Size*. The classification for size based on the height of the dam and storage capacity should be in accordance with Table 1. The height of the dam is established with respect to the maximum storage potential measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier, to the maximum water storage elevation. For the purpose of determining project size, the maximum storage elevation may be considered equal to the top of dam elevation. Size classification may be determined by either storage or height, whichever gives the larger size category.

TABLE 1—SIZE CLASSIFICATION

Category	Impoundment	
	Storage (ac-ft)	Height (ft)
Small	<1,000 and ≥50	<40 and ≥25.
Intermediate	≥1,000 and <50,000	≥40 and <100.
Large	≥50,000	≥100.

2.1.2. *Hazard Potential*. The classification for potential hazards should be in accordance with Table 2. The hazards pertain to potential loss of human life or property damage in the area downstream of the dam in event of failure or misoperation of the dam or appurtenant facilities. Dams conforming to criteria for the low hazard potential category generally will be located in rural or agricultural areas where failure may damage farm buildings, limited agricultural land, or township and country roads. Significant hazard potential category structures will be those located in predominantly rural or agricultural areas where failure may damage isolated homes, secondary highways or minor railroads or cause interruption of use or service of relatively important public utilities. Dams in the high hazard potential category will be those located where failure may cause serious damage to homes, extensive agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads.

TABLE 2—HAZARD POTENTIAL CLASSIFICATION

Category	Loss of life (extent of development)	Economic loss (extent of development)
Low	None expected (No permanent structures for human habitation).	Minimal (Undeveloped to occasional structures or agriculture).
Significant	Few (No urban developments and no more than a small number of inhabitable structures).	Appreciable (Notable agriculture, industry or structures).
High	More than few	Excessive (Extensive community, industry or agriculture).

2.2. *Selection of dams to be investigated*. The selection of dams to be investigated should be based upon an assessment of existing developments in flood hazard areas. Those dams possessing a hazard potential classified high or significant as indicated in Table 2 should be given first and second priorities, respectively, in the inspection program. Inspection priorities within each category may be developed from a consideration of factors such as size classification and age of the dam, the population size in the downstream flood area, and potential developments anticipated in flood hazard areas.

2.3. *Technical Investigations*. A detailed, systematic, technical inspection and evaluation should be made of each dam selected for investigation in which the hydraulic and hydrologic capabilities, structural stability and operational adequacy of project features are analyzed and evaluated to determine if the dam constitutes a danger to human life or property. The investigation should vary in scope and completeness depending upon the availability and suitability of engineering data, the validity of design assumptions and analyses and the condition of the dam. The minimum investigation will be designated Phase I, and an in-depth investigation designated Phase II should be made where deemed necessary. Phase I investigations should consist of a visual inspection of the dam, abutments and critical appurtenant structures, and a review of readily available engineering data. It is not intended to perform costly explorations or analyses during Phase I. Phase II investigations should consist of all additional engineering investigations and analyses found necessary by results of the Phase I investigation.

2.4. *Qualifications of investigators*. The technical investigations should be conducted under the direction of licensed professional engineers experienced in the investigation, design, construction and operation of dams, applying the disciplines of hydrologic, hydraulic, soils and structural engineering and engineering geology. All field inspections should be conducted by qualified engineers, engineering geologists and other specialists, including experts on mechanical and electrical operation of gates and controls, knowledgeable in the investigation, design, construction and operation of dams.

CHAPTER 3—PHASE I INVESTIGATION

3.1. *Purpose*. The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property.

3.2. *Scope*. The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigation and analyses are necessary and warranted. A review will be made of pertinent existing and available engineering data relative to the design, construction and operation of the dam and appurtenant structures, including electrical and mechanical operating equipment and measurements from inspection and performance instruments and devices; and a detailed systematic visual inspection will be performed of those features relating to the stability and operational adequacy of the project. Based upon findings of the review of engineering data and the visual inspection, an evaluation will be made of the general condition of the dam, including where possible the assessment of the hydraulic and hydrologic capabilities and the structural stability.

3.3. *Engineering data*. To the extent feasible the engineering data listed in Appendix I relating to the design, construction and operation of the dam and appurtenant structures, should be collected from existing records and reviewed to aid in evaluating the adequacy of hydraulic and hydrologic capabilities and stability of the dam. Where the necessary engineering data are unavailable, inadequate or invalid, a listing should be made of those specific additional data deemed necessary by the engineer in charge of the investigation and included in the Phase I report.

3.4. *Field inspections*. The field inspection of the dam, appurtenant stuctures, reservoir area, and downstream channel in the vicinity of the dam should be conducted in a systematic manner to minimize the possibility of any significant feature being overlooked. A detailed checklist should be developed and followed for each dam inspected to document

the examination of each significant structural and hydraulic feature including electrical and mechanical equipment for operation of the control facilities that affect the safety of the dam.

3.4.1. Particular attention should be given to detecting evidence of leakage, erosion, seepage, slope instability, undue settlement, displacement, tilting, cracking, deterioration, and improper functioning of drains and relief wells. The adequacy and quality of maintenance and operating procedures as they pertain to the safety of the dam and operation of the control facilities should also be assessed.

3.4.2. Photographs and drawings should be used freely to record conditions in order to minimize descriptions.

3.4.3. The field inspection should include appropriate features and items, including but not limited to those listed in Appendix II, which may influence the safety of the dam or indicate potential hazards to human life or property.

3.5. *Evaluation of hydraulic and hydrologic Features*.

3.5.1. *Design data*. Original hydraulic and hydrologic design assumptions obtained from the project records should be assessed to determine their acceptability in evaluating the safety of the dam. All constraints on water control such as blocked entrances, restrictions on operation of spillway and outlet gates, inadequate energy dissipators or restrictive channel conditions, significant reduction in reservoir capacity by sediment deposits and other factors should be considered in evaluating the validity of discharge ratings, storage capacity, hydrographs, routings and regulation plans. The discharge capacity and/or storage capacity should be capable of safely handling the recommended spillway design flood for the size and hazard potential classification of the dam as indicated in Table 3. The hydraulic and hydrologic determinations for design as obtained from project records will be acceptable if conventional techniques similar to the procedures outlined in paragraph 4.3. were used in obtaining the data. When the project design flood actually used exceeds the recommended spillway design flood, from Table 3, the project design flood will be acceptable in evaluating the safety of the dam.

TABLE 3—HYDROLOGIC EVALUATION GUIDELINES

[Recommended spillway design floods]

Hazard	Size	Spillway design flood (SDF) [1]
Low	Small	50 to 100-yr frequency.
	Intermediate	100-yr to ½ PMF.
	Large	½ PMF to PMF.
Significant	Small	100-yr to ½ PMF.
	Intermediate	½ PMF to PMF.
	Large	PMF.
High	Small	½ PMF to PMF.
	Intermediate	PMF.
	Large	PMF.

[1] The recommended design floods in this column represent the magnitude of the spillway design flood (SDF), which is intended to represent the largest flood that need be considered in the evaluation of a given project, regardless of whether a spillway is provided; *i.e.*, a given project should be capable of safely passing the appropriate SDF. Where a range of SDF is indicated, the magnitude that most closely relates to the involved risk should be selected.

1000-yr=100-Year Exceedence Interval. The flood magnitude expected to be exceeded, on the average, of once in 100 years. It may also be expressed as an exceedence frequency with a one-percent chance of being exceeded in any given year.

PMF=Probable Maximum Flood. The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is derived from probable maximum precipitation (PMP), which information is generally available from the National Weather Service, NOAA. Most Federal agencies apply reduction factors to the PMP when appropriate. Reductions may be applied because rainfall isohyetals are unlikely to conform to the exact shape of the drainage basin and/or the storm is not likely to center exactly over the drainage basin. In some cases local topography will cause changes from the generalized PMP values, therefore it may be advisable to contact Federal construction agencies to obtain the prevailing practice in specific areas.

3.5.2. *Experience data*. In some cases where design data are lacking, an evaluation of overtopping potential may be based on watershed characteristics and rainfall and reservoir records. An estimate of the probable maximum flood may also be developed from a conservative, generalized comparison of the drainage area size and the magnitude of recently adopted probable maximum floods for damsites in comparable hydrologic regions. Where the review of such experience data indicates that the recommended spillway design flood would not cause overtopping additional hydraulic and hydrologic determinations will be unnecessary.

3.6. *Evaluation of structural stability*. The Phase I evaluations of structural adequacy of project features are expected to be based principally on existing conditions as revealed by the visual inspection, together with available design and construction information and records of performance. The objectives are to determine the existence of conditions which are hazardous, or which with time might develop into safety hazards,

and to formulate recommendations pertaining to the need for any additional studies, investigations, or analyses. The results of this phase of the inspection must rely very substantially upon the experience and judgment of the inspecting engineer.

3.6.1. *Design and construction data.* The principal design assumptions and analyses obtained from the project records should be assessed. Original design and construction records should be used judiciously, recognizing the restricted applicability of such data as material strengths and permeabilities, geological factors and construction descriptions. Original stability studies and analyses should be acceptable if conventional techniques and procedures similar to those outlined in paragraph 4.4 were employed, provided that review of operational and performance data confirm that the original design assumptions were adequately conservative. The need for such analyses where either none exist or the originals are incomplete or unsatisfactory will be determined by the inspecting engineer based upon other factors such as condition of structures, prior maximum loadings and the hazard degree of the project. Design assumptions and analyses should include all applicable loads including earthquake and indicate the structure's capability to resist overturning, sliding and overstressing with adequate factors of safety. In general seepage and stability analyses comparable to the requirements of paragraph 4.4 should be on record for all dams in the high hazard category and large dams in the significant hazard category. This requirement for other dams will be subject to the opinion of the inspecting engineer.

3.6.2. *Operating records.* The performance of structures under prior maximum loading conditions should in some instances provide partial basis for stability evaluation. Satisfactory experience under loading conditions not expected to be exceeded in the future should generally be indicative of satisfactory stability, provided adverse changes in physical conditions have not occurred. Instrumentation observations of forces, pressures, loads, stresses, strains, displacements, deflections or other related conditions should also be utilized in the safety evaluation. Where such data indicate abnormal behavior, unsafe movement or deflections, or loadings which adversely affect the stability or functioning of the structure, prompt reporting of such circumstances is required without the delay for preparation of the official inspection report.

3.6.3. *Post construction changes.* Data should be collected on changes which have occurred since project construction that might influence the safety of the dam such as road cuts, quarries, mining and groundwater changes.

3.6.4. *Seismic stability.* An assessment should be made of the potential vulnerability of the dam to seismic events and a recommendation developed with regard to the need for additional seismic investigation. In general, projects located in Seismic Zones 0, 1 and 2 may be assumed to present no hazard from earthquake provided static stability conditions are satisfactory and conventional safety margins exist. Dams in Zones 3 and 4 should, as a minimum, have on record suitable analyses made by conventional equivalent static load methods. The seismic zones together with appropriate coefficients for use in such analyses are shown in Figures 1 through 4. Boundary lines are approximate and in the event of doubt about the proper zone, the higher zone should be used. All high hazard category dams in Zone 4 and high hazard dams of the hydraulic fill type in Zone 3 should have a stability assessment based upon knowledge of regional and local geology, engineering seismology, in situ properties of materials and appropriate dynamic analytical and testing procedures. The assessment should include the possibility of physical displacement of the structures due to movements along active faults. Departure from this general guidance should be made whenever in the judgment of the investigating engineer different seismic stability requirements are warranted because of local geological conditions or other reasons.

CHAPTER 4—PHASE II INVESTIGATION

4.1. *Purpose.* The Phase II investigation will be supplementary to Phase I and should be conducted when the results of the Phase I investigation indicate the need for additional in-depth studies, investigations or analyses.

4.2. *Scope.* The Phase II investigation should include all additional studies, investigations and analyses necessary to evaluate the safety of the dam. Included, as required, will be additional visual inspections, measurements, foundation exploration and testing, materials testing, hydraulic and hydrologic analysis and structural stability analyses.

4.3. *Hydraulic and hydrologic analysis.* Hydraulic and hydrologic capabilities should be determined using the following criteria and procedures. Depending on the project characteristics, either the spillway design flood peak inflow or the spillway design flood hydrograph should be the basis for determining the maximum water surface elevation and maximum outflow. If the operation or failure of upstream water control projects would have significant impact on peak flow or hydrograph analyses, the impact should be assessed.

4.3.1. *Maximum water surface based on SDF peak inflow.* When the total project discharge capability at maximum pool exceeds the peak inflow of the recommended SDF, and

operational constraints would not prevent such a release at controlled projects, a reservoir routing is not required. The maximum discharge should be assumed equal to the peak inflow of the spillway design flood. Flood volume is not controlling in this situation and surcharge storage is either absent or is significant only to the extent that it provides the head necessary to develop the release capability required.

4.3.1.1. *Peak for 100-year flood*. When the 100-year flood is applicable under the provisions of Table 3 and data are available, the spillway design flood peak inflow may be determined by use of ''A Uniform Technique for Determining Flood Frequencies,'' Water Resources Council (WRC), Hydrology Committee, Bulletin 15, December 1967. Flow frequency information from regional analysis is generally preferred over single station results when available and appropriate. Rainfall-runoff techniques may be necessary when there are inadequate runoff data available to make a reasonable estimate of flow frequency.

4.3.1.2. *Peak for PMF or fraction thereof*. When either the Probable Maximum Flood peak or a fraction thereof is applicable under the provisions of Table 3, the unit hydrograph—infiltration loss technique is generally the most expeditious method of computing the spillway design flood peak for most projects. This technique is discussed in the following paragraph.

4.3.2. *Maximum water surface based on SDF hydrograph*. Both peak and volume are required in this analysis. Where surcharge storage is significant, or where there is insufficient discharge capability at maximum pool to pass the peak inflow of the SDF, considering all possible operational constraints, a flood hydrograph is required. When there are upstream hazard areas that would be imperiled by fast rising reservoirs levels, SDF hydrographs should be routed to ascertain available time for warning and escape. Determination of probable maximum precipitation or 100-year precipitation, which ever is applicable, and unit hydrographs or runoff models will be required, followed by the determination of the PMF or 100-year flood. Conservative loss rates (significantly reduced by antecedent rainfall conditions where appropriate) should be estimated for computing the rainfall excess to be utilized with unit hydrographs. Rainfall values are usually arranged with gradually ascending and descending rates with the maximum rate late in the storm. When applicable, conservatively high snowmelt runoff rates and appropriate releases from upstream projects should be assumed. The PMP may be obtained from National Weather Service (NWS) publications such as Hydrometeorological Report (HMR) 33. Special NWS publications for particular areas should be used when available. Rainfall for the 100-year frequency flood can be obtained from the NWS publication ''Rainfall Frequency Atlas of the United States,'' Technical Paper No. 40; Atlas 2, ''Precipitation Frequency Atlas of Western United States;'' or other NWS publications. The maximum water surface elevation and spillway design flood outflow are then determined by routing the inflow hydrograph through the reservoir surcharge storage, assuming a starting water surface at the bottom of surcharge storage, or lower when appropriate. For projects where the bottom of surcharge space is not distinct, or the flood control storage space (exclusive of surcharge) is appreciable, it may be appropriate to select starting water surface elevations below the top of the flood control storage for routings. Conservatively high starting levels should be estimated on the basis of hydrometeorological conditions reasonably characteristic for the region and flood release capability of the project. Necessary adjustment of reservoir storage capacity due to existing or future sediment or other encroachment may be approximated when accurate determination of deposition is not practicable.

4.3.3. *Acceptable procedures*. Techniques for performing hydraulic and hydrologic analyses are generally available from publications prepared by Federal agencies involved in water resources development or textbooks written by the academic community. Some of these procedures are rather sophisticated and require expensive computational equipment and large data banks. While results of such procedures are generally more reliable than simplified methods, their use is generally not warranted in studies connected with this program unless they can be performed quickly and inexpensively. There may be situations where the more complex techniques have to be employed to obtain reliable results; however, these cases will be exceptions rather than the rule. Whenever the acceptability of procedures is in question, the advice of competent experts should be sought. Such expertise is generally available in the Corps of Engineers, Bureau of Reclamation and Soil Conservation Service. Many other agencies, educational facilities and private consultants can also provide expert advice. Regardless of where such expertise is based, the qualification of those individuals offering to provide it should be carefully examined and evaluated.

4.3.4. *Freeboard allowances*. Guidelines on specific minimum freeboard allowances are not considered appropriate because of the many factors involved in such determinations. The investigator will have to assess the critical parameters for each project and develop its minimum requirement. Many projects are reasonably safe without freeboard allowance because they are designed for overtopping, or other factors minimize possible overtopping. Conversely,

freeboard allowances of several feet may be necessary to provide a safe condition. Parameters that should be considered include the duration of high water levels in the reservoir during the design flood; the effective wind fetch and reservoir depth available to support wave generation; the probability of high wind speed occurring from a critical direction; the potential wave runup on the dam based on roughness and slope; and the ability of the dam to resist erosion from overtopping waves.

4.4 *Stability investigations*. The Phase II stability investigations should be compatible with the guidelines of this paragraph.

4.4.1 *Foundation and material investigations*. The scope of the foundation and materials investigation should be limited to obtaining the information required to analyze the structural stability and to investigate any suspected condition which would adversely affect the safety of the dam. Such investigations may include borings to obtain concrete, embankment, soil foundation, and bedrock samples; testing specimens from these samples to determine the strength and elastic parameters of the materials, including the soft seams, joints, fault gouge and expansive clays or other critical materials in the foundation; determining the character of the bedrock including joints, bedding planes, fractures, faults, voids and caverns, and other geological irregularities; and installing instruments for determining movements, strains, suspected excessive internal seepage pressures, seepage gradients and uplift forces. Special investigations may be necessary where suspect rock types such as limestone, gypsum, salt, basalt, claystone, shales or others are involved in foundations or abutments in order to determine the extent of cavities, piping or other deficiencies in the rock foundation. A concrete core drilling program should be undertaken only when the existence of significant structural cracks is suspected or the general qualitative condition of the concrete is in doubt. The tests of materials will be necessary only where such data are lacking or are outdated.

4.4.2. *Stability assessment*. Stability assessments should utilize in situ properties of the structure and its foundation and pertinent geologic information. Geologic information that should be considered includes groundwater and seepage conditions; lithology, stratigraphy, and geologic details disclosed by borings, ''as-built'' records, and geologic interpretation; maximum past overburden at site as deduced from geologic evidence; bedding, folding and faulting; joints and joint systems; weathering; slickensides, and field evidence relating to slides, faults, movements and earthquake activity. Foundations may present problems where they contain adversely oriented joints, slickensides or fissured material, faults, seams of soft materials, or weak layers. Such defects and excess pore water pressures may contribute to instability. Special tests may be necessary to determine physical properties of particular materials. The results of stability analyses afford a means of evaluating the structure's existing resistance to failure and also the effects of any proposed modifications. Results of stability analyses should be reviewed for compatibility with performance experience when possible.

4.4.2.1. *Seismic stability*. The inertial forces for use in the conventional equivalent static force method of analysis should be obtained by multiplying the weight by the seismic coefficient and should be applied as a horizontal force at the center of gravity of the section or element. The seismic coefficients suggested for use with such analyses are listed in Figures 1 through 4. Seismic stability investigations for all high hazard category dams located in Seismic Zone 4 and high hazard dams of the hydraulic fill type in Zone 3 should include suitable dynamic procedures and analyses. Dynamic analyses for other dams and higher seismic coefficients are appropriate if in the judgment of the investigating engineer they are warranted because of proximity to active faults or other reasons. Seismic stability investigations should utilize ''state-of-the-art'' procedures involving seismological and geological studies to establish earthquake parameters for use in dynamic stability analyses and, where appropriate, the dynamic testing of materials. Stability analyses may be based upon either time-history or response spectra techniques. The results of dynamic analyses should be assessed on the basis of whether or not the dam would have sufficient residual integrity to retain the reservoir during and after the greatest or most adverse earthquake which might occur near the project location.

4.4.2.2. *Clay shale foundation*. Clay shale is a highly overconsolidated sedimentary rock comprised predominantly of clay minerals, with little or no cementation. Foundations of clay shales require special measures in stability investigations. Clay shales, particularly those containing montmorillonite, may be highly susceptible to expansion and consequent loss of strength upon unloading. The shear strength and the resistance to deformation of clay shales may be quite low and high pore water pressures may develop under increase in load. The presence of slickensides in clay shales is usually an indication of low shear strength. Prediction of field behavior of clay shales should not be based solely on results of conventional laboratory tests since they may be misleading. The use of peak shear strengths for clay shales in stability analyses may be unconservative because of nonuniform stress distribution and possible progressive failures. Thus the available shear resistance may be less than if the peak shear strength

were mobilized simultaneously along the entire failure surface. In such cases, either greater safety factors or residual shear strength should be used.

4.4.3. *Embankment dams.*

4.4.3.1. *Liquefaction.* The phenomenon of liquefaction of loose, saturated sands and silts may occur when such materials are subjected to shear deformation or earthquake shocks. The possibility of liquefaction must presently be evaluated on the basis of empirical knowledge supplemented by special laboratory tests and engineering judgment. The possiblitity of liquefaction in sands diminishes as the relative density increases above approximately 70 percent. Hydraulic fill dams in Seismic Zones 3 and 4 should receive particular attention since such dams are susceptible to liquefaction under earthquake shocks.

4.4.3.2. *Shear failure.* Shear failure is one in which a portion of an embankment or of an embankment and foundation moves by sliding or rotating relative to the remainder of the mass. It is conventionally represented as occurring along a surface and is so assumed in stability analyses, although shearing may occur in a zone of substantial thickness. The circular arc or the sliding wedge method of analyzing stability, as pertinent, should be used. The circular arc method is generally applicable to essentially homogeneous embankments and to soil foundations consisting of thick deposits of fine-grained soil containing no layers significantly weaker than other strata in the foundation. The wedge method is generally applicable to rockfill dams and to earth dams on foundations containing weak layers. Other methods of analysis such as those employing complex shear surfaces may be appropriate depending on the soil and rock in the dam and foundation. Such methods should be in reputable usage in the engineering profession.

4.4.3.3. *Loading conditions.* The loading conditions for which the embankment structures should be investigated are (I) Sudden drawdown from spillway crest elevation or top of gates, (II) Partial pool, (III) Steady state seepage from spillway crest elevation or top of gate elevation, and (IV) Earthquake. Cases I and II apply to upstream slopes only; slopes; and Case IV applies to both upstream and downstream Case III applies to downstream slopes. A summary of suggested strengths and safety factors are shown in Table 4.

TABLE 4—FACTORS OF SAFETY[1]

Case and loading condition	Factor of safety	Shear[2] strength	Remarks
I Sudden drawdown from spillway crest or top of gates to minimum drawdown elevation.	[3] 1.2	Minimum composite of R and S shear strengths. See Figure 5.	Within the drawdown zone submerged unit weights of materials are used for computing forces resisting sliding and saturated unit weights are used for computing forces contributing to sliding.
II Partial pool with assumed horizontal steady seepage saturation.	1.5	R+S/2 for R<S ..... S for R>S	Composite intermediate envelope of R and S shear strengths. See Figure 6.
III Steady seepage from spillway crest or top of gates with K_h/K_v=9 assumed[4].	1.5	Same as Case II.	
IV Earthquake (Cases II and III with seismic loading).	1.0	([5])	See Figures 1 through 4 for Seismic Coefficients.

[1] Not applicable to embankments on clay shale foundation. Experience has indicated special problems in determination of design shear strengths for clay shale foundations and acceptable safety factors should be compatible with the confidence level in shear strength assumptions.

[2] Other strength assumptions may be used if in common usage in the engineering profession.

[3] The safety factor should not be less than 1.5 when drawdown rate and pore water pressure developed from flow nets are used in stability analyses.

[4] K_h/K_v is the ratio of horizontal to vertical permeability. A minimum of 9 is suggested for use in compacted embankments and alluvial sediments.

[5] Use shear strength for case analyzed without earthquake. It is not necessary to analyze sudden drawdown for earthquake loading. Shear strength tests are classified according to the controlled drainage conditions maintained during the test. R tests are those in which specimen drainage is allowed during consolidation (or swelling) under initial stress conditions, but specimen drainage is not allowed during application of shearing stresses. S tests allow full drainage during initial stress application and shearing is at a slow rate so that complete specimen drainage is permitted during the complete test.

4.4.3.4. *Safety factors.* Safety factors for embankment dam stability studies should be based on the ratio of available shear strength to developed shear strength, S_D:

$$S_D = \frac{C}{F.S.} + \frac{\sigma \tan \phi}{F.S.} \qquad (1)$$

Where:

C=Cohesion

φ=Angle of internal friction

σ=Normal stress

The factors of safety listed in Table 4 are recommended as minimum acceptable. Final accepted factors of safety should depend upon the degree of confidence the investigating engineer has in the engineering data

available to him. The consequences of a failure with respect to human life and property damage are important considerations in establishing factors of safety for specific investigations.

4.4.3.5. *Seepage failure.* A critical uncontrolled underseepage or through seepage condition that develops during a rising pool can quickly reduce a structure which was stable under previous conditions, to a total structural failure. The visually confirmed seepage conditions to be avoided are (1) the exit of the phreatic surface on the downstream slope of the dam and (2) development of hydrostatic heads sufficient to create in the area downstream of the dam sand boils that erode materials by the phenomenon known as ''piping'' and (3) localized concentrations of seepage along conduits or through pervious zones. The dams most susceptible to seepage problems are those built of or on pervious materials of uniform fine particle size, with no provisions for an internal drainage zone and/or no underseepage controls.

4.4.3.6. *Seepage analyses.* Review and modifications to original seepage design analyses should consider conditions observed in the field inspection and piezometer instrumentation. A seepage analysis should consider the permeability ratios resulting from natural deposition and from compaction placement of materials with appropriate variation between horizontal and vertical permeability. An underseepage analysis of the embankment should provide a critical gradient factor of safety for the maximum head condition of not less than 1.5 in the area downstream of the embankment.

$$F.S. = \frac{i_c}{i} = \frac{H_c/D_b}{H/D_b} = D_b \frac{(\gamma m - \gamma w)}{H\gamma w} \qquad (2)$$

Where:

i_c=Critical gradient
i=Design gradient
H=Uplift head at downstream toe of dam measured above tailwater
H_c=The critical uplift
D_b=The thickness of the top impervious blanket at the downstream toe of the dam
γ_m=The estimated saturated unit weight of the material in the top impervious blanket
γ_w=The unit weight of water

Where a factor of safety less than 1.5 is obtained the provision of an underseepage control system is indicated. The factor of safety of 1.5 is a recommended minimum and may be adjusted by the responsible engineer based on the competence of the engineering data.

4.4.4. *Concrete dams and appurtenant structures.*

4.4.4.1. *Requirements for stability.* Concrete dams and structures appurtenant to embankment dams should be capable of resisting overturning, sliding and overstressing with adequate factors of safety for normal and maximum loading conditions.

4.4.4.2. *Loads.* Loadings to be considered in stability analyses include the water load on the upstream face of the dam; the weight of the structure; internal hydrostatic pressures (uplift) within the body of the dam, at the base of the dam and within the foundation; earth and silt loads; ice pressure, seismic and thermal loads, and other loads as applicable. Where tailwater or backwater exists on the downstream side of the structure it should be considered, and assumed uplift pressures should be compatible with drainage provisions and uplift measurements if available. Where applicable, ice pressure should be applied to the contact surface of the structure of normal pool elevation. A unit pressure of not more than 5,000 pounds per square foot should be used. Normally, ice thickness should not be assumed greater than two feet. Earthquake forces should consist of the inertial forces due to the horizontal acceleration of the dam itself and hydrodynamic forces resulting from the reaction of the reservoir water against the structure. Dynamic water pressures for use in a conventional methods of analysis may be computed by means of the ''Westergaard Formula'' using the parabolic approximation (H.M. Westergaard, ''Water Pressures on Dams During Earthquakes,'' Trans., ASCE, Vol 98, 1933, pages 418–433), or similar method.

4.4.4.3. *Stresses.* The analysis of concrete stresses should be based on in situ properties of the concrete and foundation. Computed maximum compressive stresses for normal operating conditions in the order of ⅓ or less of in situ strengths should be satisfactory. Tensile stresses in unreinforced concrete should be acceptable only in locations where cracks will not adversely affect the overall performance and stability of the structure. Foundation stresses should be such as to provide adequate safety against failure of the foundation material under all loading conditions.

4.4.4.4. *Overturning.* A gravity structure should be capable of resisting all overturning forces. It can be considered safe against overturning if the resultant of all combinations of horizontal and vertical forces, excluding earthquake forces, acting above any horizontal plane through the structure or at its base is located within the middle third of the section. When earthquake is included the resultant should fall within the limits of the plane or base, and foundation pressures must be acceptable. When these requirements for location of the resultant are not satisfied the investigating engineer should assess the importance to stability of the deviations.

4.4.4.5. *Sliding.* Sliding of concrete gravity structures and of abutment and foundation rock masses for all types of concrete dams

should be evaluated by the shear-friction resistance concept. The available sliding resistance is compared with the driving force which tends to induce sliding to arrive at a sliding stability safety factor. The investigation should be made along all potential sliding paths. The critical path is that plane or combination of planes which offers the least resistance.

4.4.4.5.1. *Sliding resistance.* Sliding resistance is a function of the unit shearing strength at no normal load (cohesion) and the angle of friction on a potential failure surface. It is determined by computing the maximum horizontal driving force which could be resisted along the sliding path under investigation. The following general formula is obtained from the principles of statics and may be derived by resolving forces parallel and perpendicular to the sliding plane:

$$R_R = V \tan(\phi + \alpha) + \frac{cA}{\cos\alpha(1 - \tan\phi \tan\alpha)} \qquad (3)$$

Where:

R_R=Sliding Resistance (maximum horizontal driving force which can be resisted by the critical path)

φ=Angle of internal friction of foundation material or, where applicable, angle of sliding friction

V=Summation of vertical forces (including uplift)

c=Unit shearing strength at zero normal loading along potential failure plane

A=Area of potential failure plane developing unit shear strength ''c''

α=Angle between inclined plane and horizontal (positive for uphill sliding)

For sliding downhill the angle α is negative and Equation (1) becomes:

$$R_R = V \tan(\phi - \alpha) + \frac{cA}{\cos\alpha(1 + \tan\phi \tan\alpha)} \qquad (4)$$

When the plane of investigation is horizontal, and the angle α is zero and Equation (1) reduced to the following:

$$R_R = V \tan\phi + cA \qquad (5)$$

4.4.4.5.2. *Downstream esistance.* When the base of a concrete structure is embedded in rock or the potential failure plane lies below the base, the passive resistance of the downstream layer of rock may sometimes be utilized for sliding resistance. Rock that may be subjected to high velocity water scouring should not be used. The magnitude of the downstream resistance is the lesser of (a) the shearing resistance along the continuation of the potential sliding plane until it daylights or (b) the resistance available from the downstream rock wedge along an inclined plane. The theoretical resistance offered by the passive wedge can be computed by a formula equivalent to formula (3):

$$P_p = W \tan(\phi + \alpha) + \frac{cA}{\cos\alpha(I - \tan\phi \tan\alpha)} \qquad (6)$$

Where:

P_p=Passive resistance of rock wedge

W=Weight (buoyant weight if applicable) of downstream rock wedge above inclined plane of resistance, plus any superimposed loads

φ=Angle of internal friction or, if applicable, angle of sliding friction

α=Angle between inclined failure plane and horizontal

c=Unit shearing strength at zero normal load along failure plane

A=Area of inclined plane of resistance

When considering cross-bed shear through a relatively shallow, competent rock strut, without adverse jointing or faulting, W and α may be taken at zero and 45°, respectively, and an estimate of passive wedge resistance

per unit width obtained by the following equation:

$$P_p = 2\,cD \qquad (7)$$

Where:

D=Thickness of the rock strut

4.4.4.5.3. *Safety factor*. The shear-friction safety factor is obtained by dividing the resistance R_R by H, the summation of horizontal service loads to be applied to the structure:

$$S_{S-f} = \frac{R_R}{H} \qquad (8)$$

When the downstream passive wedge contributes to the sliding resistance, the shear friction safety factor formula becomes:

$$S_{S-f} = \frac{R_R + P_P}{H} \qquad (9)$$

The above direct superimposition of passive wedge resistance is valid only if shearing rigidities of the foundation components are similar. Also, the compressive strength and buckling resistance of the downstream rock layer must be sufficient to develop the wedge resistance. For example, a foundation with closely spaced, near horizontal, relatively weak seams might not contain sufficient buckling strength to develop the magnitude of wedge resistance computed from the cross-bed shear strength. In this case wedge resistance should not be assumed without resorting to special treatment (such as installing foundation anchors). Computed sliding safety factors approximating 3 or more for all loading conditions without earthquake, and 1.5 including earthquake, should indicate satisfactory stability, depending upon the reliability of the strength parameters used in the analyses. In some cases when the results of comprehensive foundation studies are available, smaller safety factors may be acceptable. The selection of shear strength parameters should be fully substantiated. The bases for any assumptions; the results of applicable testing, studies and investigations; and all pre-existing, pertinent data should be reported and evaluated.

CHAPTER 5—REPORTS

5.1. *General*. This chapter outlines the procedures for reporting the results of the technical investigations. Hazardous conditions should be reported immediately upon detection to the owner of the dam, the Governor of the State in which the dam is located and the appropriate regulatory agency without delay for preparation of the formal report.

5.2. *Preparation of report*. A formal report should be prepared for each dam investigated for submission to the regulatory agency and the owner of the dam. Each report should contain the information indicated in the following paragraphs. The signature and registration identification of the professional engineer who directed the investigation and who was responsible for evaluation of the dam should be included in the report.

5.2.1. *Phase I reports*. Phase I reports should contain the following information:

5.2.1.1. Description of dam including regional vicinity map showing location and plans, elevations and sections showing the essential project features and the size and hazard potential classifications.

5.2.1.2. Summary of existing engineering data, including geologic maps and information.

5.2.1.3. Results of the visual inspection of each project feature including photographs and drawings to minimize descriptions.

5.2.1.4. Evaluation of operational adequacy of the reservoir regulation plan and maintenance of the dam and operating facilities and features that pertain to the safety of the dam.

5.2.1.5. Description of any warning system in effect.

5.2.1.6. Evaluation of the hydraulic and hydrologic assumptions and structural stability.

5.2.1.7. An assessment of the general condition of the dam with respect to safety based upon the findings of the visual inspection and review of engineering data. Where data on the original design indicate significant departure from or non-conformance with guidelines contained herein, the engineer-in-charge of the investigation will give his opinion of the significance, with regard to safety, of such factors. Any additional studies, investigations and analyses considered essential to assessment of the safety of the dam should be listed, together with an opinion about the urgency of such additional work.

5.2.1.8. Indicate alternative possible remedial measures or revisions in operating and maintenance procedures which may (subject to further evaluation) correct deficiencies and hazardous conditions found during the investigation.

5.2.2. *Phase II reports*. Phase II reports should describe the detailed investigations and should supplement Phase I reports. They should contain the following information:

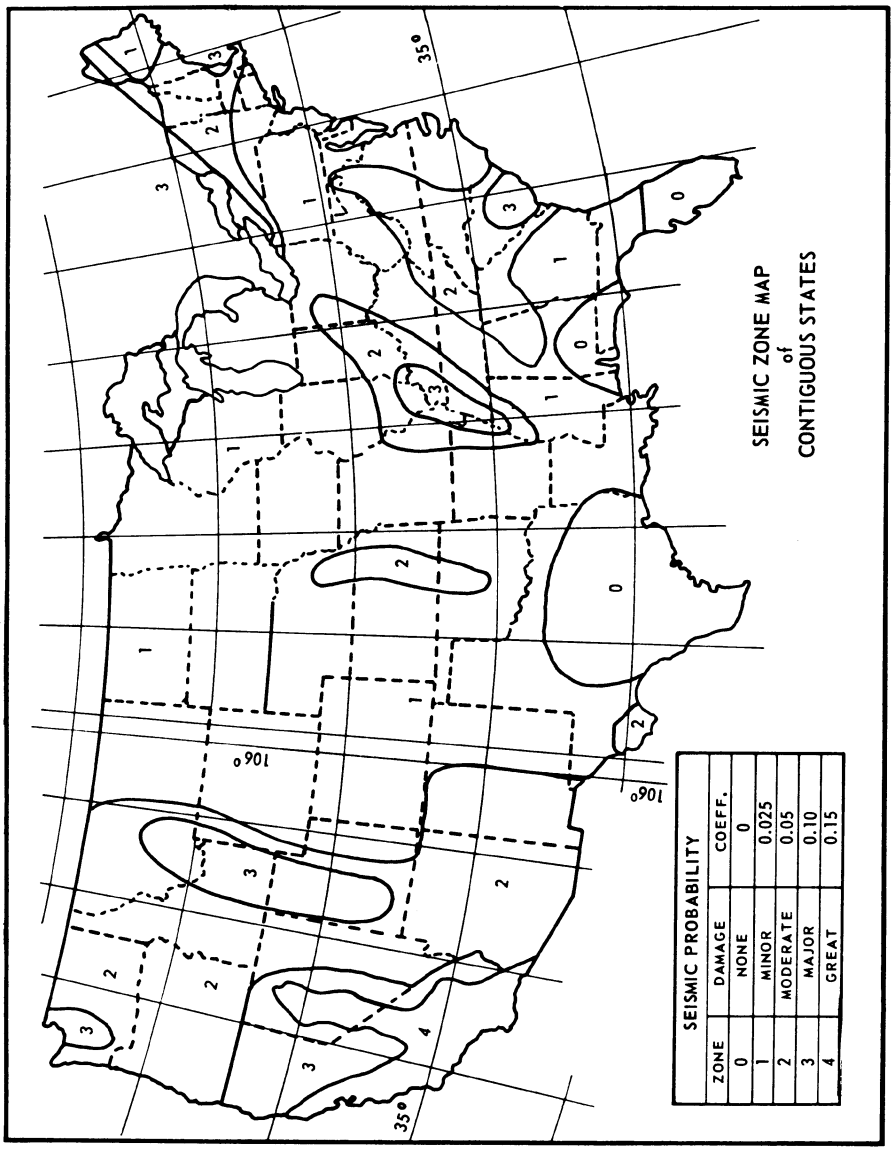
5.2.2.1. Summary of additional engineering data obtained to determine the hydraulic and hydrologic capabilities and/or structural stability.

5.2.2.2. Results of all additional studies, investigations, and analyses performed.

5.2.2.3. Technical assessment of dam safety including deficiences and hazardous conditions found to exist.

5.2.2.4. Indicate alternative possible remedial measures or revision in maintenance and operating procedures which may (subject

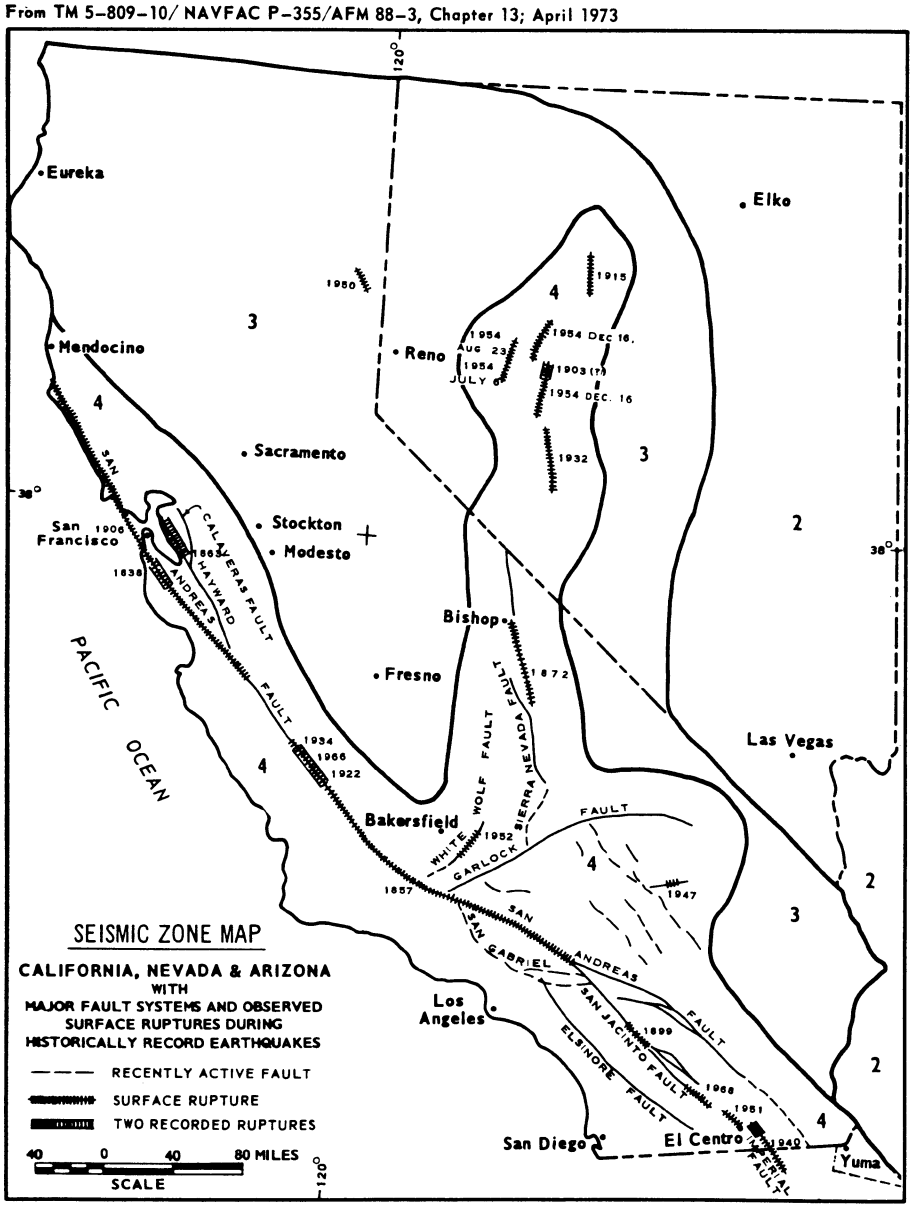
to further evaluation) correct deficiencies and hazardous conditions found during the investigation.



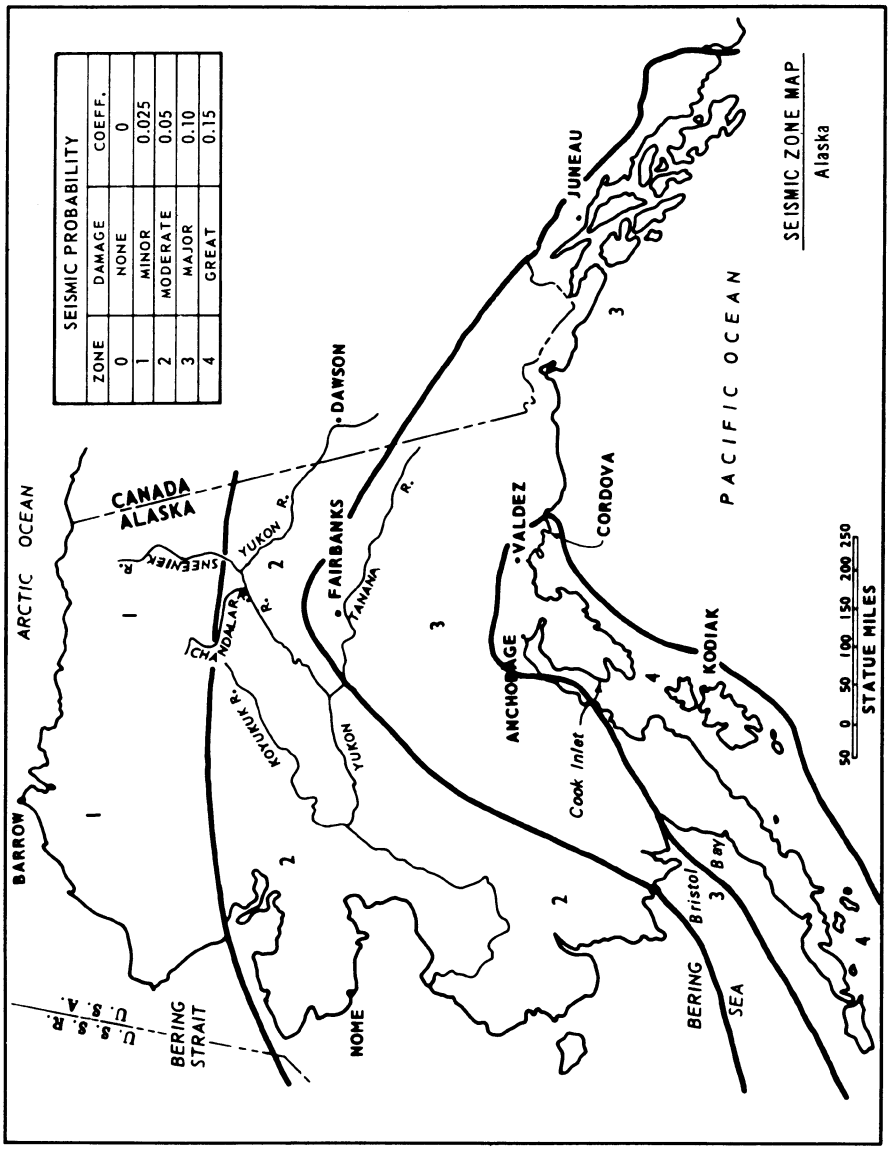
From TM 5-809-10/ NAVFAC P-355/AFM 88-3, Chapter 13; April 1973

Figure 1

From TM 5-809-10/ NAVFAC P-355/AFM 88-3, Chapter 13; April 1973

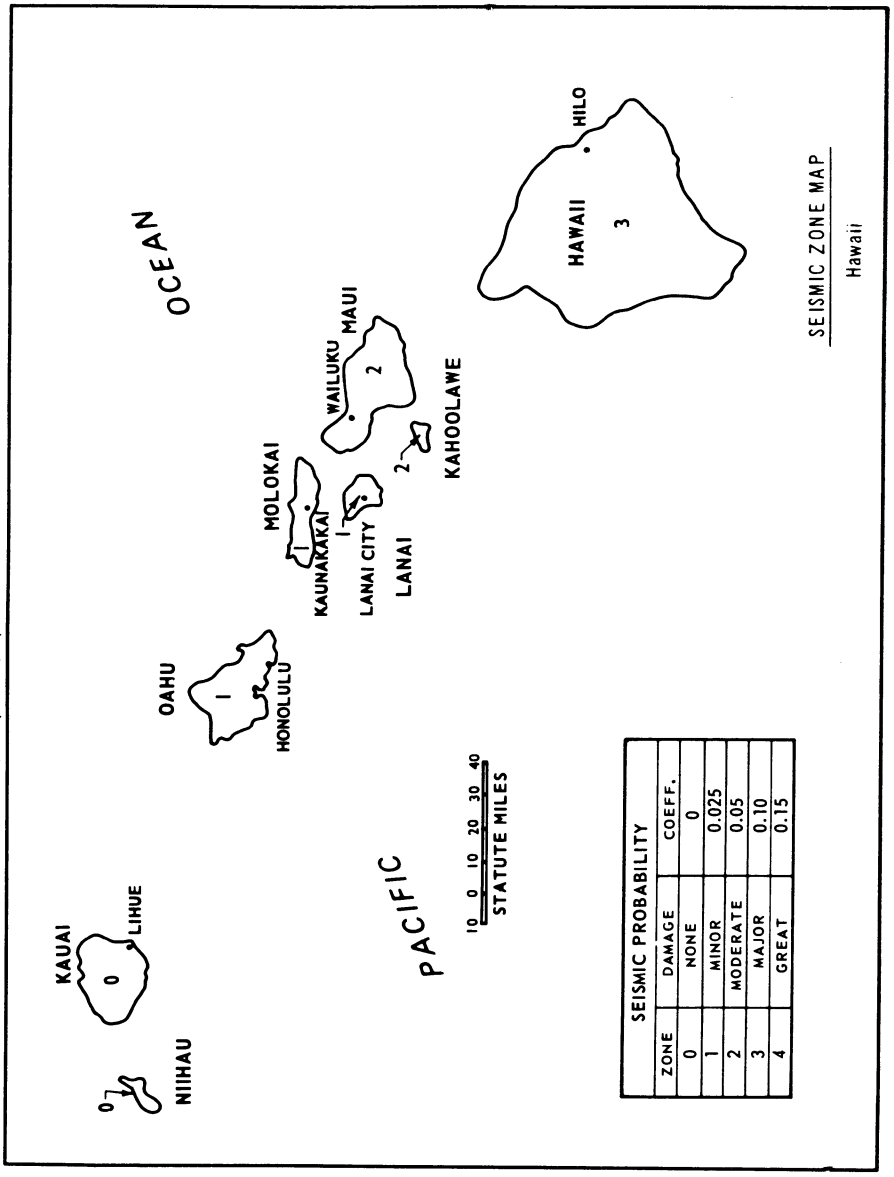


Appendix D, Figure 2



From TM 5–809–10/NAVFAC P–355/AFM 88–3, Chapter 13; April 1973

Figure 3



SEISMIC PROBABILITY

ZONE	DAMAGE	COEFF.
0	NONE	0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

From TM 5-809-10/NAVFAC P-355/AFM 88-3, Chapter 13; April 1973

Figure 4

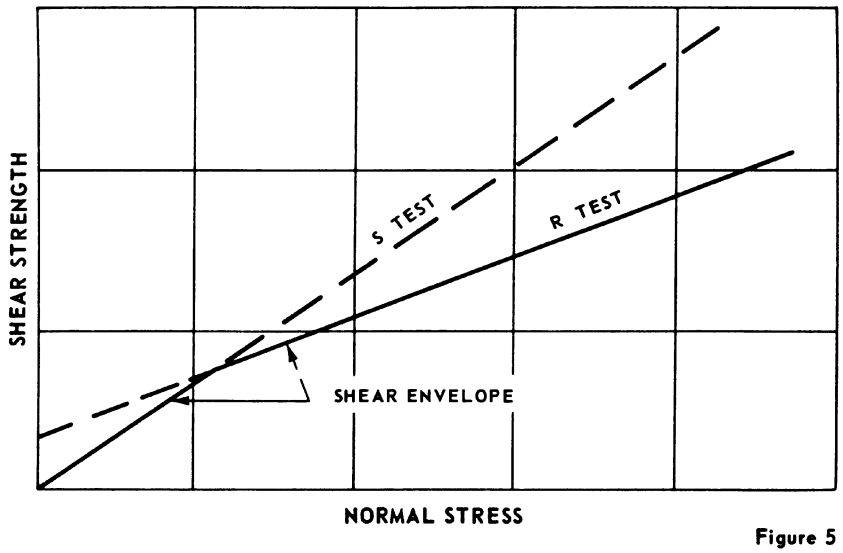


Figure 5

SHEAR ENVELOPE FOR CASE I

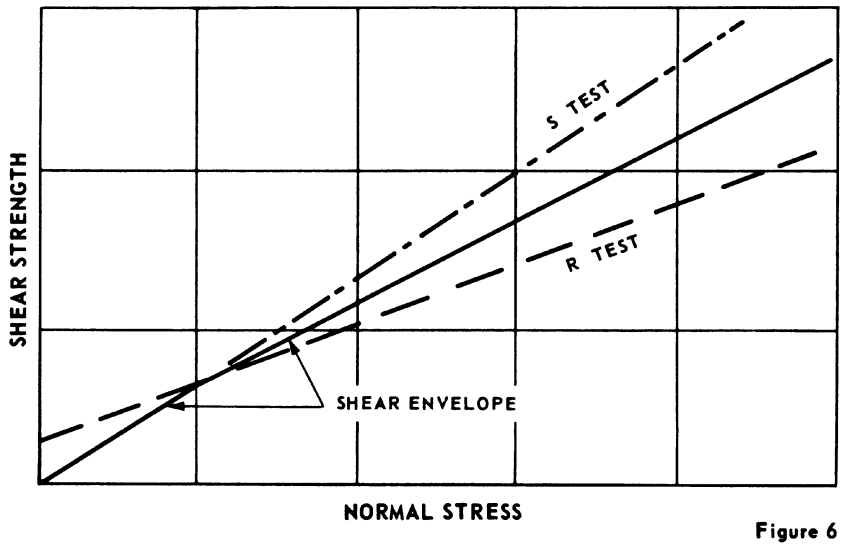


Figure 6

SHEAR ENVELOPE FOR CASES II AND III

APPENDIX I TO APP. D TO § 222.6—ENGINEERING DATA

This appendix lists engineering data which should be collected from project records and, to the extent available, included in the

Phase I investigation report. The list is intended to serve as a checklist and not to establish rigid data requirements. Such a compilation should also facilitate future inspections and investigations. Only data readily available will be included in Phase I reports, but data lacking and deemed necessary for an adequate safety evaluation should be identified.

1. *General Project Data.*

a. *Regional Vicinity Map* showing the location of the dam, the upstream drainage area and the downstream area subject to potential damage due to failure of the dam and misoperation or failure of the operating equipment.

b. *As-Built Drawings* indicating plans, elevations and sections of the dam and appurtenant structures including the details of the discharge facilities such as outlet works, limited service and emergency spillways, flashboards, fuse plugs and operating equipment.

2. *Hydrologic and Hydraulic Data* including the following:

a. Drainage area and basin runoff characteristics (indicating pending changes).

b. Elevation of top of conservation pool or normal upper retention water surface elevation, as applicable (base level of any flood impoundment).

c. Storage capacity including dead or inactive storage, corresponding to top of conservation or normal upper retention level (cumulative, excluding flood control and surcharge storage).

d. Elevation of the top of flood control pool.

e. Storage capacity of flood control zone (incremental).

f. Elevation of maximum design pool (corresponding to top of surcharge storage or spillway design flood).

g. Storage capacity of surcharge zone (incremental, above top of flood control pool or, above normal upper retention level if flood control space not provided).

h. Height of freeboard (distance between maximum design flood water surface and top of dam).

i. Elevation of top of dam (lowest point of embankment or non-overflow structure).

j. Elevation of crest, type, width, crest length and location of spillways (number, size and type of gates if controlled).

k. Type, location, entrance and exit inverts of outlet works and emergency drawdown facilities (number, size and shape of conduits and gates, including penstocks and sluices).

l. Location, crest elevation, description of invert and abutments (concrete, rock, grass, earth) and length of limited service and emergency spillways.

m. Location and dscription of flashboards and fuse plugs, including hydraulic head (pool elevation) and other conditions required for breaching, along with the assumed results of breaching.

n. Location and top elevation of dikes and floodwalls (overflow and non-overflow) affected by reservoir. Include information on low reaches of reservoir rim.

o. Type, location, observations and records of hydrometeorological gages appurtenant to the project.

p. Maximum non-damaging discharge, or negligible damage rate, at potential damage locations downstream.

3. *Foundation Data and Geological Features* including logs of borings, geological maps, profiles and cross sections, and reports of foundation treatment.

4. *Properties of Embankments and Foundation Materials* including results of laboratory tests, field permeability tests, construction control tests, and assumed design properties for materials.

5. *Concrete Properties* including the source and type of aggregate, cement used, mix design data and the results of testing during construction.

6. *Electrical and Mechanical Equipment* type and rating of normal and emergency power supplies, hoists, cranes, valves and valve operator, control and alarm systems and other electrical and mechanical equipment and systems that could affect the safe operation of the dam.

7. *Construction History* including diversion scheme, construction sequence, pertinent construction problems, alterations, modifications and maintenance repairs.

8. Water Control Plan including regulation plan under normal conditions and during flood events or other emergency conditions. The availability of dam tenders, means of communication between dam tenders and authority supervising water control, and method of gate operation (manual, automatic, or remote control) should be included. Flood warning systems should be described in sufficient detail to enable assessment of their reduction in the flood hazard potential.

9. *Operation Record.*

a. Summary of past major flood events including any experiences that presented a serious threat to the safety of the project or to human life or property. The critical project feature, date and duration of event, causative factor, peak inflow and outflow, maximum elevation of water surface, wind and wave factors if significant, issuance of alert or evacuation warnings and adequacy of project feature involved should be included in the summary of past experience of serious threat to the safety of the project.

b. Records of performance observations including instrumentation records.

c. List of any known deficiencies that pose a threat to the safety of the dam or to human life or property.

d. History of previous failures or deficiencies and pending remedial measures for correcting known deficiencies and the schedule for accomplishing remedial measures should be indicated.

10. *Earthquake History* including a summary of the seismic data of significant recorded earthquakes in the vicinity of the dam and information on major damage in the vicinity of the dam from both recorded and unrecorded earthquakes. Regional geologic maps and other documents showing fault locations should be collected.

11. *Inspection History* including the results of the last safety inspection, the organization that performed the inspection, the date inspection performed and the authority for conducting the inspection.

12. *Principal Design Assumptions and Analyses.*

a. *Hydrologic and Hydraulic Determinations.*

(1) Quantity, time and area distribution, and reference source of depth-area-duration data of spillway design storm precipitation (point precipitation if applicable).

(2) Maximum design flood inflow hydrograph including loss rates (initial and average for design flood conditions) and time of runoff concentration of reservior watershed (peak inflow only when applicable).

(3) Maximum design flood outflow hydrograph (maximum outflow only when applicable).

(4) Discharge-frequency relationship, preferably at damsite, including estimated frequency of spillway design flood for small dams, when appropriate.

(5) Reservior area and storage capacity versus water surface elevation (table or curves).

(6) Rating curves (free flow and partial gate openings) for all discharge facilities contributing to the maximum design flood outflow hydrograph. Also a composite-rating of all contributing facilities, if appropriate.

(7) Tailwater rating curve immediately below damsite including elevation corresponding to maximum design flood discharge and approximate nondamaging channel capacity.

(8) Hydrologic map of watershed above damsite including reservior area, watercourse, elevation contours, and principal stream-flow and precipitation gaging stations.

b. *Stability and Stress Analysis* of the dam, spillway and appurtenant structures and features including the assumed properties of materials and all pertinent applied loads.

c. *Seepage and Settlement Analyses.* The determination of distribution, direction and magnitude of seepage forces and the design and construction measures for their control. Settlement estimates and steps adopted to compensate for total settlement and to minimize differential settlements.

APPENDIX II TO APP. D TO § 222.6—INSPECTION ITEMS

This appendix provides guidance for performing field inspections and may serve as the basis for developing a detailed checklist for each dam.

1. *Concrete Structures in General.*

a. *Concrete Surfaces.* The condition of the concrete surfaces should be examined to evaluate the deterioration and continuing serviceability of the concrete. Descriptions of concrete conditions should conform with the appendix to ''Guide for Making a Condition Survey of Concrete in Service,'' American Concrete Institute (ACI) Journal, Proceedings Vol. 65, No. 11, November 1968, page 905–918.

b. *Structural Cracking.* Concrete structures should be examined for structural cracking resulting from overstress due to applied loads, shrinkage and temperature effects or differential movements.

c. *Movement—Horizontal and Vertical Alignment.* Concrete structures should be examined for evidence of any abnormal settlements, heaving, deflections, or lateral movements.

d. *Junctions.* The conditions at the junctions of the structure with abutments or embankments should be determined.

e. *Drains—Foundation, Joint, Face.* All drains should be examined to determine that they are capable of performing their design function.

f. *Water Passages.* All water passages and other concrete surfaces subject to running water should be examined for erosion, cavitation, obstructions, leakage or significant structural cracks.

g. *Seepage or Leakage.* The faces, abutments and toes of the concrete structures should be examined for evidence of seepage or abnormal leakage, and records of flow of downstream springs reviewed for variation with reservoir pool level. The sources of seepage should be determined if possible.

h. *Monolith Joints—Construction Joints.* All monolith and construction joints should be examined to determine the condition of the joint and filler material, any movement of joints, or any indication of distress or leakage.

i. *Foundation.* Foundation should be examined for damage or possible undermining of the downstream toe.

j. *Abutments.* The abutments should be examined for sign of instability or excessive weathering.

2. *Embankment Structures.*

a. *Settlement.* The embankments and downstream toe areas should be examined for any evidence of localized or overall settlement, depressions or sink holes.

b. *Slope Stability.* Embankment slopes should be examined for irregularities in

alignment and variances from smooth uniform slopes, unusual changes from original crest alignment and elevation, evidence of movement at or beyond the toe, and surface cracks which indicate movement.

c. *Seepage*. The downstream face of abutments, embankment slopes and toes, embankment—structure contacts, and the downstream valley areas should be examined for evidence of existing or past seepage. The sources of seepage should be investigated to determine cause and potential severity to dam safety under all operating conditions. The presence of animal burrows and tree growth on slopes which might cause detrimental seepage should be examined.

d. *Drainage Systems*. All drainage systems should be examined to determine whether the systems can freely pass discharge and that the discharge water is not carrying embankment or foundation material. Systems used to monitor drainage should be examined to assure they are operational and functioning properly.

e. *Slope Protection*. The slope protection should be examined for erosion-formed gullies and wave-formed notches and benches that have reduced the embankment cross-section or exposed less wave resistant materials. The adequacy of slope protection against waves, currents, and surface runoff that may occur at the site should be evaluated. The condition of vegetative cover should be evaluated where pertinent.

3. *Spillway Structures*. Examination should be made of the structures and features including bulkheads, flashboards, and fuse plugs of all service and auxiliary spillways which serve as principal or emergency spillways for any condition which may impose operational constraints on the functioning of the spillway.

a. *Control Gates and Operating Machinery*. The structural members, connections, hoists, cables and operating machinery and the adequacy of normal and emergency power supplies should be examined and tested to determine the structural integrity and verify the operational adequacy of the equipment. Where cranes are intended to be used for handling gates and bulkheads, the availability, capacity and condition of the cranes and lifting beams should be investigated. Operation of control systems and protective and alarm devices such as limit switches, sump high water alarms and drainage pumps should be investigated.

b. *Unlined Saddle Spillways*. Unlined saddle spillways should be examined for evidence of erosion and any conditions which may impose constraints on the functioning of the spillway. The ability of the spillway to resist erosion due to operation and the potential hazard to the safety of the dam from such operation should be determined.

c. *Approach and Outlet Channels*. The approach and outlet channels should be examined for any conditions which may impose constraints on the functioning of the spillway and present a potential hazard to the safety of the dam.

d. *Stilling Basin (Energy Dissipators)*. Stilling basins including baffles, flip buckets or other energy dissipators should be examined for any conditions which may pose constraints on the ability of the stilling basin to prevent downstream scour or erosion which may create or present a potential hazard to the safety of the dam. The existing condition of the channel downstream of the stilling basin should be determined.

4. *Outlet Works*. The outlet works examination should include all structures and features designed to release reservoir water below the spillway crest through or around the dam.

a. *Intake Structure*. The structure and all features should be examined for any conditions which may impose operational constraints on the outlet works. Entrances to intake structure should be examined for conditions such as silt or debris accumulation which may reduce the discharge capabilities of the outlet works.

b. *Operating and Emergency Control Gates*. The structural members, connections, guides, hoists, cables and operating machinery including the adequacy of normal and emergency power supplies should be examined and tested to determine the structural integrity and verify the operational adequacy of the operating and emergency gates, valves, bulkheads, and other equipment.

c. *Conduits, Sluices, Water Passages, Etc*. The interior surfaces of conduits should be examined for erosion, corrosion, cavitation, cracks, joint separation and leakage at cracks or joints.

d. *Stilling Basin (Energy Dissipator)*. The stilling basin or other energy dissipator should be examined for conditions which may impose any constraints on the ability of the stilling basin to prevent downstream scour or erosion which may create or present a potential hazard to the safety of the dam. The existing condition of the channel downstream of the stilling basin should be determined by soundings.

e. *Approach and Outlet Channels*. The approach and outlet channels should be examined for any conditions which may impose constraints on the functioning of the discharge facilities of the outlet works, or present a hazard to the safety of the dam.

f. *Drawdown Facilities*. Facilities provided for drawdown of the reservoir to avert impending failure of the dam or to facilitate repairs in the event of stability or foundation problems should be examined for any conditions which may impose constraints on their functioning as planned.

5. *Safety and Performance Instrumentation*. Instruments which have been installed to measure behavior of the structures should be

examined for proper functioning. The available records and readings of installed instruments should be reviewed to detect any unusual performance of the instruments or evidence of unusual performance or distress of the structure. The adequacy of the installed instrumentation to measure the performance and safety of the dam should be determined.

a. *Headwater and Tailwater Gages*. The existing records of the headwater and tailwater gages should be examined to determine the relationship between other instrumentation measurements such as stream flow, uplift pressures, alignment, and drainage system discharge with the upper and lower water surface elevations.

b. *Horizontal and Vertical Alignment Instrumentation (Concrete Structures)*. The existing records of alignment and elevation surveys and measurements from inclinometers, inverted plumb bobs, gage points across cracks and joints, or other devices should be examined to determine any change from the original position of the structures.

c. *Horizontal and Vertical Movement, Consolidation, and Pore-Water Pressure Instrumentation (Embankment Structures)*. The existing records of measurements from settlement plates or gages, surface reference marks, slope indicators and other devices should be examined to determine the movement history of the embankment. Existing piezometer measurements should be examined to determine if the pore-water pressures in the embankment and foundation would under given conditions impair the safety of the dam.

d. *Uplift Instrumentation*. The existing records of uplift measurements should be examined to determine if the uplift pressures for the maximum pool would impair the safety of the dam.

e. *Drainage System Instrumentation*. The existing records of measurements of the drainage system flow should be examined to establish the normal relationship between pool elevations and discharge quantities and any changes that have occurred in this relationship during the history of the project.

f. *Seismic Instrumentation*. The existing records of seismic instrumentation should be examined to determine the seismic activity in the area and the response of the structures of past earthquakes.

6. *Reservoir*. The following features of the reservoir should be examined to determine to what extent the water impounded by the dam would constitute a danger to the safety of the dam or a hazard to human life or property.

a. *Shore line*. The land forms around the reservoir should be examined for indications of major active or inactive landslide areas and to determine susceptibility of bedrock stratigraphy to massive landslides of sufficient magnitude to significantly reduce reservoir capacity or create waves that might overtop the dam.

b. *Sedimentation*. The reservoir and drainage area should be examined for excessive sedimentation or recent developments in the drainage basin which could cause a sudden increase in sediment load thereby reducing the reservoir capacity with attendant increase in maximum outflow and maximum pool elevation.

c. *Potential Upstream Hazard Areas*. The reservoir area should be examined for features subject to potential backwater flooding resulting in loss of human life or property at reservoir levels up to the maximum water storage capacity including any surcharge storage.

d. *Watershed Runoff Potential*. The drainage basin should be examined for any extensive alterations to the surface of the drainage basin such as changed agriculture practices, timber clearing, railroad or highway construction or real estate developments that might extensively affect the runoff characteristics. Upstream projects that could have impact on the safety of the dam should be identified.

7. *Downstream Channel*. The channel immediately downstream of the dam should be examined for conditions which might impose any constraints on the operation of the dam or present any hazards to the safety of the dam. Development of the potential flooded area downstream of the dam should be assessed for compatibility with the hazard classification.

8. *Operation and Maintenance Features*.

a. *Reservoir Regulation Plan*. The actual practices in regulating the reservoir and discharges under normal and emergency conditions should be examined to determine if they comply with the designed reservoir regulation plan and to assure that they do not constitute a danger to the safety of the dam or to human life or property.

b. *Maintenance*. The maintenance of the operating facilities and features that pertain to the safety of the dam should be examined to determine the adequacy and quality of the maintenance procedures followed in maintaining the dam and facilities in safe operating condition.

APPENDIX III TO APP. D TO § 222.6—PUB. L. 92–367

Public Law 92-367
92nd Congress, H. R. 15951
August 8, 1972

An Act

To authorize the Secretary of the Army to undertake a national program of inspection of dams.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the term "dam" as used in this Act means any artificial barrier, including appurtenant works, which impounds or diverts water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of fifty acre-feet or more. This Act does not apply to any such barrier which is not in excess of six feet in height, regardless of storage capacity or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet, regardless of height.

National dam inspection program.
"Dam."

SEC. 2. As soon as practicable, the Secretary of the Army, acting through the Chief of Engineers, shall carry out a national program of inspection of dams for the purpose of protecting human life and property. All dams in the United States shall be inspected by the Secretary except (1) dams under the jurisdiction of the Bureau of Reclamation, the Tennessee Valley Authority, or the International Boundary and Water Commission, (2) dams which have been constructed pursuant to licenses issued under the authority of the Federal Power Act, (3) dams which have been inspected within the twelve-month period immediately prior to the enactment of this Act by a State agency and which the Governor of such State requests be excluded from inspection, and (4) dams which the Secretary of the Army determines do not pose any threat to human life or property. The Secretary may inspect dams which have been licensed under the Federal Power Act upon request of the Federal Power Commission and dams under the jurisdiction of the International Boundary and Water Commission upon request of such Commission.

Army, authorization.
Exceptions.
41 Stat. 1063; 49 Stat. 863. 16 USC 791a.
86 STAT. 506
86 STAT. 507

SEC. 3. As soon as practicable after inspection of a dam, the Secretary shall notify the Governor of the State in which such dam is located the results of such investigation. The Secretary shall immediately notify the Governor of any hazardous conditions found during an inspection. The Secretary shall provide advice to the Governor, upon request, relating to timely remedial measures necessary to mitigate or obviate any hazardous conditions found during an inspection.

Notice to Governors.

SEC. 4. For the purpose of determining whether a dam (including the waters impounded by such dam) constitutes a danger to human life or property, the Secretary shall take into consideration the possibility that the dam might be endangered by overtopping, seepage, settlement, erosion, sediment, cracking, earth movement, earthquakes, failure of bulkheads, flashboard, gates on conduits, or other conditions which exist or which might occur in any area in the vicinity of the dam.

SEC. 5. The Secretary shall report to the Congress on or before July 1, 1974, on his activities under the Act, which report shall include, but not be limited to—

Report to Congress

(1) an inventory of all dams located in the United States;

(2) a review of each inspection made, the recommendations furnished to the Governor of the State in which such dam is located and information as to the implementation of such recommendation;

86 STAT. 507

(3) recommendations for a comprehensive national program for the inspection, and regulation for safety purpose of dams of the Nation, and the respective responsibilities which should be assumed by Federal, State, and local governments and by public and private interests.

Liability.

SEC. 6. Nothing contained in this Act and no action or failure to act under this Act shall be construed (1) to create any liability in the United States or its officers or employees for the recovery of damages caused by such action or failure to act; or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

Approved August 8, 1972.

LEGISLATIVE HISTORY:

HOUSE REPORT No. 92-1232 (Comm. on Public Works).
CONGRESSIONAL RECORD, Vol. 118 (1972):
July 24, considered and passed House.
July 25, considered and passed Senate.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 8, No. 33:
Aug. 9, Presidential statement.

APPENDIX E TO § 222.6—SUGGESTED OUTLINE

Inspection Report—National Dam Inspection Program (RCS-DAEN-CWE-17 and OMB No. 49-R0421)

Title Sheet

Name of Dam
ID Number from Inventory
State, County and River or Stream where dam is located
Owner
Size and Hazard Classification
Names of Inspectors
Names of Review Board
Approval Signature of District Engineer

Table of Contents

General Assessment

Give brief assessment of general condition of dam with respect to safety, including a listing of deficiencies, and recommendations indicating degree of urgency.

1. Introduction

a. Authority
b. Purpose and Scope of Inspection

2. Project Information

a. Site Information
b. Description of Structures—Dam, Outlet, Spillway and other principal features.
c. Purpose of Dam
d. Design, Construction and Operating History

3. Field Inspection

Briefly describe physical condition of the dam and appurtenant structures as they were observed during the field inspection. (If field inspection form is appended, only present summary.) Describe operational procedures, including any warning system, condition of operating equipment, and provision for emergency procedures. Describe any pertinent observations of the reservoir area and downstream channel adjacent to dam.

4. Evaluation

a. Structural and Geotechnical

(1) General

(2) Embankment and/or Foundation Condition

(3) Stability—Briefly discuss pertinent information such as design, construction and operating records. Assess stability under maximum loading on basis of the record data, together with observations of field inspection and results of any additional, brief calculations performed by inspectors. If additional, detailed stability analyses are considered necessary, recommend that the owner engage a qualified engineer or firm to provide the analysis.

b. Hydrologic and Hydraulic

(1) Spillway Adequacy—Briefly describe pertinent record information such as hydrologic and hydraulic design data, flood of record, and previous analyses. Describe any hydraulic and hydrologic analyses made for this inspection. Present conclusion with respect to adequacy of spillway to pass the recommended spillway design flood without overtopping dam. If overtopping would occur, and if available from the type of analysis used, give maximum depth over top of dam and duration of overtopping, assuming the dam does not fail. Also indicate the largest flood, as a percentage of the probable maximum flood which can be passed without overtopping.

(2) Effects of overtopping—If dam is overtopped by the recommended spillway design flood, provide assessment as to whether or not dam would likely fail, and if, in case of failure, the hazard to loss of life downstream of the dam would be substantially increased over that which would exist without failure. If information upon which to base a reasonable assessment is insufficient, so state and describe the needed data, and recommend that the necessary studies be performed by engineers engaged by the owner.

c. Operation and Maintenance

Assess operating equipment and procedures, emergency power for gate operation, and Emergency Action Plan. Assess quality of maintenance as it pertains to dam safety.

5. Conclusions

Provide conclusions on condition of dam and list all deficiencies. If dam is considered unsafe, so state and give reason.

6. Recommendations

List all recommended actions, including additional studies, installation of new surveillance procedures and devices, development of Emergency Action Plans, and remedial work. Recommend that a qualified engineering firm be retained to accomplish any recommended additional investigations and studies and also to design and supervise remedial works.

Appendixes

a. Inspection Checklist (if available)

b. Other Illustrations as follows:

(1) Include a map showing location of the dam. Usually a portion of a USGS quadrangle sheet can be used which will show the topography of the area, location of the dam, exent of the lake and drainage basin, and perhaps indicate the downstream development.

(2) If available, include a plan and section of the dam.

(3) General photographs of the dam and downstream channel should be included.

(4) Color photographs of deficiencies should be included. These should be held to the minimum required to illustrate the deficiencies.

(5) Available engineering data including Hydrologic/Hydraulic calculation and physical test results that might be available.

APPENDIX F TO § 222.6

Instructions for Unsafe Dam Data Sheet
(RCS-DAEN-CWE-17 and OMB No. 49–R0421)

The indicated information shall be provided in the format shown on Pg F–3 for each dam assessed to be unsafe during the reporting period. A separate data sheet should be provided for each unsafe dam. The information supplied should conform to the following.

a. *Name*—Name of dam.

b. *Id. No.*—Dam inventory identity number.

c. *Location*—List state county, river or stream and nearest D/S city or town where the dam is located.

d. *Height*—Maximum hydraulic height of dam.

e. *Maximum Impoundment Capacity*—List the capacity of the reservior at maximum attainable water surface elevation including any surcharge loading.

f. *Type*—Type of dam, *i.e.*, earth, rockfill, gravity, combination earth-gravity, etc.

g. *Owner*—Owner of dam.

h. *Date Governor Notified of Unsafe Condition*—The date and method of notification, such as, by telegram, letter, report, etc.

i. *Condition of Dam Resulting in Unsafe Assessment*—Brief description of the deficiencies discovered which resulted in the unsafe assessment.

j. *Description of Danger Involved*—Downstream (D/S) hazard potential category and a brief description of the danger involved.

k. *Recommendations Given to Governor*—Brief description of the actions recommended to Governor at time of notification of unsafe condition to eliminate or reduce the danger.

l. *Urgency Category*—State whether the unsafe condition of the dam is an emergency or non-emergency situation. An emergency situation should be considered to exist if the failure of the dam is judged to be imminent

and requires immediate action to eliminate or reduce the danger.

m. *Emergency Actions Taken*—In case of an emergency situation, list the actions taken. For non-emergency situation, put NA for ''not applicable.''

n. *Remedial Action Taken*—For non-emergency situations list remedial actions taken.

o. *Remarks*—For other pertinent information.

Format for Unsafe Dam Data Sheet (RCS-DAEN-CWE-17 and OMB No. 49–R0421

National Program of Inspection of Non-Federal Dams—Unsafe Dam Data Sheet

a. *Name:*
b. *Type:*
c. *Height:*
d. *Id. No.*
e. *Location:*
State: *County:*
Nearest D/S City, Town or Village:
River or Stream:
f. *Owner:*
g. *Date Governor Notified of Unsafe Condition:*
h. *Condition of Dam Resulting in Unsafe Assessment:*
i. *Description of Danger Involved:*
j. *Recommendations Given to Governor:*
k. *Urgency Category:*
l. *Emergency Actions Taken:*
m. *Remarks:*

APPENDIX G TO § 222.6

National Program for Inspection of Non-Federal Dams—Monthly Progress Report (RCS-DAEN-CWE-19)

I. *Instructions for Monthly Progress Report.* The indicated information shall be provided in the format shown on page G–2.

1. Division Reporting:
2. Date:
3. Information Required for Each State Regarding Total Number of Inspections Performed (AE Inspections included) (Cumulative):
3.1. Number of Inspections Initiated by on-site inspection or the review of engineering data from project records.[1]
3.2. Number of Inspections Competed (The number of inspection reports which have been submitted to the District Engineer for review and approval).
3.3 Number of Dams Reported to the Governor as Unsafe.[2]
3.4. Number of Approved Inspection Reports Submitted to the Governor.
4. Information Required for Each State Regarding Inspections Performed Under AE Contracts (Cumulative):
4.1. Number of Dams Contracted for Inspection by AE's with State or Corps.
4.2. Number of Inspections Initiated by AE's by on-site inspection or the review of engineering data from project records.[1]
4.3. Number of Inspections Completed by AE's (The number of inspection reports which have been submitted to the District Engineer for review and approval).
4.4. Number of Approved Inspection Reports Prepared by AE's Submitted to the Governor.

II. *Formation for Monthly Progress Report.*

National Program for Inspection of Non-Federal Dams—Monthly Progress Report

1. Division Reporting:
2. Date:
3. Information Required for Each State Regarding Total Number of Inspections Performed (Cumulative):

State	Inspection Initiated (3.1)	Inspection Completed (3.2)	Unsafe Dams Reported (3.3)	Approved Reports (3.4)
Total.				

4. Information Required for Each State Regarding Inspections Performed Under A/E Contracts (Cumulative):

State	Dams Under A/E Contract (4.1)	A/E Inspections Initiated (4.2)	A/E Inspections Completed (4.3)	A/E Reports Approved (4.4)
Totals.				

APPENDIX H TO § 222.6

Suggested Scope of Work Contract for Architect-Engineer Services for Safety Inspection of Dams Within the State of _____

1. *General Description of Scope of Work.* The services to be rendered by the Architect-Engineer (AE) under the proposed contract

[1] Each of the initiated inspections reported should be planned for completion within a reasonable period of time (30 days.)

[2] An unsafe dam is defined as a dam with deficiencies of such a nature that if not corrected could result in the failure of the dam with subsequent loss of lives or substantial property damage.

[1] See footnote on previous page.

shall include all engineering functions, hereinafter described, as needed to inspect the dams listed in Appendix A of this contract for the purpose of evaluating their risk of failure. A report which (a) describes the assessed condition of the dam, (b) provides conclusions as to which particular conditions could cause failure, (c) makes recommendations on remedial measures believed necessary, and (d) makes recommendations on whether and what type of future investigation should be conducted shall be provided for each inspected dam. The work shall proceed in accordance with Phase I of the Recommended Guidelines for Safety Inspection of Dams established by the Office of the Chief of Engineers (OCE) and the supplemented requirements listed in paragraph 3 below. The OCE guidelines are listed in Appendix B of this contract.

2. *Information and Services To Be Furnished by the Government*. The Contracting Officer will furnish the following information and services to the AE:

a. All information pertaining to each dam to be inspected as contained in the National Inventory of Dams.

b. Copies of recommended format for preparation of inspection report, engineering data check list and visual inspection check list.

c. All available pertinent information pertaining to the Dam Inspection Program and previous investigations having a bearing on inspections to be performed under this contract.

d. Right-of-entry for access to each dam site.

3. *Services To Be Rendered by the Architect-Engineer*. The principal services, subject to the optional provisions of the contract, to be rendered by the AE are itemized below:

a. *Technical Investigations*.

(1) *Engineering Data Collection*. To the extent feasible, the engineering data listed in Appendix I of the OCE guidelines relating to the design, construction and operation of the dam and appurtenant structures, should be collected from existing records and reviewed to aid in evaluating the general condition of each dam, including an assessment of the hydraulic and hydrologic features and structural stability of the dam. Where the necessary engineering data are unavailable, inadequate or invalid, a listing shall be made of those specific additional data deemed necessary by the engineer in charge of the investigation and included in the inspection report. The engineering data checklist provided by the Contracting Officer shall be used as a guide to compile this data.

(2) *Field Inspections*. The field inspection of each dam shall include examination of the items listed in Appendix II of the OCE guidelines, electrical and mechanical equipment for operation of the control facilities, reservoir area, downstream channel in the vicinity of the dam and any other significant feature to determine how these features affect the risk of failure of the dam. The inspection shall be conducted in a systematic manner to minimize the possibility of any significant feature being overlooked. The visual inspection checklist provided by the Contracting Officer shall be used as a guide to document the examination of each significant feature.

Particular attention shall be given to detecting evidence of leakage, erosion, seepage, slope instability, undue settlement, displacement, tilting, cracking, deterioration, and improper functioning of drains and relief wells. The degree and quality of maintenance and regulating procedures for operation of the control facilities shall be assessed. The design and existing condition of such control facilities (*i.e.*, spillway, outlet works, etc.) shall be evaluated. An assessment of the degree of siltation that is evident and its effect on the dam's reservoir shall be performed. Photographs and drawings should be used to record conditions in order to minimize written descriptions.

(3) *Engineering Analyses*.

(a) *Evaluation of Hydraulic and Hydrologic (H&H) Features*. Evaluation of the hydraulic and hydrological features of each dam shall be based on criteria set forth in the OCE guidelines. If it is determined that the available H&H data are insufficient, the Contracting Officer must be so informed and may exercise an option of requiring the AE to perform an overtopping analysis at additional agreed-upon compensation. The methodology to be used by the AE for this analysis will be based on the OCE guidelines and subject to the approval of the Contracting Officer.

(b) *Evaluation of Structural Stability*. The evaluation of structural stability of each dam is to be based principally on existing conditions as revealed by the visual inspection, available design and construction information, and records of performance. The objectives are to determine the existence of conditions, identifiable by visual inspection or from records, which may pose a high risk of failure and to formulate recommendations pertaining to the need for any remedial improvements, additional studies, investigations, or analysis. The results of this phase of the inspection must rely substantially upon the experience and judgment of the inspecting engineer. Should it be determined that sufficient data are not available for a reasonable evaluation of the structural stability of a dam and appurtenances, the Contracting Officer should be informed which information is required prior to attempting to evaluate the risk of failure of the dam.

(c) *Evaluation of Operational Features*. Where critical mechanical/electrical operating equipment is used in controlling the

reservoir of a dam, an evaluation of the operational characteristics of this equipment from the standpoint of risk of failure must be performed.

(d) *Evaluation of Reservoir Regulation Plan and Warning System.* The operational characteristics of each dam's existing reservoir regulation plan and warning system in event of a threatened failure shall be investigated.

b. *Emergency Situations.* The Contracting Officer must be immediately notified of any observed condition which is deemed to require immediate remedial action. After being notified, the Contracting Officer will contact the appropriate State personnel and will meet the AE at the site to determine the appropriate course of action. This will not relieve the AE of his responsibility to prepare a comprehensive inspection report at the earliest practicable date.

c. *Qualifications of Investigators.* The technical investigations shall be conducted by licensed professional engineers with a minimum of five years experience after licensing in the investigation, design and contruction of earthfill, rockfill and concrete dams and/or in making risk of failure evaluations of completed dams. These engineers must be knowledgeable in the disciplines of hydrology, hydraulics, geotechnical, electrical, mechanical and structural engineering, as necessary. All field inspections should be conducted by engineers, engineering geologists and other specialists who are knowledgeable in the investigation, design, construction and operation of dams, including experts on mechanical and electrical operation of gates and controls, where needed.

d. *Preparation of Report.* A formal report shall be prepared for each dam inspected for submission to the Contracting Officer. Each report should contain the information specified in OCE guidelines and any other pertinent information. The recommended format provided by the Contracting Officer shall be used to document each report. The signature and registration identification of the professional engineer who directed the investigation and who was responsible for evaluation of the dam should be included in the report.

4. *Supervision and Approval of Work.* All work performed under this contract shall be subject to the review and approval of the Contracting Officer or his designee. Meetings will be held on a regular basis in the District office, during which the progress of inspections will be discussed and questions relating to inspection reports previously received by the Contracting Officer will be addressed. Reports will be revised as necessary when required by the Contracting Officer.

5. *Coordination.* During the progress of work, the AE shall maintain liaison with the *_____ and other local authorities through the Contracting Officer as required to assure the orderly progression of the inspection. Copies of all correspondence with such authorities shall be provided to the Contracting Officer.

6. *Submission of Report.*

a. Each inspection report will be submitted for review to the Contracting Officer. Reports will be revised as required by the Contracting Officer. After all revisions have been made, the original and ____ copies of each inspection report shall be submitted to the Contracting Officer.

b. Text of all reports shall be typewritten and printed on both sides of 8″×10½″ paper. All notes, inspection forms, sketches or similar matter shall be legible, distinct and suitable for reproduction.

7. *Period of Services.*

a. All inspections and reports included under this contract shall be completed within ____ days from date of Notice to Proceed.

b. If the option for performing an H&H analysis for any particular site is exercised, the AE shall complete such analysis within ____ days from date of Notice to Proceed. However, the overall completion time stated in paragraph 7a above shall not change.

APPENDIX I TO § 222.6

Procedure for Using NASA Land Satellite Multispectral Scanner Data for Verification and Updating the National Inventory of Dams

1. *Purpose.* This appendix states the objective, defines the scope, prescribes procedures, and assigns responsibilities for using NASA Land Satellite (LANDSAT) Multispectral Scanner data along with NASA's Surface Water Detection And Mapping (DAM) Computer program to assist in verification and updating the National Inventory of Dams.

2. *Applicability.* This appendix is applicable to all divisions and districts having Civil Works responsibilities except POD.

3. *Reference.* NASA, DETECTION AND MAPPING PACKAGE, Users Manuals, Volumes 1, 2a, 2b, and 3 dated June 1976, published by the Johnson Space Center, Houston, Texas.

4. *Objectives.* Provide a uniform method, nation-wide, to help insure that all dams subject to Public Law 92–367, 8 August 1972 are properly identified and located in the National Inventory of Dams.

5. *Scope.* The computer printer overlay maps produced by the procedure described in reference 3b will be used by district and/or state or contractor personnel as a tool to assist in verification and updating of the National Inventory of Dams.

*NOTE: Write in the designated State Authority.

6. *Exceptions*. a. If a Division/District attempts the use of the procedure for a given region within their area of responsibility and finds the overlay maps cannot be used to assist in verification and updating the National Inventory of Dams, they may request an exception for a selected region. A selected region may include areas where conditions can reasonably be assumed to be the same as the region where the procedure was tried.

b. Request for exceptions should be documented to include firm boundary definitions and appropriate justification to demonstrate why the procedure cannot be used. This request should be submitted to WRSC WASH DC 20314, through the normal engineering chain of command.

c. Map overlays will be produced for all areas of the Continental United States even if they are not used in a few selected regions. This processing is required for a future Computer Water Body Change Detection system.

7. *Procedures*. Acquisition of LANDSAT data, registration of satellite coordinates to earth latitude and longitude and computer processing to produce overlay maps will be accomplished by two Regional Centers. Nashville District and Seattle District have been designated as the Regional Centers, with each responsible for processing maps by state based on Divisional assignments in Appendix A. Regional Centers will support divisions as follows:

Regional Center	Division
Nashville District	New England North Atlantic South Atlantic Ohio River Lower Mississippi Valley North Central
Seattle District	Southwestern Missouri River North Pacific South Pacific

8. *Responsibilities*. a. The Water Resources Support Center at Fort Belvoir has overall responsibility for coordination and monitoring of this activity between NASA, Division Offices, and Regional Centers, and for providing Regional Center funding.

b. Regional Centers are responsible for:

(1) Acquiring proper LANDSAT data tape from EROS Data Center (Sioux Falls, South Dakota). Actual data scene selection will be coordinated with Division and/or District to insure proper consideration is given to local priorities and seasonal coverage.

(2) Arranging computer processing support using NASA's DAM package.

(3) Establishing proper control between satellite scanner-oriented coordinates and earth latitude/longitude.

(4) Producing total coverage of map overlays at a scale of 1:24,000 and/or smaller scales as required by Divisions and/or Districts.

(5) Instructing District, State, or contractor personnel in the assembly and use of map overlays.

c. Divisions/Districts are responsible for:

(1) Designating one person from each Division and District as the point of contact with the Regional Center and provide this person's name and phone number to the Regional Center.

(2) Providing the Regional Center with map coverage of their area of responsibility. This will include state indexes and 7½ minute quadrangle sheets (scale 1:24,000) where available.

(3) Coordinating with the Regional Center in selecting LANDSAT data tapes.

(4) Providing information to Regional Center on scale and priorities of desired computer produced map overlays.

(5) Assembling computer print-outs into overlay maps, and using as appropriate to assist in verification and updating the National Inventory of Dams.

9. *Points of Contact*. The points of contact in the Regional Centers for this program are as follows:

Name, Office Symbol, and Telephone

Jim Cook—DAEN-ORNED, (615) 251–7366; FTS 852–7366.

Jack Erlandson—DAEN-NPSEN, (206) 764–3535; FTS 399–3535.

[44 FR 55336, Sept. 26, 1979, as amended at 45 FR 18925, Mar. 24, 1980. Redesignated at 60 FR 19851, Apr. 21, 1995]

PART 223—BOARDS, COMMISSIONS, AND COMMITTEES

§ 223.1 Mississippi River Water Control Management Board.

(a) *Purpose*. This regulation establishes and prescribes the objectives, composition, responsibilities and authority of the Mississippi River Water Control Management Board.

(b) *Applicability*. This regulation is applicable to the Board members and to all field operating agencies concerned with water control management within the Mississippi River Basin.

(c) *Objectives*. The objectives of the Board are:

(1) To provide oversight and guidance during the development of basin-wide management plans for Mississippi River Basin projects for which the U.S. Army Corps of Engineers has operation/regulation responsibilities.