

E.9. Georgia



FEMA

391-3-8-.09 Standards for the Design and Evaluation of Dams. Amended.(

(1)The design and/or evaluation of new and existing dams shall conform to accepted practices of the engineering profession and dam safety industry. Design manuals, evaluation guidelines, and procedures used by the following agencies can be considered as acceptable design or evaluation references, except as those references differ from Georgia Law and these regulations:

- (a)U.S. Army Corps of Engineers;
- (b)Natural Resources Conservation Service;
- (c)U.S. Department of Interior, Bureau of Reclamation;
- (d)Federal Energy Regulatory Commission;

(2)Other design and evaluation methods may be used to demonstrate compliance with the objectives of these rules, but are subject to the approval of the Director.

(3)Design and Evaluation of Dams under Paragraph (1) and (2) above shall, as a minimum, consider the following basic principles:

(a)All dams must be stable under all conditions of construction and/or operation of the impoundment. Details of stability evaluation shall be submitted to the Director for approval. Analyses using the methods, guidelines and procedures of the agencies listed in Paragraph (1) yielding the following Minimum Safety Factors can be considered as acceptable stability:

Earthen Embankments

- 1. End of Construction1.3
- 2. Steady State Seepage1.5
- 3. Steady State Seepage with Seismic Loading1.1
- 4. Rapid Drawdown (Upstream)1.3
- 5. Submerged Toe with Rapid Drawdown1.3

Concrete Structures (cohesion included)

- 1. Normal Reservoir 3.0
- 2. Normal Reservoir with Seismic Loading1.0
- 3. Design Flood2.0

(b)Details of the engineering evaluation of material properties in the dam or appurtenant structures shall be submitted to the Director for review and approval. Conservative selections for soil strength values shall be used for analyses or evaluations. Details of any foundation investigation and laboratory testing supporting assumed design or evaluation parameters shall be included for review.

(c)All dams and appurtenant structures shall be capable of withstanding seismic accelerations defined in the most current "Map for Peak Acceleration with a 2% exceedance in 50 years" for the contiguous United States published by the United States Geological Survey (a.k.a. NEHRP maps). The minimum seismic acceleration shall be 0.05g . The seismic accelerations may be reduced or seismic evaluation eliminated if the applicant's engineer can successfully demonstrate to the Director by engineering analyses or judgment that smaller seismic accelerations are appropriate or no seismic evaluation is needed.

(d)All dams shall have a means of draining the reservoir to a safe level as demonstrated by the applicant's engineer. The submittal by the applicant's engineer shall include the computation of the maximum time required to drain the reservoir. Exceptions to this rule

may be given by the Director based on an engineering evaluation demonstrating the lack of this capability would not endanger the public.

(e) All earthen embankments shall be protected from surface erosion by appropriate vegetation, or some other type of protective surface such as riprap or paving, and shall be maintained in a safe condition. Examples of appropriate vegetation include, but are not limited to, Bermuda, Tall Fescue, Centipede grasses and Lespedeza sericea. Inappropriate vegetation on existing dams such as trees shall be removed only after consultation with the Division or other qualified persons on the proper procedures for removal. Hedges and small shrubs may be allowed on existing dams if they do not obscure inspection or interfere with the operation and maintenance of the dam.

(f) Design Storm. Each dam shall be capable of safely passing the fraction of the flood developed from the PMP hydrograph depending on the subclassification of the dam. The design storm for each subclassification of a dam is as follows:

1. Small Dam 25 percent PMP
2. Medium Dam 33.3 percent PMP
3. Large Dam 50 percent PMP
4. Very Large Dam 100 percent PMP

Based on visual inspection and detailed hydrologic and hydraulic evaluation, including documentation of completed design and construction procedures, up to 10 percent lower requirement (22.5, 30, 45, 90) may be accepted on existing PL566 (including RC&D structures) and PL 534 Project Dams at the discretion of the Director, provided the project is in an acceptable state of maintenance. The design storm may be reduced on existing dams if the applicant's engineer can successfully demonstrate to the Director, by engineering analysis, that the dam is sufficient to protect against probable loss of human life downstream at a lesser design storm. Earth emergency spillways shall not function until the 50 year storm.

(g) Seepage Control. All dams shall be able to prevent the development of instability due to excessive seepage forces, uplift forces, or loss of materials in the embankment, abutments, spillway areas, or foundation. For new dams, seepage analysis for design, and inspection during construction shall be in sufficient detail to prevent the occurrence of critical seepage gradients.

(i) For new dams, the design shall include a seepage control method which meets the minimum acceptable safety standards, as determined by the Division. All internal drainage systems with pipe collection systems shall have cleanouts.

(ii) In existing dams, seepage shall be investigated by an engineer and appropriate control measures shall be taken as necessary.

(h) Monitoring Devices.

(i) Monitoring devices, including but not limited to piezometers, settlement plates, tell-tale stakes, seepage outlets and weirs, and permanent bench marks may be required by the Director for use in the inspection and monitoring of the safety of a dam during operation.

(ii) For new dams or existing dams where appropriate, a reservoir filling monitoring and surveillance plan to be implemented during reservoir filling or re-filling shall be submitted to the Director for approval prior to start of filling or re-filling.

(i).Design Life. The design life for proposed dams and reservoirs shall be adequate for the dams and reservoirs to perform effectively as planned, as determined by the following criteria:

(i)The time required to fill the reservoir with sediment from the contributing watershed; and

(ii)The durability of appurtenances and materials used to construct the dams.

(j)Freeboard. Appropriate freeboard for wave action shall be considered by an engineer through engineering analysis. The required freeboard shall be provided above the maximum reservoir surface elevation that would result from the inflow from the design storm for the structure. The resulting maximum reservoir surface elevation plus freeboard shall determine the elevation of the top of the dam. In lieu of determining the appropriate amount of freeboard by engineering analysis, a minimum of three (3) feet of freeboard shall be provided on earth dams.

(k)Existing concrete and/or masonry dams and appurtenant structures shall be structurally sound and shall have joints free of trees and other vegetation and shall show no signs of significant structural deterioration such as excessive cracks, spalling, efflorescence and exposed reinforcing steel.

(4). Other design standards may be imposed as deemed appropriate by the Director after review of design of new structures or through a visual inspection of an existing structure conducted pursuant to Rule 391-3-8-.08 (2)(b) of these regulations, or based on a review of the detailed engineering study prepared by an engineer.

Authority O.C.G.A. Secs. 12-5-370. **Administrative History.** Original Rule entitled "Permits for the Construction and Operation of New Dams" was filed as Emergency Rule 391-3-8-0.5-.09 on August 28, 1978, effective July 28, 1978, the date of adoption, to remain in effect for a period of 120 days or until the effective date of a permanent Rule covering the same subject matter superseding said Emergency Rule, as specified by the Agency. **Amended:** Permanent Rule of the same title adopted superseding Emergency Rule 391-3-8-0.5-.09. Filed August 31, 1978; effective September 20, 1978. **Amended:** Rule renumbered as Rule 391-3-8-.10 and Rule 391-3-8-.08 entitled "Design Standards for Existing Dams" amended and renumbered as Rule 391-3-8-.09. Filed October 29, 1985; effective November 18, 1985. **Amended:** F. Aug. 31, 1990; eff. Sept. 20, 1990. **Amended:** F. Oct. 5, 1998; eff. Oct. 25, 1998.

FEMA Workshop on Hydrologic Research Needs for Dam Safety Analysis

Hydrologic Practices in the State of Georgia and other states east of the Mississippi River

By
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State of Georgia

The Georgia Safe Dams Act regulates high hazard dams that are either 25 feet tall or store more than 100 acre-feet of water at maximum pool. These regulated dams are evaluated to determine if they have adequate spillway capacity and wave action freeboard at maximum design pool to pass the design storm as defined by the Georgia Safe Dams Act (Act) and Rules for Dam Safety (Rules). The spillway capacity is prescribed in the Act based on the height of the dam and/or its maximum storage capacity.

- 1) Small dams - Those dams with a storage capacity not exceeding 500 acre-feet and a height not exceeding 25 feet - 25 percent PMP spillway design capacity.
- 2) Medium dams - Those dams with a storage capacity exceeding 500 acre-feet but not exceeding 1000 acre-feet or a height exceeding 25 feet but not exceeding 35 feet - 33 percent PMP spillway design capacity.
- 3) Large dams - Those dams with a storage capacity exceeding 1000 acre-feet but not exceeding 50,000 acre-feet or a height exceeding 35 feet but not exceeding 100 feet - 50 percent PMP spillway design capacity.
- 4) Very large dams - Those dams with a storage capacity exceeding 50,000 acre-feet or a height exceeding 100 feet - 100 percent PMP spillway design capacity.

Typically, the Georgia Safe Dams Program develops Visual Inspection Reports which are a streamed lined version of the old USACOE Phase I reports that were done in the late 1970's and early 1980's for state dam safety programs across the United States. In that report, our Program evaluates the spillway capacity of existing dams with respect to compliance with the Act and Rules. Except in rare instances, the hydrology evaluation uses the NRCS/SCS Curve Number, Lag Time methodology. Of note, because the spillway capacity requirements are set forth in the Act, and the design storm is restricted to the 6-hour PMP, the Program requires the use of Antecedent Moisture Condition III for the evaluation of spillway capacity. This dramatically affects the Curve Numbers used. We use HMR 51/52 to develop the design storm. The spillway rating curves are done using standard hydraulic practice accounting for weir, orifice, and full pipe flow for principal spillway pipes/open channel flow in earth emergency spillways, etc. This

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information is imputed into the HECI model with a Type II distribution to evaluate the hydraulic adequacy of the dam.

On very large drainage basins, a unit hydrograph is developed based on existing stream data on the particular stream or one in the area with similar watershed characteristics.

For more detailed information, please see the attached section on Hydrology and Hydraulics, pages 28 to 33 of the Georgia Safe Dams Program's Engineering Guidelines. The Guidelines were developed in conjunction with consulting engineers who are involved with the design of dams in Georgia.

Other states east of the Mississippi River

Because there is a need for the state dam safety regulators to provide significant input on practices, research needs and development needs in the field of hydrology and hydraulics modeling, I polled 26 states east of the Mississippi River including: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, Kentucky, West Virginia, Tennessee, Virginia, North Carolina, South Carolina, Florida, Maryland, New Jersey, Mississippi, Louisiana, Arkansas, and Puerto Rico. Delaware and Alabama were not polled because they had no dam safety laws or programs. I received 19 state responses.

The following questions were asked in the survey and where appropriate, the number of responses are tallied. In some cases, a state regulatory agency may use/accept more than one methodology.

1. What Hydrologic Model(s) are used/accepted by your state? Do you accept more than one methodology?

- a. NRCS/SCS Curve Number/Lag Equations - 16
- b. HECI - 17
- c. HECHMS - 10
- d. USGS/State Regression Equations - 9
- e. Unit Hydrographs - 6
- f. Snyder Unit Hydrograph - 5
- g. SITES - 6
- h. TR20- 5
- i. TR55 - 3
- j. HydroCAD 5.11 - 3
- k. Others - 1

2. What are the difficulties/problems you encounter with these models?

- a. HEC1
 - DOS based program - glitches sometimes when loaded on a Windows Operating System.
 - PM card record is outdated for PMF determination in conjunction with the use of HMR51/52.
 - Time distribution of rainfall losses.
 - Unit hydrograph for eastern shore needs to be modified.
- b. Lack of site specific data (mentioned 5 times.)
- c. HECHMS
 - Does not have the ability to run multiple storm events
 - Bizarre results sometimes.
- d. Engineers who do not know how to use the model appropriately. Identified as an issue by six states.
- e. Hydro CAD 5.11/SCS unit hydrograph is limited a 24 hour duration storm, surcharge flows are not allowed.

Of note, two states reported no difficulties.

3. Are extended flow periods (days) vs. single events an issue? Is it dependant on the size of the drainage basin or the location of the dam?

Yes - One

No - Ten

Maybe - (extremely large drainage basin) - Seven

4. Please rank the following issues in priority:

- a. low cost/rapid assessment of inflow flood (47 points)
- b. extensive detailed investigative assessment of the inflow flood (54 points)
- c. risk assessment vs. PMF (34 points)
- d. determinate inflow design flood (55 points)
- e. all equally important (20 points)

*To evaluate the responses, I assigned a point value of 5 to 1 for the priority ranking with 5 being the highest priority and 1 being the lowest priority.

5. Any suggestions for short and long terms hydrologic needs and development?

Short term hydrologic needs

A. HECHMS needs the following:

- level pool routing/results & summaries

- overtopping subroutine
 - breaching subroutine
 - multiplan feature
 - printout of inputs
 - other routing subroutines (Muskingum-Cunge)
 - link HECRAS to HECHMS
 - add Arcview
 - develop multiple stage outlet modeling
- B. Comparison of USGS Regression inflow curves vs. other methodology. Publish results for different parts of the country.
- C. Cooperation between NWS and HEC and other Federal agencies.

Long-term hydrology needs

- A. Update NRCS/SCS Curve Number methodology.
- B. What is the appropriate time period of the design storm event? PMP is variable across the country and changes within a region.
- C. Define what antecedent moisture condition is appropriate for what type of design storm.
- D. Couple NEXRAD or IFLOWS for river basins for real time hydrologic forecasting (Virginia).
- E. Further development of the Green-Ampt loss rate function nationwide.
- F. Additional continuous stream gaging streams.

Conclusions and Recommendations:

The majority of the dams in the United States are regulated by the states. Hydrologic research should focus on creating models for design storms that will produce reasonably accurate results that do not involve extensive data gathering and interactive modeling. The results should be reproducible from universally accepted data sources.

I believe the short terms needs include the following:

- Complete HECHMS model development. Make it compatible with other software and link it to HECRAS, ARCVIEW, and NWS DAMBREAK.
- Improve cooperation between Federal Agencies to develop hydrologic data and software models that states can use.
- Do detailed comparison of various hydrologic methodologies that produce inflow floods including sensitivity evaluations. Make the comparison meaningful by region/sub region. Publish results.

Long term hydrologic needs include further development of certain hydrologic models/modeling methods.

- Update NRCS/SCS Curve Numbers and lag time routines.
- Better regionalization of PMP rainfall events.
- Define and update Antecedent Moisture Conditions.
- Further development of the Green-Ampt loss rate function nationwide. If this was as usable as the NRCS/SCS Curve Number/soils mapping methodology, modeling long terms storm event would be doable with reasonable results.

While I believe that accuracy in hydrologic modeling is important, so is a certain measure of conservatism to account for the undefined and unknown variables that exist in every drainage basin when dealing with public safety.

E.10. Hawaii



FEMA

NOTICE TO PUBLIC

**Addendum No. 1 to Proposed Hawaii Administrative Rules, Title 13,
Subtitle 7, Chapter 190.1 as Required by the “Hawaii Dam and Reservoir
Safety Act of 2007”, Chapter 179D HRS - Dams and Reservoirs**

The Department of Land and Natural Resources has posted the following Addendum No 1 to the Proposed Hawaii Administrative Rules, Title 13, Subtitle 7, Chapter 190.1 due to typographical errors in the dam size classification table of Section §13-190.1-4.1 “Additional design requirements”. These corrections were made to this table under the impoundment size column, which is consistent with the similar table in the existing Dam Safety Inspection Guidelines.

Should there be any questions on this Addendum or any portion of the rules, please contact anyone of our dam safety staff:

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Internet posting: September 13, 2010

§13-190.1-4.1 Additional design requirements.

(a) Significant and high hazard dams shall also have a stability analysis of the structure demonstrating the stability of the embankment slopes for various loading conditions and minimum factors of safety generated by a methodology accepted by the department.

(b) Regulated dam spillways shall safely pass the appropriate inflow design flood:

Hazard Classification	Size Classification	Inflow design flood
Low	Small	100 year
	Intermediate	100 year
	Large	½ PMF
Significant	Small	½ PMF
	Intermediate	½ PMF
	Large	PMF
High	All Sizes	PMF

Category	Impoundment	
	Storage (Acre-feet)	Height (feet)
Small	<1000 and ≥50	<40 and ≥25
Intermediate	≥1,000 and <50,000	≥40 and <100
Large	≥50,000	≥100

Note: PMF or Probable Maximum Flood, is defined as 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 the 24 hour probable maximum precipitation (PMP), which information is available from the National Weather Service, NOAA, Publication HMR-39, "Hydrometeorological Report No. 39 - Probable Maximum Precipitation in the Hawaiian Islands", or current standard. ½ PMF = PMF divided by two. 100 year is defined as the flood associated with the 1 percent probability storm event that is derived from

the 24 hour 100 year precipitation rate, which is identified in the US Weather Bureau Technical Paper No. 43 Rainfall-Frequency Atlas of the Hawaiian Islands and as updated by NOAA Atlas 14, Volume 4 Precipitation-Frequency Atlas of the United States, Hawaiian Islands, or current standard.

(c) Freeboard shall be the greater of the following:

- (1) Two feet above the water level during the peak spillway flow associated with the inflow design flood;
- (2) Sum of the wave run-up and reservoir setup resulting from a 100 mph wind speed during the peak spillway flow associated with the inflow design flood. (Eff.) (Auth: HRS §179D-6) (Imp: HRS §179D-8)

E.11. Idaho



FEMA

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**IDAPA 37
TITLE 03
CHAPTER 06**

37.03.06 - SAFETY OF DAMS RULES

000. LEGAL AUTHORITY (RULE 0).

These rules are adopted pursuant to Chapter 17, Section 42-1714, Idaho Code, and implement the provisions of Sections 42-1709 through 42-1721, Idaho Code. (7-1-93)

001. TITLE AND SCOPE (RULE 1).

01. Title. (7-1-93)

02. Scope. (7-1-93)

a. The requirements that follow are intended as a guide to establish acceptable standards for construction and to provide guidelines for safety evaluation of new or existing dams. The rules apply to all new dams, to existing dams to be enlarged, altered or repaired, and maintenance of certain existing dams, as specifically provided in the rules. The Director will evaluate any deviation from the standards hereinafter stated as they pertain to the safety of any given dam. The standards are not intended to restrict the application of other sound engineering design principles. Engineers are encouraged to submit new ideas which will advance the state of the art and provide for the public safety. (7-1-93)

b. Under no circumstances shall these rules be construed to deprive or limit the Director of the Department of Water Resources of any exercise of powers, duties and jurisdiction conferred by law, nor to limit or restrict the amount or character of data, or information which may be required by the Director from any owner of a dam for the proper administration of the law. State sovereignty as expressed in Policy 1A of the adopted State Water Plan for independent review and approval of dam construction, operation and maintenance will not be waived due to any overlapping jurisdiction from federal agencies. (7-1-93)

002. WRITTEN INTERPRETATION (RULE 2).

003. ADMINISTRATIVE APPEALS (RULE 3).

Any owner who is aggrieved by a determination or order of the Director may request a hearing pursuant to the provisions of Section 42-1701A(3), Idaho Code, and the Department's adopted Rules of Procedure. (7-1-93)

004. -- 009. (RESERVED).

010. DEFINITIONS (RULE 10).

Unless the context otherwise requires, the following definitions govern these rules. (7-1-93)

01. Active Storage. The water volume in the reservoir stored for irrigation, water supply, power generation, flood control, or other purposes but does not include flood surcharge. Active storage is the total reservoir capacity in acre-feet, less the inactive and dead storage. (7-1-93)

02. Alterations, Repairs or Either of Them. Only such alterations or repairs as may directly affect the safety of the dam or reservoir, as determined by the Director. Alterations, repairs does not include routine maintenance items. (See Rule Subsections 055.02.a. and 055.02.b.) (7-1-93)

03. Appurtenant Structures. Ancillary features (e.g. outlets, tunnels, gates, valves, spillways, auxiliary barriers) used for operation of a dam, which are owned by the dam owner or the owner has responsible control. (7-1-93)

04. Board. The Idaho Water Resource Board. (7-1-93)

05. Certificate of Approval. A certificate issued by the Director for all dams listing restrictions imposed by the Director, and without which no new dams shall be allowed by the owner to impound water. A

certificate of approval is also required for existing dams before impoundment of water is authorized. (7-1-93)

06. Dam. Any artificial barrier together with appurtenant works, which is or will be ten (10) feet or more in height or has or will have an impounding capacity at maximum storage elevation of fifty (50) acre-feet or more. Height of a dam is defined as the vertical distance from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the Director, 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. (7-1-93)

07. Small Dams. Artificial barriers twenty (20) feet or less in height that are capable of storing less than one hundred (100) acre-feet of water. (7-1-93)

08. Intermediate Dams. Artificial barriers more than twenty (20) feet, but less than forty (40) feet in height, or are capable of storing one hundred (100) acre-feet or more, but less than four thousand (4,000) acre-feet of water. (7-1-93)

09. Large Dams. Artificial barriers forty (40) feet or more in height or are capable of storing four thousand (4,000) acre-feet or more of water. (7-1-93)

10. Department Jurisdiction. The following are not subject to department jurisdiction: (7-1-93)

a. Artificial barriers constructed in low risk areas as determined by the Director, which are six (6) feet or less in height, regardless of storage capacity. (7-1-93)

b. Artificial barriers constructed in low risk areas as determined by the Director, which impound ten (10) acre-feet or less at maximum water storage elevation, regardless of height. (7-1-93)

c. Artificial barriers in a canal used to raise or lower water therein or divert water therefrom. (7-1-93)

d. Fills or structures determined by the Director to be designed primarily for highway or railroad traffic. (7-1-93)

e. Fills, retaining dikes or structures, which are under jurisdiction of the Department of Environmental Quality, designed primarily for retention and treatment of municipal, livestock, or domestic wastes, or sediment and wastes from produce washing or food processing plants. (7-1-93)

f. Levees, that store water regardless of storage capacity. Levee means a retaining structure alongside a natural lake which has a length that is two hundred (200) times or more greater than its greatest height measured from the lowest elevation of the toe to the maximum crest elevation of the retaining structure. (7-1-93)

11. Days Used in Establishing Deadlines. Calendar days including Sundays and holidays. (7-1-93)

12. Dead Storage. The water volume in the bottom of the reservoir stored below the lowest outlet and generally is not withdrawn from storage. (7-1-93)

13. Department. The Idaho Department of Water Resources. (7-1-93)

14. Design Evaluation. The engineering analysis required to evaluate the performance of a dam relative to earthquakes, floods or other site specific conditions that are anticipated to affect the safety of a dam or operation of appurtenant facilities. (7-1-93)

15. Director. The Director of the Idaho Department of Water Resources. (7-1-93)

16. Engineer. A registered professional engineer, licensed as such by the state of Idaho. (7-1-93)

17. Enlargement. Any change in or addition to an existing dam or reservoir, which raises or may raise the water storage elevation of the water impounded by the dam. (7-1-93)

- 18. Factor of Safety.** A ratio of available shear strength to shear stress, required for stability. (7-1-93)
- 19. Flood Surcharge.** A variable volume of water temporarily detained in the upper part of a reservoir, in the space (or part thereof) that is filled by excess runoff or flood water, above the maximum storage elevation. Flood surcharge cannot be retained either because of physical or administrative factors but is passed through the reservoir and discharged by the spillway(s) until the reservoir level has been drawn down to the maximum storage elevation. (7-1-93)
- 20. Inflow Design Flood (IDF).** The flood specified for designing the dam and appurtenant facilities. (7-1-93)
- 21. Maximum Credible Earthquake.** The largest earthquake that reasonably appears capable of occurring under the conditions of the presently known geological environment. (7-1-93)
- 22. Operation Plan.** A specific plan that will assure the project is safely managed for its intended purpose and which provides reservoir operating rule curves or specific limits and procedures for controlling inflow, storage, and/or release of water, diverted into, passed through or impounded by a dam. (7-1-93)
- 23. Owner.** Includes any of the following who own, control, operate, maintain, manage, hold the right to store and use water from the reservoir or propose to construct a dam or reservoir. (7-1-93)
- a.** The state of Idaho and any of its departments, agencies, institutions and political subdivisions; (7-1-93)
 - b.** The United States of America and any of its departments, bureaus, agencies and institutions; provided that the United States of America shall not be required to pay any of the fees required by Section 42-1713, Idaho Code, and shall submit plans, drawings and specifications as required by Section 42-1712, Idaho Code, for information purposes only; (7-1-93)
 - c.** Every municipal or quasi-municipal corporation. (7-1-93)
 - d.** Every public utility; (7-1-93)
 - e.** Every person, firm, association, organization, partnership, business trust, corporation or company; (7-1-93)
 - f.** The duly authorized agents, lessees, or trustees of any of the foregoing; (7-1-93)
 - g.** Receivers or trustees appointed by any court for any of the foregoing. (7-1-93)
- 24. Reservoir.** Any basin which contains or will contain the water impounded by a dam. (7-1-93)
- 25. Storage Capacity.** The total storage in acre-feet at the maximum storage elevation. (7-1-93)
- 26. Water Storage Elevation.** The maximum elevation of the water surface which can be obtained by the dam or reservoir. It is further defined as the storage level attained when the reservoir is filled to capacity (i.e. to the spillway crest) or an authorized storage level attained by installing flashboards to increase the reservoir capacity, or a specified upper storage limit, which is attained by operation of moveable gates that raises the reservoir to a controlled operating level. The maximum storage elevation is an equivalent term of water storage elevation. (7-1-93)
- 27. Release Capability.** The ability of a dam to pass excess water through the spillway(s) and outlet works and otherwise discharge. (7-1-93)
- 011. -- 024. (RESERVED).**
- 025. DAM SIZE CLASSIFICATION AND RISK CATEGORY (RULE 25).**

01. Size Classification. The following table defines the height and storage capacity limits used by the Department to classify dams:

Size Classification	Height (ft)		Storage Capacity
Small	20 ft. or less	and	Less than 100 acre-ft.
Intermediate	More than 20 ft. but less than 40 ft.	or	100 Acre-ft or more, but less than 4000 acre ft
Large	40 ft. or more	or	4000 acre-ft., or more

(7-1-93)

02. Risk Category. The following table describes categories of risk used by the Department to classify losses and damages anticipated in down-stream areas, that could be attributable to failure of a dam during typical flow conditions.

Risk Category	Dwellings	Economic Losses
Low	No permanent structures for human habitation.	Minor damage to land, crops, agricultural, commercial or industrial facilities, transportation, utilities or other public facilities or values.
Significant	No concentrated urban development, 1 or more permanent structures for human habitation which are potentially inundated with flood water at a depth of 2 ft. or less or at a velocity of 2 ft. per second or less.	Significant damage to land, crops, agricultural, commercial or industrial facilities, loss of use and/or damage to transportation, utilities or other public facilities or values.
High	Urban development, or any permanent structure for human habitation which are potentially inundated with flood water at a depth of more than 2 ft. or at a velocity of more than 2 ft. per second.	Major damage to land, crops, agricultural, commercial or industrial facilities, loss of use and/or damage to transportation, utilities or other public facilities or values.

(7-1-93)

03. Determination of Size and Risk Category. The Director shall determine the size and risk category of a new or existing dam. (7-1-93)

026. -- 029. (RESERVED).

030. AUTHORITY OF REPRESENTATIVE (RULE 30).

When plans, drawings and specifications are filed by another person on behalf of an owner, written evidence of authority to represent the owner shall be filed with the plans, drawings and specifications. (7-1-93)

031. -- 034. (RESERVED).

035. FORMS (RULE 35).

Forms required by these rules are available from the Department to interested parties upon request. Construction of a small dam requires the filing of Form 1710 and construction of an intermediate or large dam requires the filing of Form 1712. (7-1-93)

036. -- 039. (RESERVED).

040. CONSTRUCTION PLANS, DRAWINGS AND SPECIFICATIONS (RULE 40).

The following provisions shall apply in submitting plans, drawings and specifications. (7-1-93)

01. Submission of Duplicate Plans, Drawings and Specifications. Any owner who shall desire to construct, enlarge, alter or repair any intermediate or large dam, shall submit duplicate plans, drawings and specifications prepared by an engineer for the proposed work to the Director with required fees. The Director may, however, require the submittal of plans, drawings and specifications prior to the construction of any dam. (7-1-93)

02. Applying for and Obtaining Written Approval. Construction of a new dam or enlargement, alteration or repairs on existing dams shall not be commenced until the owner has applied for and obtained written approval of the plans, drawings and specifications. Alteration or repairs do not include routine maintenance for which prior approval is not required. (See Rule Subsections 055.02.a and 055.02.b) (7-1-93)

03. Plans Shall Be Prepared on a Good Quality Vellum or Mylar. Transparent copies reproducible by standard duplicating processes, if accurate, legible and permanent, will be accepted. Plans may initially be submitted in the form of nonreproducible paper prints. After reviewing the plans, the Director will notify the owner of any required changes. (7-1-93)

04. Preparation and Submission of Plans. Plans and drawings shall be of a sufficient scale with an adequate number of views showing proper dimensions, so that the plans and drawings may be readily interpreted and so that the structure and appurtenances can be built in conformance with the plans and drawings. (7-1-93)

05. Information Included with Plans. Plans for new dams shall include the following information and plans for enlargement, alteration or repair of an existing dam shall include as much of the following information as required by the Director to adequately describe the enlargement, alteration or repair and the affect on the existing dam or its appurtenant facilities: (7-1-93)

a. A topographic map of the dam site showing the location of the proposed dam by section, township and range, and location of spillway, outlet works, and all borings, test pits, borrow pits; (7-1-93)

b. A profile along the dam axis showing the locations, elevations, and depths of borings or test pits, including logs of bore holes and/or test pits; (7-1-93)

c. A maximum cross-section of the dam showing elevation and width of crest, slopes of upstream and downstream faces, thickness of riprap, zoning of earth embankment, location of cutoff and bonding trenches, elevations, size and type of outlet conduit, valves, operating mechanism and dimensions of all other essential structural elements such as cutoff walls, filters, embankment zones, etc.; (7-1-93)

d. Detailed drawings showing plans, cross and longitudinal sections of the outlet conduits, valves and controls for operating the same, and trash racks; (7-1-93)

e. A curve or table showing the capacity of the reservoir in acre-feet vs gauge height (referenced to a common project datum) of the reservoir storage level, and the computations used in making such determinations. (7-1-93)

f. A curve or table showing the outlet discharge capacity in cubic feet per second vs gauge height of reservoir storage level, and the equation used in making such determination; (7-1-93)

g. A curve showing the spillway discharge capacity in cubic feet per second vs gauge height of the reservoir or flood surcharge level above the spillway crest and the equation used in making such determinations; (7-1-93)

h. Detailed drawings of spillway structure(s), cross-sections of the channel heading to and from the spillway and a spillway profile; (7-1-93)

i. Plans for flow measuring devices capable of providing an accurate determination of the flow of the stream above and below the reservoir, and a permanent reservoir or staff gauge near the outlet of the reservoir plainly

marked in feet and tenths of a foot referenced to a common project datum; (7-1-93)

j. Plans or drawings of instruments, recommended by the owner's engineer to monitor performance of intermediate or large dams to assure safe operation, or as may be required by the Director to monitor any dam regardless of size, that is situated upstream of a high risk area. (7-1-93)

06. Specifications. Specifications shall include provisions acceptable to the Director for adequate observation, inspection and control of the work by a registered professional engineer, during the period of construction. (7-1-93)

07. Changes to Specifications. The specifications shall not be materially changed without prior written consent of the Director. Significant design changes, while construction is underway, shall be submitted for the Director's review and approval. (7-1-93)

08. Inspections. The owner shall provide for and allow inspections by the Department to assure the dam and appurtenant structures are constructed in conformance with the approved plans and specifications, or as may be revised by the engineer and approved by the Director if there are unforeseen conditions discovered during site excavation or construction of the dam which potentially jeopardize the future integrity and safety of the dam. Certain stages of construction shall not proceed without inspection and approval by the Director, including the following: (7-1-93)

a. After clearing and excavation of the foundation area and cutoff trench and prior to placing any fill material. (7-1-93)

b. After installation of the outlet conduit and collars and before placing any backfill material around the conduit; (7-1-93)

c. After construction is completed and before any water is stored in the reservoir. (7-1-93)

d. At such other times as determined necessary by the Director. The Director will, upon seven (7) days notice, inspect and if satisfactory, approve the completed stage of construction. The Director may conduct inspections upon shorter notice upon good reason being shown or upon a schedule jointly agreed upon by the Director and the owner. (7-1-93)

09. Inspection, Examination and Testing of Materials. All materials and workmanship shall be subject to inspection, examination and testing by the Director at any and all times. (7-1-93)

10. Rejection of Defective Material. The Director shall have the right to require the owner or engineer to reject defective material and workmanship or require its removal or correction respectively. Rejected workmanship shall be corrected and rejected material shall be replaced with proper material. (7-1-93)

11. Suspension of Work. The Director may order the engineer to suspend any work that may be subject to damage by inclement weather conditions. (7-1-93)

12. Responsibility of Engineer. These provisions shall not relieve the engineer of his responsibility to assure that construction is accomplished in accordance with the approved plans and specifications or to suspend work on his own motion. (7-1-93)

13. Detailing Provisions of Specifications. The specifications shall state in sufficient detail, all provisions necessary to insure that construction is accomplished in an acceptable manner and provide needed control of construction to insure that a safe structure is constructed. (7-1-93)

14. Design Report. Owners proposing to construct, enlarge, alter or repair an intermediate or large dam shall submit an engineering or design evaluation report with the plans and specifications. The engineering report shall include as much of the following information as necessary to present the technical basis for the design and to describe the analyses used to evaluate performance of the structure and appurtenances. (7-1-93)

- a. All technical reference(s); equations and assumptions used in the design; (7-1-93)
- b. Hydrologic data used in determining runoff from the drainage areas; reservoir flood routing(s); and hydraulic evaluations of the outlet(s) and the spillway(s). (7-1-93)
- c. Engineering properties of the foundation area and of each type of material to be used in the embankment. (7-1-93)
- d. A stability analysis, including an evaluation of overturning, sliding, slope and foundation stability and a seepage analysis; (7-1-93)
 - i. Seismic design loads shall be evaluated and applied at all large dams to be located in significant or high risk areas, in Seismic Zone 3, which for purposes of these rules is the area in Idaho east of Range 22 East, Boise Meridian. The evaluation required of large dams, that are classified significant or high risk, shall use the maximum ground motion/ acceleration generated by the maximum credible earthquake, which could affect the dam site. (7-1-93)
 - ii. Seismic analysis may be required as determined by the Director for large dams located above high risk areas in Seismic Zone 2, which for purposes of these rules is the area in Idaho west of Range 22 East, Boise Meridian. (7-1-93)

15. Additional Information/Waiver. The Director may require the filing of such additional information which in his opinion is necessary or waive any requirement herein cited if in his opinion it is unnecessary. (7-1-93)

16. Alternate Plans. The Director may accept plans and specifications or portions thereof prepared for other agencies which are determined to meet the requirements of Rule 40. (7-1-93)

041. -- 044. (RESERVED).

045. OPERATION PLAN (RULE 45).

An operation plan is required as described in the following rules and shall provide procedures for emergency operations and include guidelines and procedures for inspection, operation and maintenance of the dam and appurtenances, including any instruments required to monitor performance of the dam during normal operating cycles, critical filling or flood periods, or as may be required to monitor new or existing dams subject to earthquake effects. (7-1-93)

01. New, Reconstructed or Enlarged Dams. Prior to the initial filling of the reservoir or refilling the reservoir for a reconstructed or enlarged dam in the following categories, the owner shall file with the Director an operation plan for review and approval: (7-1-93)

- a. Small, high risk. (7-1-93)
- b. Intermediate, significant risk. (7-1-93)
- c. Intermediate, high risk. (7-1-93)
- d. Large, any risk category. (7-1-93)

02. Existing Dams. Unless exempted by the Director, owners of the following categories of dams shall file an operation plan with the Director on or before July 1, 1992 for review and approval: (7-1-93)

- a. Intermediate, high risk. (7-1-93)
- b. Large, significant risk. (7-1-93)
- c. Large, high risk. (7-1-93)

03. Alternate Plans. The Director may accept existing studies or plans in lieu of an operation plan if the Director determines the information provided fulfills the requirements of Rule 45. (7-1-93)

046. -- 049. (RESERVED).

050. NEW INTERMEDIATE OR LARGE DAMS (RULE 50).

The following minimum criteria shall be used to evaluate the design of intermediate or large earthfill dams in Idaho. These standards are intended to serve as guidelines for a broad range of circumstances, and engineers should not consider them as a restriction to the use of other sound engineering design principles. Exclusion from this established criteria will be considered by the Director on a case-by-case basis in approving plans and specifications and evaluating dams. Dams constructed of other materials shall comply with these criteria as found appropriate by the Director and with other engineering criteria approved by the Director. (7-1-93)

01. Embankment Stability. Slope stability analyses shall determine the appropriate upstream and downstream slopes. Unless slope stability analysis determines otherwise, the embankment slopes shall be:

Upstream slope	3:1 or flatter
Downstream slope	2:1 or flatter

(7-1-93)

a. For large high and significant hazard dams and intermediate high hazard dams the embankment shall be designed, constructed and maintained to assure stability under static loads and prevent instability due to seepage or uplift forces, or drawdown conditions. Transmission of seepage through the embankment, abutments and foundation shall be controlled to prevent internal removal of material and instability where seepage erodes or emerges. (7-1-93)

b. The design analysis shall consider the need for installing filters, filter fabric and/or toe drains to stabilize the fill and protect against piping of the embankment fill material. (7-1-93)

c. The minimum factor of safety for a dam under steady state condition shall be 1.5. During rapid drawdown of the reservoir, the minimum factor of safety for the embankment shall be 1.2. For dams constructed in Seismic Zone 3, the minimum factor of safety under seismic load shall be 1.0. (7-1-93)

d. The stability of an embankment subjected to earthquake ground motions can be analyzed by dynamic response or pseudo-static analyses. Pseudo-static analyses are acceptable for embankment dams constructed of soils that will not build-up excess pore pressures due to shaking, nor sustain more than fifteen percent (15%) strength loss during earthquake events, otherwise the stability of an embankment dam shall be analyzed by a dynamic response method. A pseudo-static analysis simplifies the structural analysis (i.e. the resultant force of the seismic occurrence is represented by a static horizontal force applied to the critical section to derive the factor of safety against sliding along an assumed shear surface). The value of the horizontal force used in the pseudo-static analysis, is the product of the seismic coefficient and the weight of the assumed sliding mass. (7-1-93)

e. Slope deformation analyses are required for dams located in Seismic Zone 3, that are constructed of cohesionless soils and/or on foundations which are subject to liquefaction, when the peak acceleration at the site is anticipated to exceed 0.15g. (7-1-93)

f. The design analyses for new dams located in high risk areas (in Seismic Zone 2 or 3) shall include geologic and seismic reports, location of faults and history of seismicity. (7-1-93)

g. Where in the opinion of the Director, embankment design or conditions warrant, instrumentation of the embankment and/or foundation will be required. (7-1-93)

h. The design analyses for new large dams located in high risk areas (in Seismic Zone 3) shall include an evaluation of potential landslides in the vicinity of the dam or immediate area of the reservoir, which could cause

damage to the dam or appurtenant structures, obstruct the spillway or suddenly displace water in the reservoir causing the dam to overtop. If potential landslides pose such a threat, they shall be stabilized against sliding, with a minimum factor of safety of 1.5. (7-1-93)

02. Top Width. The crest width shall be sufficient to provide a safe percolation gradient through the embankment at the level of the maximum storage elevation. The minimum crest width (top of embankment) shall be determined by:

$$W = H / 5 + 10$$

W = Width, in feet
H = Structural Height, in feet

The minimum top width for any dam is twelve (12) feet. (7-1-93)

03. Cutoff Trenches or Walls. Cutoff trenches shall be excavated through relatively pervious foundation material to an impervious stratum or zone. The trench shall be backfilled with suitable material, compacted to the specified density. The cutoff trench shall extend up the abutments to the maximum storage elevation. (7-1-93)

a. Cutoff trenches shall be wide enough to allow the free movement of excavation and compaction equipment. Side slopes shall be no steeper than one to one (1:1) for depths up to twelve (12) feet, and no steeper than one and one half to one (1 1/2:1) for greater depths to provide for proper compaction. Flatter slopes may be required for safety and stability. (7-1-93)

b. Concrete cutoff walls may be used to bond fills to smooth rock surfaces in a similar manner as cutoff trenches and shall be entrenched in the rock to a depth approximately one-half the thickness of the cutoff wall. Concrete cutoff walls shall be doweled into the rock a minimum of eight (8) inches with a maximum spacing of eighteen (18) inches for three-fourths (3/4) inch steel dowels. Concrete walls shall have a minimum projection of three (3) feet perpendicular to the rock surface and shall have a minimum thickness of twelve (12) inches. (7-1-93)

04. Impervious Core Material. The approved earth materials (silt soils are seldom acceptable) shall be zoned as shown in the plans and placed in the embankment in continuous, approximately level layers, having a thickness of not more than six (6) inches before compaction. Compaction shall be based on ASTM D-698. A minimum compaction of ninety-five percent (95%) is required. (7-1-93)

a. An acceptable working range of moisture content for the core material shall be established and maintained. (7-1-93)

b. The material shall be compacted by means of a loaded sheep's foot or pneumatic roller to the required density. (7-1-93)

c. No rock shall be left in the core material which has a maximum dimension of more than four (4) inches. The core material shall be free of organic and extraneous material. (7-1-93)

d. The core material shall be carried up simultaneously the full width and length of the dam, and the top of the core material shall be kept substantially level at all times, or slope slightly toward the reservoir. (7-1-93)

e. No frozen or cloddy material shall be used, and no material shall be placed upon frozen, muddy or unscarified surfaces. (7-1-93)

f. All materials used in the dam shall meet the stability and seepage requirements as shown by a design analysis of the structure and shall be properly installed to meet these requirements. (7-1-93)

05. Drains. Toe or chimney drains or free draining downstream material shall be installed where necessary to maintain the phreatic line within the downstream toe. (7-1-93)

a. Filter design for chimney drains, filter blankets and toe drains in clay and silt soils shall be selected using the following design criteria, unless deviations are substantiated by laboratory tests. All tests are subject to

review and approval by the Director.

D15 filter/D15 base > 5 but < 20

D15 filter/D85 base < 5

D50 filter/D50 base < 25

D85 filter > 2 times diameter of pipe perforations, or 1.2 times width of pipe slots. (7-1-93)

b. Filter material requirements are determined by comparing the particle size distribution of the filter to the particle size distribution of the materials to be protected;

e.g. D50 filter
D50 material to be protected

Where D is the particle size passing a mechanical (sieve) analysis expressed as a percentage by weight. (7-1-93)

c. The base material should be analyzed considering the portion of the material passing the No. 4 sieve, for designing filters for base materials that contain gravel size particles. To assure internal stability and prevent segregation of the filter material, the coefficient of uniformity (D60/D10) shall not be greater than 20. (7-1-93)

d. The minimum thickness of filter blankets and chimney drains shall be twelve (12) inches, with the maximum size particle passing the one (1) inch sieve. The maximum particle size may be increased with increasing thickness of the filter, by the rate of one (1) inch per foot of filter. However, the maximum particle shall not exceed three (3) inches. Zoned filters and chimney drains must not be less than twelve (12) inches thick per each zone. The width of granular filters shall not be less than the width of the installation equipment unless the plans and specifications include construction procedures adequate to insure the integrity of a narrower width. (7-1-93)

e. Perforated drain pipes must have a minimum of six (6) inches of drain material around the pipe. The maximum particle size shall not exceed one-half (1/2) inch unless the layer thickness is increased at the rate of one (1) inch per foot of filter. Underdrains and collection pipes must be constructed of noncorrosive material. (7-1-93)

06. Freeboard. The elevation of the top of the embankment shall be constructed and maintained above the flood surcharge level to prevent the dam from overtopping during passage of the inflow design flood and to provide freeboard for wind generated waves. Camber shall be included in the design and incorporated in the construction of the top of the embankment, unless waived by the Director. Camber may be estimated by multiplying the structural height of the dam by five percent (5%). (7-1-93)

a. The height of wind generated waves (H) moving across a surcharged reservoir can be estimated by the following equation:

$H = 1.95 (F/2)$ where F = fetch, the distance in miles across the reservoir, measured perpendicular to the major axis of the dam. (7-1-93)

b. For large, high risk dams the minimum freeboard shall be two (2) feet plus wave height during passage of the one percent (1%) flood or equal to the surcharge elevation of the reservoir during passage of the inflow design flood whichever is greater. (7-1-93)

c. Estimation of the height of the wind generated wave using the empirical equation in Rule 050.06.a. shall not preclude a more conservative design including consideration of fill materials, embankment zoning, slope surface protection, drainage or other safety factors. (7-1-93)

07. Riprap. All dams which are subject to erosion shall be protected from wave action. The design engineer, with approval of the Director, shall determine whether or not rock riprap or other protection is necessary. (7-1-93)

a. Where rock riprap is used, it shall be placed on a granular bedding material, and extend up the slope, from three (3) feet below the normal minimum operating level to the top of the dam. (7-1-93)

b. Where riprap is required by Rule Subsection 055.07, pipes, cables, brush, tree growth, dead growth, logs, or floating debris are not acceptable substitutes for rock riprap and granular bedding material. (7-1-93)

08. Outlet Conduits. All reservoirs shall be provided with an outlet conduit of sufficient capacity to prevent interference with natural streamflow through the reservoir to the injury of downstream appropriators unless waived by the Director. In addition to any natural flow releases, the outlet conduit should be of sufficient capacity to pass at the same time, the maximum water requirement of the owner. A larger outlet conduit may be required to provide adequate release capability as determined by the Director. (7-1-93)

a. Outlet conduits shall be laid on a firm, stable foundation and normally not be placed on fills which can consolidate, allow differential settlement, and cause separation or misalignment of the pipe. Unless otherwise required, the outlet shall have a minimum inside diameter of twelve (12) inches. The conduits shall be of reinforced concrete or of metal pipe encased in concrete, poured with a continuous seal between the concrete and the trench except as otherwise approved by the Director. Void spaces and uncompacted areas shall not be covered over when the outlet trench is backfilled. Outlets shall be properly aligned on an established grade and may be supported on a concrete cradle, or otherwise supported and kept aligned when the outlet is covered. (7-1-93)

b. Asphalt dipped or other metal pipe is not acceptable unless it is encased in concrete. Exceptions may be made only where conditions warrant, but in no case shall the reasonable life expectancy of the pipe be less than the design life of the dam. (7-1-93)

c. All outlet conduits shall have a seepage path through the impervious zone at least equivalent in length to the maximum head above the downstream end of the system. Only one-third (1/3) the horizontal distance through the impervious zone will be utilized when calculating the length of the seepage path. Collars may be used to satisfy this requirement but all collars shall extend a minimum of two (2) feet outside the conduit for dams up to thirty (30) feet in height and a minimum of three (3) feet for dams above that height. Collars shall be spaced at intervals of at least seven (7) times their height and no collar may be closer to the outer surface of the impervious zone than the distance it extends out from the conduit. (7-1-93)

d. The use of multiple conduits is allowed only upon the written approval of the Director. (7-1-93)

09. Gates. All conduits shall be gated on the upstream end, unless otherwise approved by the Director, with either a vertical or an inclined gate. All conduits shall be vented directly behind the gate unless otherwise determined by the Director. Reservoirs storing water during the winter and subject to severe ice conditions shall have inclined gate controls enclosed in a protective sleeve which is buried. All gate stem pedestals shall be made of concrete. All trash racks shall slope toward the reservoir. At least one (1) of the sides of the inlet structure shall be open to allow water to flow into the outlet conduit and shall be covered with a trash rack. Trash racks should be designed with bars primarily in one (1) direction so they can be cleaned. If fish screens are used, they shall be placed over the trash rack and shall be removable for cleaning, or of the self-cleaning type. (7-1-93)

10. Outlet Controls. Outlet controls shall be installed at a stable location, on the crest or on an elevated platform, or within an enclosure when required, which is readily accessible, but secured to prevent unauthorized operation. (7-1-93)

11. Release Capability. Based on the size of the dam and on the risk category assigned by the Director, the release capability of a dam shall equal or exceed the inflow design flood in the following table:

Downstream Risk Category	Size Classification	Inflow Design Flood
Low	Small	Q50
	Intermediate	Q100

Downstream Risk Category	Size Classification	Inflow Design Flood
	Large	Q500
Significant	Small	Q100
	Intermediate	Q500
	Large	0.5 PMF
High	Small	Q100
	Intermediate	0.5 PMF
	Large	PMF

NOTE: The inflow design flood(s) indicated in the table include specific frequency floods (2%/50yr, 1%/100 yr.) expressed in terms of exceedance with a probability the flood will be equaled or exceeded in any given year (a fifty (50) year flood has a two percent (2%) chance of occurring in any given year and a one hundred (100) year flood has a one percent (1%) chance of occurring in any given year); or PMF - probable maximum flood, which may be expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is derived from the probable maximum precipitation (PMP) which is the greatest theoretical depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year. (7-1-93)

a. All spillways shall be stabilized for the discharge of flow by the use of concrete, masonry, riprap or sod, if not constructed in resistant rock. (7-1-93)

b. Where site conditions allow, the spillway shall be constructed independent of embankment dams. The spillway(s) shall guide the discharge of water away from the dam embankment so as not to erode or endanger the structure. (7-1-93)

c. The minimum base width of an open-channel spillway shall be ten (10) feet. Conduits or siphon pipes other than glory hole spillways are not acceptable substitutes for an open-channel spillway. (7-1-93)

d. The effectiveness of spillways shall be undiminished by bridges, fences, pipelines or other structures. (7-1-93)

e. Unless expressly authorized in writing by the Director, or approved as an integral part of an operation plan, stop logs or flashboards shall not be installed in spillways. (7-1-93)

12. Reservoir Site. The dam site shall be cleared of all trees, brush, large rocks, and debris unless otherwise waived by the Director. The reservoir site shall be cleared of all woody material, growth or debris that is large enough to lodge in the spillway, or outlet works, except as otherwise approved by the Director. (7-1-93)

13. Inspection and Completion Reports. As construction proceeds, it is the responsibility of the engineer to submit test reports (e.g. soil material analyses, density tests, concrete strength tests) along with periodic inspection and progress reports to the Director. (7-1-93)

a. Upon completion of construction the owner or his engineer shall provide the Director a short, written narrative account of all items of work. Record drawings and revised specifications shall be submitted to the Director if the completed project has been substantially changed from the plans and construction specifications originally approved. (7-1-93)

b. The engineer representing the owner shall certify that construction, reconstruction, enlargement, replacement or repair of the dam and appurtenances was completed in accordance with the record drawings and specifications, or as revised. (7-1-93)

051. -- 054. (RESERVED).

055. EXISTING INTERMEDIATE OR LARGE DAMS (RULE 55).

All dams regulated by the department shall be operated and maintained to retain the embankment dimensions and the hydraulic capacity of the outlet works and spillway(s) as designed and constructed, or as otherwise required by these rules. (7-1-93)

01. Analyses Required. The analyses required by Rule 40 are not applicable to existing dams except as required in Rule Subsections 055.01.a. and 055.01.e. unless for good cause, the Director specifically requires the analyses. Dams constructed of other than earth material shall comply with these criteria, as determined by the Director, or with other engineering criteria approved by the Director. (7-1-93)

a. For large, significant or high risk dams, the release capability required by Rule Subsection 050.11 shall be evaluated and applied to the structure. Dams of other size and risk are required to provide the release capability of Rule Subsection 050.11 but are not required to conduct the analyses. (7-1-93)

b. Every dam, unless exempted by the Director shall have a spillway with a capacity to pass a flood of one percent (1%) (two percent (2%) for small low hazard dams) occurring with the reservoir full to the spillway crest at the beginning of the flood while maintaining the freeboard required by Rule Subsection 050.06. (7-1-93)

c. The Director may waive the spillway requirement for dams proposing off stream storage or upon a showing acceptable to the Director. (7-1-93)

d. The release capability can include the capacity of spillway(s) and outlet(s), diversion facilities, or other appurtenant structures, and any approved operating procedures which utilize upstream storage, diversion and flood routing storage to pass flood events. The remainder of the required release capacity, if any, may be met by the following: (7-1-93)

i. Reconstruction, enlargement or addition of spillway(s), outlet(s), diversion facilities or other appurtenant structures. (7-1-93)

ii. A showing acceptable to the Director that failure of the dam during a flood of the specified magnitude described in Rule Subsection 050.11 would not substantially increase downstream damages over and above the losses and damages that would result from any natural flood up to that magnitude. (7-1-93)

iii. A showing acceptable to the Director that the release capability of the dam together with other emergency release modes such as a controlled failure or overtopping of the dam would not result in a larger rate of discharge than the rate of inflow to the reservoir. (7-1-93)

iv. A showing acceptable to the Director that limiting physical factors unique to the dam site exist that prevent construction of a spillway or other release capability mechanisms during a flood of the specified magnitude described in Rule Subsection 050.11 provided the owner implements storage operational procedures and/or provides for emergency warning to protect life and property. (7-1-93)

e. For large, high risk dams, the seismic design loads shall be evaluated and applied to dams located east of Range 22E, B.M. The evaluation shall use the maximum ground motion/acceleration generated by the maximum credible earthquake. (7-1-93)

f. The Director may accept existing studies relative to requirements of Rule Subsections 055.01.a. and 055.01.e., if the Director determines the information provided fulfills the requirements of Rule Subsections 055.01.a. and 055.01.e. (7-1-93)

g. The Director may allow until July 1, 1992 for completion of the analyses required in Rule Subsections 055.01.a. and 055.01.g. and may allow the owner of an existing dam a compliance period of up to ten years for completing the studies, to complete structural modifications or implement other improvements necessary to provide the release capability determined to be required (Rule Subsection 055.01.a.) or complete structural modifications necessary to assure the dam and appurtenant facilities will safely function under earthquake loads

(Rule Subsection 055.01.g.) (7-1-93)

h. Within thirty (30) days after completing the analyses required in Rule Subsection 055.01.a. or 055.01.g., the owner of an existing dam that is deficient in either case (Rule Subsection 055.01.a. or 055.01.g.) shall file with the Director a schedule outlining the dates work or construction items will be completed. (7-1-93)

02. Other Requirements. (7-1-93)

a. Routine maintenance items include the following: (7-1-93)

i. Eradication of rodents and filling animal burrows. (7-1-93)

ii. Removal of vegetation and debris from the dam. (7-1-93)

iii. Restoring original dimensions of the dam by the addition of fill material. (7-1-93)

iv. Addition of bedding or riprap material which will not increase the height or storage capacity. (7-1-93)

v. Repair or replacement of gates, gate stems, seals, valves, lift mechanisms or vent pipes with similar equipment. (7-1-93)

vi. Repair or replacement of wingwalls, headwalls or aprons including spalling concrete. (7-1-93)

b. The following are not routine maintenance items: (7-1-93)

i. Reconstruction of embankment slopes. (7-1-93)

ii. Replacement, reconstruction or extension of outlets. (7-1-93)

iii. Foundation stabilization. (7-1-93)

iv. Filter or drain construction or replacement. (7-1-93)

v. Spillway size alteration or modification. (7-1-93)

vi. Installation of instrumentation or piezometers. (7-1-93)

vii. Release capability modification. (7-1-93)

c. Items not specifically described in Rule Subsections 055.02.a. and 055.02.b. will be determined by the Director to be included in one rule or the other upon receipt of a written request from the owner or his representative seeking such a determination. (7-1-93)

d. Where riprap is required to prevent erosion and to maintain a stable embankment, pipes, cables, brush, tree growth, logs, or floating debris are not acceptable substitutes for rock riprap and granular bedding material. Dams or portions thereof which are stable without riprap, are not required to have riprap. (7-1-93)

e. Upon completion of reconstruction of a dam or feature of a dam included in Rule Subsection 055.02.b., the owner or his engineer shall provide the Director a short written narrative account of all items of work. Record drawings and revised specifications shall be submitted to the Director if the completed project has been substantially changed from the plans and construction specifications originally approved. (7-1-93)

f. Upon request, the owner of every dam shall provide his name and address to the Director and shall advise the Director of future changes in ownership. If the owner does not reside in Idaho, the owner shall provide the name and address of the person residing in Idaho who is responsible for the operation, maintenance and repair of the dam. (7-1-93)

056. -- 061. (RESERVED).

060. SMALL DAM DESIGN CRITERIA (RULE 60).

The following provisions apply to small dams. (7-1-93)

01. Design and Construction of Small Dams. Design and construction of small dams located in high risk areas as determined by the Director require submittal of fees, plans and specifications prepared by an engineer and shall follow the same general criteria established under Rules 40, 45, 50, and 55. Other small dams not determined to be in a high risk area shall follow the same general criteria established under Rules 50 and 55 or larger dams, except that submittal of plans, specifications and test results is not required. (7-1-93)

02. Notification Prior to Construction. The owner shall notify the Director in writing ten (10) calendar days prior to commencing construction. (7-1-93)

03. Approval Required. The owner shall not proceed with the following stages of construction without approval from the Director. (7-1-93)

a. After clearing and excavation of the foundation area and cutoff trench, and prior to placing any fill material; (7-1-93)

b. After installation of the outlet conduit, and before placing any backfill material around the conduit; (7-1-93)

c. After construction is completed, and before any water is stored in the reservoir; (7-1-93)

d. At such other times as determined necessary by the Director. The Director, will, upon seven (7) day notice, inspect and, if satisfactory, approve the completed stage of construction. (7-1-93)

04. Notification upon Completion of Construction. The owner shall in writing notify the Director upon completion of construction. (7-1-93)

061. -- 064. (RESERVED).

065. DAMS STORING TAILINGS AND WATER (RULE 65).

01. Construction of Dams Storing Fifty Acre-Feet or More. Construction of dams intended to store or likely to store fifty (50) acre-feet or more of water in excess of the water contained in the tailings material shall meet the requirements specified in Rules 40, 45, 50 and 55 of these rules. The Director may waive any or all of these requirements if, in the opinion of the Director, sound engineering design provided by the owner indicates such requirements are not applicable. (7-1-93)

02. Abandonment Plan. An abandonment plan which provides a stable, maintenance-free condition at any time tailings are not being actively placed for an extended period of time, as determined by the Director, shall be submitted to the Director by the owner of a dam storing tailings and water. This rule may be waived by the Director if determined not to be applicable. (7-1-93)

066. -- 999. (RESERVED).

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E.12. Illinois



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Joint Committee on Administrative Rules
ADMINISTRATIVE CODE

TITLE 17: CONSERVATION
CHAPTER I: DEPARTMENT OF NATURAL RESOURCES
SUBCHAPTER h: WATER RESOURCES
PART 3702 CONSTRUCTION AND MAINTENANCE OF DAMS
SECTION 3702.30 APPLICABILITY

Section 3702.30 Applicability

- a) Classification
 - 1) Dams will be categorized in one of three classes, according to the degree of threat to life and property in the event of a dam failure. The three classes of dams are:
 - A) Class I – Dams located where failure has a high probability for causing loss of life or substantial economic loss in excess of that which would naturally occur downstream of the dam if the dam had not failed. A dam has a high probability for causing loss of life or substantial economic loss if it is located where its failure may cause additional damage to such structures as a home, a hospital, a nursing home, a highly travelled roadway, a shopping center, or similar type facilities where people are normally present downstream of the dam. This is similar to U.S. Army Corps of Engineers HIGH HAZARD POTENTIAL category as defined in the Corps Guidelines, and the U.S. Soil Conservation Service Class (c) dams as defined in Soil Conservation Service Technical Release No. 60.
 - B) Class II – Dams located where failure has a moderate probability for causing loss of life or may cause substantial economic loss in excess of that which would naturally occur downstream of the dam if the dam had not failed. A dam has a moderate probability for causing loss of life or substantial economic loss if it is located where its failure may cause additional damage to such structures as to a water treatment facility, a sewage treatment facility, a power substation, a city park, a U.S. Route or Illinois Route highway, a railroad or similar type facilities where people are downstream of the dam for only a portion of the day or on a more sporadic basis. This is similar to U.S. Army Corps of Engineers SIGNIFICANT HAZARD POTENTIAL category and the U.S. Soil Conservation Service Class (b) dams.
 - C) Class III – Dams located where failure has low probability for causing loss of life, where there are no permanent structures for human habitation, or minimal economic loss in excess of that which would

naturally occur downstream of the dam if the dam had not failed. A dam has a low probability for causing loss of life or minimal economic loss if it is located where its failure may cause additional damage to agricultural fields, timber areas, township roads or similar type areas where people seldom are present and where there are few structures. This corresponds to U.S. Army Corps of Engineers LOW HAZARD POTENTIAL category and U.S. Soil Conservation Service Class (a) dams.

- 2) Dams will be categorized in one of three size classifications. Such size classifications shall be based on dam height and impounding capacity. If either the height or impounding capacity meets the minimum requirement for the larger size, the dam will be classified in the larger size category.

<u>CLASSIFICATION</u>	<u>IMPOUNDING CAPACITY ACRE-FEET</u>	<u>DAM HEIGHT FEET</u>
Small	Less than 1,000	Less than 40
Intermediate	Greater than 1,000 to Less than 50,000	Greater than 40 to Less than 100
Large	Greater than 50,000	Greater than 100

b) New Dams

1) Class I and II Dams

The owner of a proposed Class I or II dam shall obtain a OWR permit prior to the start of construction. The owner must do all construction and maintenance of the dam in accordance with this Part governing such Class I or II dam.

2) Class III Dams

A) The owner of a proposed Class III dam shall obtain a OWR permit prior to the start of construction if the dam meets any of the following criteria:

- i) the drainage area of the proposed dam is 6400 acres or more in a Rural Area or 640 acres or more in an Urban Area, or
- ii) the dam is 25 feet or more in height provided that the impounding capacity is greater than 15 acre-feet, or
- iii) the dam has an impounding capacity of 50 acre-feet or more provided that the dam height is greater than 6 feet.

B) If a permit is required for the Class III dam under any of these criteria, then the owner must do all construction and maintenance of the dam in accordance with this Part governing Class III dams.

c) Existing Dams

The owner of a dam that was permitted and built in compliance with a OWR permit before September 2, 1980, and that is currently in good repair shall not be required, except in compliance with Sections 3702.150 or 3702.190, to make changes in the design, structure, or construction of such dam. The owner of a dam that was permitted and built before September 2, 1980, but is not in accordance with the OWR permit or is not in good repair, shall be required to meet all current standards for existing dams. The owner of a dam built after September 2, 1980, shall be required to meet all standards for proposed dams existing at the time of its construction. Operation, maintenance, inspection and financial responsibility standards must be complied with at all dams.

1) Class I and II Dams

- A) OWR has developed an inventory of dams in Illinois. OWR and federal agencies have conducted and are conducting inspections of existing dams having a potential for loss of life or property damage in case of a dam failure. As inspection reports are completed, OWR will furnish in writing to the owner of the dam a detailed and specific list of defects discovered in the course of the inspection of the dam, including the specific nature of any inadequacies of the capacity of the spillway system and any indications of seepage, erosion or other evidence of structural deficiency in the dam or spillway; together with a statement of the applicable standards found in 17 Ill. Adm. Code 3702 which if complied with by the owner of the dam will put the dam into compliance with this Part.
- B) If an inspection by OWR or in which OWR concurs finds that a dam is in an unsafe condition, OWR will notify the appropriate officials of the affected city or county, the State's Attorney of the county in which the dam is located, and the Illinois Emergency Management Agency (IEMA); and will assist IEMA) in any emergency actions deemed necessary by that agency.
- C) OWR will notify the dam owner whose dam has been inspected if the owner must obtain a permit or amendment to an existing permit for the dam.
- D) If an existing Class I or II dam has been inspected and found to have serious deficiencies requiring major modifications, then within 90 days after receipt of notice from OWR that a permit or amendment to an existing permit is required under this Part, the owner of a Class I or II dam must provide written assurance to OWR of the following: the owner's intention to rectify the deficiencies noted, the date which the owner will submit a completed permit application, the time frame for initiating and completing the appropriate remedial measures, and the methods and designs to be used for the remedial measures.
- E) If an existing Class I or II dam has been inspected and found to have no serious deficiencies requiring major modifications, OWR will notify the owner of the dam that he must submit within 90 days a permit application including the following if such has not been previously

provided to OWR:

- i) an Operating Plan (Section 3702.40(b)(4));
 - ii) a Maintenance Plan (Section 3702.40(b)(5));
 - iii) a Financial Responsibility Statement (Section 3702.40(b)(6));
and
 - iv) a Right of Access Statement (Section 3702.40(b)(7)(A)).
- F) An owner initiating major modifications to an existing Class I or Class II dam must obtain a new permit or amendment to an existing permit prior to the initiation of the modifications.
- 2) Class III Dams
- A) Using the inventory of dams or other similar information, OWR, over a period of time, upon receipt of a complaint or upon its own investigation, may contact owners of those existing Class III dams which
- i) have a drainage area of 6400 acres or more in a Rural Area or 640 acres or more in an Urban Area, or
 - ii) are 25 feet or more in height, provided that the impounding capacity is greater than 15 acre-feet, or
 - iii) have an impounding capacity of 50 acre-feet or more provided that the dam height is greater than 6 feet.
- B) OWR will inform the owners of such dams that they must submit to OWR a maintenance program and a statement indicating actions to be taken to remedy the noted deficiencies.
- C) If an inspection by OWR or in which OWR concurs finds that a dam is in an unsafe condition, OWR will notify the appropriate officials of the affected city or county, the State's Attorney of the county in which the dam is located, and IEMA.
- D) Owners of existing Class III dams in locations where there is potential for downstream urban development, which could cause a change in dam classification in the foreseeable future, when so notified by OWR, shall be required to report annually the existing land uses downstream of the dam. Extent of downstream land use to be reported is dependent upon factors such as slope and width of flood plain and density and intensity of downstream development. Extent downstream will not exceed 2 miles unless otherwise indicated by OWR. The owner may provide information indicating that an extent downstream which is shorter than 2 miles is appropriate. The width of flood plain shall be the width of the area inundated by the 100-year flood.

- E) Owners of Class III dams desiring to make major modifications to their dams shall obtain a OWR permit or an amendment to an existing OWR permit for the work prior to the initiation of the modifications.

d) Designation by OWR of Dam Classification

Before assigning or changing the dam classification for a new or existing dam, OWR shall give notice and opportunity for hearing pursuant to Section 3702.170 to the applicant or existing dam owner and other interested persons of such action.

1) Initial Assignment of Dam Classification

A) New Dams

The classification of new dams will be based upon information available to OWR. Such information includes, but is not limited to, U.S.G.S. quadrangle maps of the downstream area, the preliminary report and support data from the owner's engineer, known elevations of structures downstream of the proposed dam, information from the public, and previous study data. Such information is available from in-house data and data supplied by the owner's engineer, the public, federal or state agencies. The owner of the proposed dam shall submit information to establish the degree of threat to life and property damage in the event of a dam failure.

B) Existing Dams

- i) The classification of existing dams which have been inspected by the U.S. Army Corps of Engineers, other federal agencies, or OWR will be based upon the agency's inspection report.
- ii) The classification of existing dams which have not been inspected by federal agency or OWR but which have had major modifications proposed by the dam owner will be processed as new dams in accordance with Section 3702.30(d)(1)(A).

2) Change in Dam Classification

Upon receipt and verification of information indicating that significant change in the degree of threat to life or property from a dam failure has occurred since the dam's original classification, the classification of that dam shall be changed to reflect the new hazard potential. Upon reclassification, the dam owner shall be subject to the applicable dam safety requirements for the current classification (Section 3702.30(c)).

e) Removal of Dams

The owner of a Class I, II or III dam as defined in this Part, who wishes to remove his dam, shall obtain, prior to the initiation of the dam removal, a OWR permit to remove the dam in accordance with Section 3702.50 governing the removal of dams.

(Source: Amended at 11 Ill. Reg. 1941, effective January 13, 1987)

Joint Committee on Administrative Rules
ADMINISTRATIVE CODE

TITLE 17: CONSERVATION
CHAPTER I: DEPARTMENT OF NATURAL RESOURCES
SUBCHAPTER h: WATER RESOURCES
PART 3702 CONSTRUCTION AND MAINTENANCE OF DAMS
SECTION 3702.40 REQUIREMENTS FOR APPROVAL OF PERMITS FOR
CONSTRUCTION OF NEW DAMS AND MAJOR MODIFICATIONS OF EXISTING
DAMS

Section 3702.40 Requirements for Approval of Permits for Construction of New Dams and Major Modifications of Existing Dams

a) The following are OWR requirements which must be met in order to obtain a permit for construction of a new dam or major modification of an existing dam. Applicants are encouraged to submit to OWR a preliminary report for approval of concept prior to completion of the permit application form. The preliminary and all subsequent plans and reports shall be prepared under the direction of an engineer or other qualified personnel. The engineer or qualified personnel may be assisted by other professional personnel applying the disciplines of hydrologic engineering, hydraulic engineering, soil mechanics, structural engineering, or engineering geology.

b) OWR staff will be available for consultation prior to initiation of design studies, and at any time during the development of the permit application if questions should arise.

1) Structural and Geotechnical Design Requirements

The basis for OWR review and approval of the structural and geotechnical design requirements of Class I, II and III dams is the Corps Guidelines subject to modification as indicated in this Part. The criteria for structural and geotechnical design contained in the Corps Guidelines are minimum criteria. Variations from the criteria may be required or allowed by OWR for special physical conditions at the proposed site as necessary or appropriate to meet the interest of the overall structural and geotechnical requirements of this Part. Technical publications, other than the Corps Guidelines, may be used by OWR to assure the use of current and applicable data for the structural and geotechnical review of the dam design.

2) Hydrologic and Hydraulic Design Requirements

The basis for OWR review and approval of the hydrologic and hydraulic design requirements for Class I, II and III dams is the Corps Guidelines, subject to modifications as indicted herein. Technical publications other than the Corps Guidelines may be used to assure the use of current and

applicable data for the hydrologic and hydraulic review of dam design.

A) Proposed Dams

The following minimum spillway design floods shall be used for proposed structures:

i) Principal Spillway Design Flood

<u>CLASSIFICATION</u>	<u>SIZE</u>	<u>PRINCIPAL SPILLWAY DESIGN FLOOD</u>
Class I	All	100-yr.
Class II	All	50-yr.
Class III	All	25-yr.

ii) Total Spillway Design Flood

<u>CLASSIFICATION</u>	<u>SIZE</u>	<u>PRINCIPAL SPILLWAY DESIGN FLOOD</u>
Class I	Small	0.5 PMF
	Intermediate	1.0 PMF
	Large	1.0 PMF
Class II	Small	100-yr.
	Intermediate	0.5 PMF
	Large	1.0 PMF
Class III	Small	100-yr.*
	Intermediate	100-yr.
	Large	0.5 PMF

*For proposed Class III dams where the dam height multiplied by the impounding capacity is less than or equal to 300, no specific total spillway capacity is required.

iii) For all proposed Class II or III dams, a determination of alternatives for increasing the total spillway capacity to accommodate the PMF shall also be submitted to OWR. The initial dam design shall provide for the capability of increasing the spillway capacity. Future downstream land use, land use controls, and growth projections will be considered in the review of the spillway capacity design.

B) Existing Dams

The minimum spillway design flood for modifications to existing dams built after September 2, 1980 shall be the same as the criteria for proposed dams. The minimum spillway design flood for modifications to existing dams that were constructed and in service on or before September 2, 1980, are as follows:

i) Principal Spillway Design Flood

<u>CLASSIFICATION</u>	<u>SIZE</u>	<u>TOTAL SPILLWAY DESIGN FLOOD</u>
Class I	All	100-yr.
Class II	All	50-yr.
Class III	All	No specific requirement.

ii) Total Spillway Design Flood

<u>CLASSIFICATION</u>	<u>SIZE</u>	<u>TOTAL SPILLWAY DESIGN FLOOD</u>
Class I	Small	0.3 PMF
	Intermediate	0.6 PMF
	Large	0.6 PMF
Class II	Small	100-yr.
	Intermediate	0.3 PMF
	Large	0.6 PMF
Class III	Small	100-yr.*
	Intermediate	100-yr.
	Large	0.3 PMF

*For modifications to existing Class III dams where the height multiplied by impounding capacity is less than or equal to 300, no specific total spillway capacity is required.

iii) The Department may approve total spillway design capacities for existing dams other than the spillway design floods listed above. A total spillway design capacity less than the 100-yr. flood will only be allowed for small size, Class III structures with dam height multiplied by impounding capacity less than or equal to 300. Any submittal for variation from the above-listed spillway design flood must include a detailed hydraulic risk assessment that shows that additional spillway capacity will not provide a decrease in potential loss of life or property damage or a detailed economic risk assessment that shows that the chosen spillway design alternative provides the minimum rehabilitation costs plus damage losses; a detailed early warning and emergency evacuation plan coordinated with the local ESDA; and a list (with mailing addresses) of all persons living within the dam breach wave inundation area.

iv) All hearings regarding variation from the above-listed spillway design criteria shall be in accordance with Section 3702.170 of this Part.

- C) For Class I and II dams, a dam breach wave analysis for downstream impacts from failure during the total spillway design flood and impoundment initially at normal pool shall be required for:
- i) a nearly instantaneous total failure and
 - ii) should the applicant so desire, a failure to the degree and timing believed reasonable by the applicant.
- D) Dewatering Capabilities
- i) All new Class I and II dams, all new Class III dams unless exempted by OWR for functional reasons, and existing Class I and II dams requiring major modifications shall have a capability for dewatering the reservoir within a reasonable period of time. In determining a reasonable time period, OWR shall consider the damage potential posed by possible failure, risk and nature of potential failure, purpose of the dam and reservoir, capability and stability of available drainage courses to convey the waters released in the event of an emergency dewatering, and influence of rapid drawdown on stability of the dam. Although each permit must be considered based on its individual circumstances, in general, a reasonable time to dewater 50% of the normal pool storage volume is 7 days for Class I dams, 14 days for Class II dams and 30 days for Class III dams.
 - ii) No dewatering capability shall be required for any existing Class III dam or for any existing Class I or II dam which OWR determines to require no major modifications thereto under this Part.
- E) Specific requirements for minimum freeboard allowances are not appropriate because of the many factors involved in such determinations. The applicant must assess the factors affecting the individual project and develop the appropriate minimum freeboard allowance. Many projects are reasonably safe without freeboard allowance because they are designed for overtopping, or because other factors minimize possible overtopping. Conversely, freeboard allowances of several feet may be necessary to provide a safe condition for some dams. Factors 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.
- F) The applicant must provide stilling basins or other appropriate structures or devices capable of dissipating the energy created at the outlet of the principal spillway and at dewatering outlets for all

flows.

3) Erosion Protection Requirements

- A) As a minimum the applicant shall adequately protect by structural or nonstructural means the upstream face of earth embankment dams from an elevation below normal pool of two feet or 0.50 times the anticipated wave height (if greater than 2.0 feet) up to the minimum freeboard elevation. In addition, if normal pool water surface varies, the upstream face shall be protected within the range of variation.
- B) The applicant shall vegetate or otherwise protect from erosion the downstream face and top of earth embankment dams. The applicant should design earth embankment dams to provide a dam section which can be easily maintained.
- C) The applicant shall provide riprap or other appropriate protection as necessary at dam abutments, dam slope toes (the line of the dam embankment slopes where it intersects the natural ground at the upstream or downstream edge), spillways, stilling basins, and at other locations which, if left unprotected, could lead to damage to, or failure of the dam.
- D) If the spillway design of the dam requires that an earth emergency spillway pass any portion of the 100-year flood, the applicant shall protect the earth emergency spillway against erosion consistent with the dam classification and physical characteristics of the dam site. The applicant must construct all earth emergency spillways on in situ material or on well compacted cohesive materials that will be stable during design flows.
- E) The applicant shall submit plans for control of erosion and water pollution during the anticipated construction or major modifications, including plans for adequate measures to limit the erosion of the soil from exposed slopes after completion of construction. Such plans shall indicate that adequate control measures will be taken during construction to protect the quality of stream flow below the project site, and during the estimated time for filling.

4) Operating Requirements

An applicant for a Class I or II dam shall submit an operational plan specifying the method and schedule for the operation of the dam and the routine operating procedures to keep the dam in good working order, including an emergency warning plan. The emergency warning plan must outline the procedures to be followed during major storm events or other emergency situations. Under this plan, a person designated by the dam owner would monitor dam conditions, and would warn appropriate state and local officials if major problems require immediate repairs and would indicate how the owner plans to accomplish the needed repairs, and indicate if evacuation of persons in areas downstream of the dam may be necessary.

5) Maintenance Requirements

As a condition of each permit, dam owners shall submit a maintenance plan detailing the procedures and schedules to be followed to maintain the dam and its appurtenances in a reasonable state of repair. The maintenance plan shall include but not be limited to the following:

A) Class I and II Dams

The dam owner shall retain an engineer or other qualified personnel to make an initial inspection and report and subsequent inspections and reports as required by this Part. The owner of a Class I dam shall submit the report annually on forms furnished by OWR. The owner of a Class II dam shall submit the report every three years on forms furnished by OWR. In the intervals between the engineer or other qualified personnel reports on Class II dams, the owner shall file with OWR an annual statement on forms furnished by OWR stating that he is maintaining the dam in accordance with the maintenance plan prepared by his engineer or other qualified personnel and indicating any change in land use which may have occurred in the 100-year flood plain within the previously accepted limits downstream of the dam. The reports shall outline modifications made to the dam, any deficiencies found, detail the remedial measures necessary, and the method and time the owner will use to correct the deficiencies found. The dam owner may be required to provide additional inspections and reports by an engineer or other qualified personnel, following unusual storms or seismic events; provided such inspection procedures are required as a part of the maintenance plan approved by OWR in issuing a permit. A sketch showing land use in the flood plain downstream of the dam shall be included in the reports. The extent of downstream land use to be reported is dependent upon factors such as slope and width of the 100-year flood plain and the density and intensity of downstream development. The extent downstream will not exceed 2 miles unless otherwise indicated by OWR. The owner may provide information for review by OWR indicating that an extent downstream which is shorter than 2 miles may be appropriate.

B) Class III Dams

The owner of a new Class III dam or owner of an existing Class III dam qualifying under the provisions of Section 3702.30 (relating to the major modification of existing Class III dams), shall retain an engineer or other qualified personnel to make an initial inspection and report and subsequent inspections and reports on a 5-year interval, in accordance with this Part. The dam owner shall submit to OWR on forms furnished by OWR the engineer's initial report and subsequent fifth year reports. The reports shall include a description of flood plain land use downstream of the dam. In the intervals between the engineer's reports, the owner shall file with OWR an annual statement on forms furnished by OWR stating that he is maintaining the dam in accordance with the maintenance plan prepared by his engineer or other qualified personnel and indicating

any change in land use downstream of the dam. The extent of downstream land use to be reported is dependent upon factors such as slope and width of the 100-year flood plain and the density and intensity of downstream development. The extent downstream will not exceed 2 miles unless otherwise indicated by OWR.

6) Financial Responsibility of Owner

- A) For Class I and II dams, the owner shall document that he has the financial capability to adequately maintain or breach his dam in a safe condition. This may be established by showing that the applicant has the resources and the authority to obtain funds in the amount required to safely breach the dam within 10 days of receipt of notice of the need to breach or repair. For public bodies, this may be done by showing taxing power or other revenue generating ability and passage of an appropriate ordinance or resolution indicating the authority to take such action if necessary. If the owner cannot adequately demonstrate this financial capability, OWR may require the applicant to post a performance bond. The amount of the bond will be that estimated by OWR as reasonably necessary to safely breach the dam in an environmentally sound manner if the condition of the dam becomes a threat to life or property. The owners shall notify OWR when each performance bond has been renewed or extended in time.
- B) Except in emergencies, should the cost of repair to place the dam in a safe condition be less than the cost of breaching, the performance bond may be used to pay for repair, rather than breach of the dam.

7) Other Requirements

- A) The owner shall grant the State the right of access to inspect the dam site and immediate vicinity before, during and after construction and for the life of the dam and appurtenances. Except under emergency conditions, such as when the dam is in imminent danger of failure or is in the process of failing, the State shall notify the owner at least 10 days in advance of any inspection.
- B) For Class I and II dams, the owner shall notify OWR prior to initiating foundation preparations, including cut-off trench excavation.
- C) For Class I and II dams, OWR will require the owner to have continuous inspection during construction. The construction shall be under the direction of an engineer, or other qualified personnel. For Class III dams, OWR may require the owner to have continuous inspection during construction if foundation conditions have not been completely determined or if the dam has been designed with minimal factors of safety.
- D) For Class I and II dams – prior to commencing filling operations, or refilling operations after a drawdown, the applicant shall request

OWR inspection of the dam, and must receive authority from OWR before commencing filling. When drawdowns are performed on a frequent basis as a part of the approved operation plan, the authority is not necessary.

- E) If OWR has not acted to grant or deny the authorization to fill within 30 days after receipt of request, the owner may proceed with filling or refilling operations.
- F) For all new dams, or for major modifications to existing dams, the dam owner shall
 - i) own or have permanent flood easements for all land that will be inundated in the reservoir up to the proposed 100-year frequency flood pool elevation, or
 - ii) submit hydraulic computations showing that, for floods up to the 100-year frequency flood, the pool elevation will not be increased above existing conditions.

(Source: Amended at 11 Ill. Reg. 1941, effective January 13, 1987)

PROCEDURAL GUIDELINES
for
PREPARATION OF TECHNICAL DATA
to be included in
APPLICATIONS FOR PERMITS
for
CONSTRUCTION AND MAINTENANCE OF DAMS

STATE OF ILLINOIS
DEPARTMENT OF NATURAL RESOURCES
OFFICE OF WATER RESOURCES
ONE NATURAL RESOURCES WAY
SPRINGFIELD, ILLINOIS 62702-1271

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Appendices

Appendix #1
Seismic Coefficients

Appendix #2
Sample Operation and Maintenance Manual

Appendix #3
Emergency Action Plan Development Information

The "Rules for Construction and Maintenance of Dams" require that only engineers which are registered as a structural and/or professional engineer in The State of Illinois, under the Professional Engineering Practice Act [225 ILCS 325] and the Structural Engineers Act [225 ILCS 340], and with expertise in the investigation, design, construction, and operation of dams prepare the engineering data to be submitted with an application for a permit. These guidelines have been written with the intent of providing a basic understanding of the type of information that will need to be provided with an application for a permit to construct a new dam and to modify, remove or abandon an existing dam. They have also been prepared for the engineer to understand the methods of review that will be used by the staff of the Office of Water Resources in reviewing an application for a permit. Some of the information presented herein would also be applicable to the preparation of data for an application for permit to operate and maintain an existing dam.

Section IX of these guidelines has been developed to address and provide guidance concerning the issue of the removal of dams including the abandonment of slurry disposal impoundment dams. Abandonment may differ from removal of a dam in that abandonment may leave the embankment intact. However, both removal and abandonment usually result in the dam ultimately being eliminated from the Office of Water Resources regulatory purview.

It is not the intent of these guidelines to be dictatorial as to the methods to be used to achieve the required data. Rather, the user is provided information concerning generally accepted methods of testing, analysis, and computation.

Questions regarding the preparation of the documentation noted in these guidelines may be directed to the Office of Water Resources offices in Springfield (Tel. No. 217/782-3863), Bartlett (Tel. No. 847/608-3100 ext. 2025).

II.

PRELIMINARY DESIGN REPORT

It is strongly recommended that applicants submit a preliminary design report to OWR for approval of the design concept prior to initiation of detailed design studies. This report should include:

A. Ownership and Engineer Information

1. The owner of the dam (names, addresses, telephone numbers)

2. The owner's engineer (names, addresses, telephone numbers, a description of expertise in the investigation, design, construction, and operation of dams, and a listing of previously acquired permits for dams from the Office of Water Resources or its predecessors)

B. Purpose, Location and Configuration - General information regarding the dam and appurtenances. This information should include a statement of the purpose for which the dam is to be used, a legal description of the location of the dam, calculations to verify the drainage area controlled by the dam, the height of the dam and the maximum impounding capacity of the dam.

C. Downstream Hazards and Breach Analysis - In order for OWR to provisionally determine the dam classification, as described in the "Rules for Construction and Maintenance of Dams", information describing the downstream area for a distance of at least two miles is required. This information should include the number of and access to homes and buildings, roads, utilities and other property that would be endangered should failure of the dam occur. Contoured aerial photographs or recent U.S. Geological Survey topographic maps may be used for this purpose. Submittal of additional data, including a dam breach analysis, may be necessary at some sites. If a dam breach analysis is submitted, it should include failures during a range of events from normal pool through the Probable Maximum Flood. The owner should also be cognizant of the possibility for development of the downstream area which could change the dam classification and require modifications to the dam. The original design should provide for these modifications to be more easily accomplished.

- D. Topography - Maps showing the location of the proposed structure that include the location of county and State roads, access to the site, the outline of the reservoir at normal pool elevation, the drainage area limits, and the general topography of the dam site and reservoir area. Contoured aerial photographs or recent U.S. Geological Survey topographic maps may be used for this purpose.
- E. Plans and Drawings - Preliminary drawings that include cross-sections, plans and profiles of the dam, proposed pool levels, and types of spillways.
- F. Basic Design Criteria - Preliminary design criteria including a description of the size, ground cover conditions, and extent of development of the watershed; the proposed geotechnical and exploration testing program, geology and geotechnical engineering assumptions for the foundation and embankment materials; the proposed hydrologic and hydraulic analyses methods; and the type of materials to be used in the dam and the spillway system(s).

III.

FINAL DESIGN REPORT

In order for the Office of Water Resources to assess the safety aspects of a dam from an engineering standpoint, the final design report submitted with the Permit Application must contain the information and calculations to verify the adequacy of the design for the given size and downstream hazard potential of the dam. The safety evaluation will be based upon the capability of the project to meet the minimum performance standards established in the "Rules for Construction and Maintenance of Dams". The remaining sections of these guidelines have been written as an aid in the preparation of the data required to support the application for permit.

Computer programs which are used in the preparation of data for submittal should either be federal public domain programs or have sufficient documentation submitted with a copy of the program to allow for the review of the program. Spreadsheet applications which include equations should also be submitted to allow for the review of their equations. The data generated by all computer programs and spreadsheet applications may not be accepted as correctly representing the information required to be submitted.

IV.

HYDROLOGIC AND HYDRAULIC INVESTIGATIONS

Various methods of analyzing the hydrologic and hydraulic characteristics of a watershed, reservoir, and dam are available. Some of the procedures which are generally acceptable for determination of the hydrologic and hydraulic characteristics are presented in the paragraphs that follow. In general, procedures developed by the following agencies are acceptable: U.S. Army Corps of Engineers; U.S. Department of the Interior, Bureau of Reclamation; U.S. Department of Agriculture, Natural Resources Conservation Service; and U.S. Department of Commerce, National Weather Service. The Office of Water Resources will use the Corps of Engineers and the National Weather Service computer programs as its primary review aids. The programs typically used by OWR for review include: HEC-1, HEC-HMS, HEC-2, HEC-RAS, and FLDWAV.

A. Maximum Water Surface Based on Spillway Design Flood Peak Inflow:

When the total project uncontrolled spillway discharge capability at maximum pool exceeds the peak inflow of the spillway design flood, a reservoir routing is not required. Flood volume is not controlling in this situation and surcharge storage is either absent or insignificant in relation to the spillway and outlet capacity.

When the 100-year, 50-year, or 25 year floods are applicable under the provisions of the "Rules for Construction and Maintenance of Dams", and streamflow data at or near the dam site are available, the spillway design flood peak inflow can be determined by a flood frequency analysis. The recommended method is outlined in "Guidelines for Determining Flood Flow Frequency" by the U.S. Water Resources Council, Hydrology Committee, Bulletin 17B, Revised March, 1982.

When streamflow data are not available, the recommended method is described in the latest version of documents from the U.S. Geological Survey for estimating the magnitude and frequency of floods on rural streams in Illinois. Adjustments to the computed rural discharges must be made to account for urbanization in the watershed. The U.S. Geological Survey has also published documents to assist in the determination of this adjustment. The methods described in TR55, "Urban Hydrology for Small Watersheds") may also be used if the appropriate rainfall values (see Section B1 below) are used.

B. Maximum Water Surface Based on Spillway Design Flood Inflow Hydrograph:

When either the Probable Maximum Flood (PMF) peak or a fraction thereof is required, the "unit hydrograph-infiltration loss rate technique" is considered the most expeditious method of computing the spillway design flood (SDF) peak inflow for most projects. Both the peak and the volume are required in this analysis. Where the 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. Determination of the probable maximum precipitation (PMP) or the 100, 50, or 25 year precipitations, whichever is applicable, and unit hydrographs will be required, followed by the determination of the spillway design flood hydrograph.

1. Rainfall and Distribution

The PMP value used for dam safety purposes should be of at least a 24-hour duration and should be obtained from the National Weather Service Hydrometeorological Report No. 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian", June, 1978. The method of applying the PMP for HMR51 is described in a companion report, Hydrometeorological Report No. 52, "Application of Probable Maximum Precipitation Estimates - United States East of the 105th Meridian," August, 1982. Generalized rainfall reduction factors, such as the Hop Brook Factor, should not be used for the PMP estimates regardless of the source from which the estimates were obtained.

Rainfall values for frequency events, i.e. 100-year, 50-year and 25-year should be obtained from the Illinois State Water Survey (ISWS) Circular 172, "Frequency Distribution and Hydroclimatic Characteristics for Heavy Rainstorms in Illinois." The suggested method to distribute this rainfall is described in the ISWS publication, Circular 173, "Time Distributions of Heavy Rainstorms in Illinois".

2. Rainfall Excess

Rainfall excess is that portion of the rainfall which is not lost to infiltration, interception, and depression storage. Loss rates should be estimated for computing the rainfall excess. Consideration should be given to the seasonal variation of rainfall amounts, the associated ground cover, and the current land use. Also when applicable, snowmelt runoff rates and appropriate releases from upstream projects should be estimated.

The Natural Resources Conservation Service's weighted watershed curve number (CN) procedure is one of the most widely used methods for determining rainfall excess. If the applicant prefers, a rainfall-runoff relation for the studied basin, or one with similar characteristics, can be developed to determine the rainfall excess.

3. Unit Hydrograph

The unit hydrograph, i.e., the graph of discharge against time, is used to forecast the streamflow at a given point from one inch of direct runoff from a storm of specified duration. The duration selected should not exceed about 1/4 of the time of concentration. The time of concentration is the travel time of water from the hydraulically most distant point of the watershed to the point of interest. There are three basic approaches to the derivation of the unit hydrograph:

(A) Analysis of recorded runoff at a streamflow gaging station at or near the damsite on the same stream.

(B) Transposition of a unit hydrograph from another basin of comparable size and watershed runoff characteristics.

(C) Synthetic unit hydrographs based upon equations relating hydrograph parameters such as peak flow, time to peak, time base, etc. to the physical characteristics of the basin such as area, length, slope, etc.

Several of the more popular accepted methods of synthetic unit hydrograph derivation include:

(1) Clark's method used by the Corps of Engineers in the HEC-1 and HEC-HMS computer programs.

(2) Natural Resources Conservation Service's curvilinear or triangular unit hydrograph.

(3) Snyder's method for Illinois developed by the Illinois State Water Survey.

4. Design Storm Inflow Hydrograph

Design storm refers to the intensity-duration combination of the precipitation which produces the most severe flood runoff and/or reservoir stage for the specified precipitation frequency. The time duration for a designated storm will vary depending on the hydrologic and physiographic characteristics of a specified watershed and the affect on the reservoir will depend on the storage-outflow relationship of the proposed reservoir. The design precipitation event is

divided into increments of time equal to the duration of the unit hydrograph using the appropriate distribution methods. The rainfall excess is determined by subtracting the appropriate loss rates from the rainfall depths to determine the runoff values. The ordinates of the unit hydrograph at the same time increment are then multiplied by the rainfall excess, lagged accordingly, then summed to determine the direct runoff inflow hydrograph.

If a storm hydrograph for a ratio of the PMF is required, the total PMF inflow hydrograph to the reservoir must be determined. The appropriate ratio should then be applied to the ordinates of the PMF inflow hydrograph. Ratios should not be taken of the PMP. If there are other dams or flow restrictive structures, upstream of the dam being analyzed, the total PMF hydrograph to the dam and its reservoir should be determined. Ratios can then be applied to the PMF to determine the response of the dam and reservoir to this design storm inflow hydrograph. Upstream dams and restrictive structures should be included in the analysis only if they are assured of remaining in their current configuration, such as a government owned and controlled flood control or water supply dam.

The use of a partial storm hydrograph (such as is noted in TR55, "Urban Hydrology for Small Watersheds") is not appropriate for use when the design storm inflow hydrograph is needed. These methods may be used to determine the peak inflow (see Section A above) if the appropriate rainfall values (see Section B1) are used.

5. Reservoir Area-Storage-Elevation Data

Reservoir surface area and storage capacity versus water surface elevation (tables or curves) are required. These data are usually determined by planimetry from topographic contour maps with scales equal to USGS 7.5 minute quadrangles or better.

6. Spillway Discharge-Elevation Data

Rating curves or tables are required for all discharge facilities contributing to the maximum design flood outflow hydrograph. If flow capacity is developed synthetically based upon semi-empirical equations for weir, orifice, or pipe flow, assumed coefficients and how they were selected should be stated and

referenced. When sufficient criteria and guidance are not available to determine the spillway flow capacity synthetically, a physical hydraulic model study should be performed with all model tests and performance results documented.

7. Downstream Tailwater Discharge-Elevation Data

A tailwater rating curve showing the downstream flow capacity versus elevation is required. Elevations of bankfull (at top of bank) channel capacity, principal and total spillway design floods, and 100-year flood immediately below the dam site should be noted. The method and support calculations used to determine the downstream water surface elevations (i.e., standard step backwater analysis, normal depth solution of Manning's equation, etc.) including all channel and overbank roughness, length, slope or cross section data and tailwaters due to a receiving waterway should be listed.

8. Design Storm Outflow Hydrograph

The outflow hydrograph from a dam spillway system may be estimated by either hydrologic or hydraulic routing methods. One of the simplest and most popular methods of reservoir routing is called the "Modified Puls" storage routing method. This method is described in most hydrology text books. It is also a feature of computer programs such as the Natural Resources Conservation Service's TR-48 or the Corps of Engineer's HEC-1 and HEC-HMS. A hydraulic routing procedure is also acceptable and is a better method to be used for situations where a hydrograph is rapidly varying. The NWS computer program FLDWAV, the Corps of Engineers' computer programs UNET and HEC-RAS, and the USGS computer program FEQ have this capability.

C. Potential Upstream Flood Hazard Areas

Areas adjacent to the normal storage retention level that would be potentially subject to flooding should be examined to determine if a hazard to life or property could occur during sudden or frequent increases in the reservoir water surface elevation. Ownership or flood easement agreements are required from upstream property owners up to the 100-year flood elevation for new dams or for modifications to dams which include an increase in the reservoir water surface elevations.

D. Emergency and Normal Drawdown Capability

An assessment of the capability to reduce the reservoir storage within a reasonably rapid time interval to avert impending failure, or to facilitate repairs in the event of structural, embankment, or foundation problems should be made. The capability for dewatering the reservoir within a reasonable time period should be addressed with allowances for reservoir siltation and at least the typical base flow for the waterway. Gravity systems which have the capability of dewatering the entire reservoir should be provided. Other systems, such as siphons or pumps which dewater only a portion of the reservoir, will only be authorized for unique situations such as at existing dams without a current dewatering system. Factors that will be considered by OWR in determining the required drawdown time include: the purpose of the dam and reservoir; the risk and nature of a potential failure; the damage potential posed by possible failure; and the potential damage to downstream properties. Computations and assumptions used for calculating the total reservoir drawdown time and for an emergency drawdown of 50% of the normal pool storage volume, should be submitted. Recommended times for 50% drawdown are 7 days for Class I Dams, 14 days for Class II Dams, and 30 days for Class III Dams.

The capability and stability of available drainage courses to convey the waters released during a dewatering and the influence of a drawdown on the stability of the dam should be assessed. Except for emergency situations, the maximum drawdown rate should not typically exceed approximately 1.0 ft. per day.

E. Freeboard Design

Factors that should be considered in determining the minimum freeboard include the duration of high water levels in the reservoir during the design flood; the 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.

References for the method of analysis and the pertinent data utilized for determining the minimum freeboard should be submitted in order to verify that the dam is safe against overtopping during occurrence of the total spillway design flood and wave action using the maximum wave determination.

F. Upstream Face Protection

It is necessary to protect the upstream face of an earth embankment dam from wave erosion. The orientation, length, and purpose of the reservoir, the duration of higher reservoir stages, and the embankment material all affect the need for and the type of embankment protection. Upstream slope protection usually consists of rock riprap which should consist of a well graded, hard, durable rock. For small reservoirs with minimal change in pool elevation during flood events, a flat slope on the upstream face with a designed vegetative protection method can provide the necessary embankment protection.

The protection must also extend below the normal pool elevation a minimum of 2 ft. or 0.50 times the anticipated wave height (if greater than 2 ft.). In determining the elevation of the protection below the normal pool elevation beyond the minimum requirements, consideration should be given to the potential variation of the pool due to the purpose of the reservoir, operational factors, and the base flow of the inflow stream. The protection also serves the purpose of discouraging muskrats and other burrowing animals from burrowing a den into the embankment. The riprap and filter layer should extend at least 3 ft. below the pool elevation to offer a better deterrent to the animals.

G. Design of the Energy Dissipator Structures

Energy dissipators should be capable of sufficiently reducing the energy to insure against damage to the spillway or outlet system. Types of energy dissipators are numerous. Several of the more common type include the following: hydraulic jump stilling basin; impact-type dissipator; deflector bucket; submerged deflector bucket; plunge pool; and baffled chute. All design computations should include an assessment of the impact of a range of flows up to and including the total spillway design flood. The design should also address variations in the flows and tailwaters in the downstream channel due to flows from the principal and emergency spillways and in the receiving waterway.

A proper design should include the evaluation of the topographic features of the site, the relationship of storage capacity to flood volume, the geologic or foundation conditions, the type and height of the dam, and any other unique conditions pertaining to a particular site. In unusual situations when sufficient criteria and guidance are not available for analytical design, a

physical hydraulic model study should be performed with the model tests and performance results reported.

H. Dam Breach Wave Analysis

Analyses should be made to determine the most adverse failure conditions and the resulting peak outflows and water surface elevations downstream of the dam following failure of the dam. To provide sufficient information for classification of a dam, the breach analyses should also assume nearly instantaneous total (full height) failures covering a range of events from normal pool up to and including the probable maximum flood (PMF). For Class I and II dams, computations for the dam breach wave analysis are required for a nearly instantaneous total (full height) failure of the dam during normal pool and total spillway design flood conditions. Analyses completed for flood conditions should use the maximum reservoir elevation to initiate the modeled failure of the dam. However, if the maximum reservoir elevation overtops the dam, then the lower elevation of the maximum elevation or 1 ft. above the top of the dam should be used to initiate the modeled failure of the dam. Inundation maps on 7.5 minute quadrangles or better mapping should be provided for each failure condition studied.

The term "nearly instantaneous," for the purposes of this document, is the shortest time interval for which the computer model being used will provide mathematically stable results. This time is usually about 5 minutes and typically does not exceed 15 minutes and is consistent with failure times for earth embankment dams. The failure times for concrete dams are typically quicker than those for embankment dams.

Based upon dam failures which have occurred in the past, the average breach width for an embankment dam is usually in the range of 2 to 5 multiplied by the height of the dam. The side slopes of the breach of an embankment dam are typically greater than the angle of repose of the dam materials but may vary between vertical to 1 horizontal:1 vertical.

A dam breach analysis requires several steps: developing the reservoir inflow hydrograph; routing that hydrograph through the reservoir; selecting failure conditions for the structure (i.e., mode, shape, size, and time); calculating the outflow hydrograph from the failed structure; and modeling the movement of the flood wave downstream, including downstream tributary inflows, to determine travel

times, inundated areas, and maximum water surface elevations.

To determine the classification of a dam, the acquisition of additional information relative to the potentially impacted structures downstream of the dam may be necessary. Information such as the types of structures (residences, other building uses, infrastructure) within the breach inundation area, the low entry and first floor elevations of buildings, and the availability of alternate access routes to buildings if the primary access is damaged is typical. In general, the routing of the dam breach hydrograph should continue downstream to the point where the breach versus non-breach water surface profile elevation difference does not exceed 1 foot or the breach wave is contained within the channel.

Criteria, methodology, and computer programs developed by the National Weather Service, U.S. Corps of Engineers, and the U.S. Geological Survey, for simulating a hypothetical dam failure are, in general, acceptable. Simplified methods usually do not provide sufficient detail to be considered acceptable except in emergency situations where time does not allow a more detailed analysis. Documentation explaining theoretical aspects of the mathematical models, forecast ability, simulation accuracy, computer input parameter requirements, etc. are available directly from these federal agencies.

I. Hydrologic & Hydraulic Design References

The following list is provided to aid the design engineer and is not intended to be a complete listing of all available reference material.

General

"Handbook of Applied Hydrology" by Ven Te Chow,
McGraw-Hill Book Company

"Handbook of Applied Hydraulics" by David &
Sorensen McGraw-Hill Book Company

"Handbook of Hydraulics" by King and Brater
McGraw-Hill Book Company

"Water Resources Engineering" by Linsley and
Franzini, McGraw-Hill Book Company

Bureau of Reclamation

"Design of Arch Dams"

"Design of Gravity Dams"

"Design of Small Canal Structures"

"Design of Small Dams"

"Discharge Coefficients for Irregular Overfall
Spillways", Engineering Monograph No. 9

"Hydraulic Design of Stilling Basin for Pipe or
Channel Outlets", Research Report No. 24

"Hydraulic Design of Stilling Basins and Energy
Dissipators", Engineering Monograph No. 25

"Unitgraph Procedures"

"Design Standards No. 13, Embankment Dams"

Corps of Engineers

"Shore Protection Manual," Volumes 1-3

Engineering Manuals (EM):

1110-2-1602, Hydraulic Design of Reservoir Outlet
Structures

1110-2-1603, Hydraulic Design of Spillways

1110-2-50, Low Level Discharge Facilities for
Drawdown of Impoundments

1110-2-1450, Hydrologic Frequency Estimates

1110-2-2300, Earth and Rock Fill Dams, General
Design and Construction Considerations

Engineering Technical Letters (ETL):

1110-2-221, Wave Runup and Wind Setup on
Reservoir Embankments

1110-2-305, Determining Sheltered Water Wave
Characteristics

Mine Safety and Health Administration

Engineering and Design Manual, Coal Refuse
Disposal Facilities

Natural Resources Conservation Service

"SITES," Water Resource Site Analysis Program

National Engineering Handbook:

Section 4 - Hydrology

Section 5 - Hydraulic

Section 11 - Drop spillways

Section 14 - Chute spillways

Technical Releases (TR):

2, Earth Spillways

16, Rainfall-Runoff Tables for Selected Runoff
Curve Numbers

20, Computer Program for Project Formulation-
Hydrology

25, Design of Open Channels

29, Hydraulics of Two-Way Covered Risers

39, Hydraulics of Broad-Crested Spillway

48, Computer Program for Project Formulation-
Structure Site Analysis "DAMS-2"

49, Criteria for the Hydraulic Design of Impact
Basins

52, A Guide for Design & Layout of Earth
Emergency Spillways

55, Urban Hydrology for Small Watersheds

56, A Guide for Design and Layout of Vegetative
Wave Protection for Earth Dam Embankments

59, Hydraulic Design of Riprap Gradient Control
Structures

60, Earth Dams and Reservoirs

61, Computer Program for Water Surface Profiles

Design Notes (DN):

DN-6 Riprap Lined Plunge Pool for Cantilever
Outlet

DN-8 Entrance Head losses in Drop-Inlet Spillways

Federal Emergency Management Agency

"Federal Guidelines for Selecting and
Accommodating Inflow Design Floods for Dams".

National Weather Service

Hydrometeorological Report No. 51 - "Probable
Maximum Precipitation Estimates, United States
East of the 105th Meridian"

Hydrometeorological Report No. 52 - "Application
of Probable Maximum Precipitation Estimates -
United States East of the 105th Meridian"

"BREACH": An Erosion Model for Earthen Dams

"FLDWAV": A Generalized Flood Routing Model

Illinois State Water Survey

Bulletin 70, "Frequency Distribution and
Hydroclimatic Characteristics of Heavy Rainstorms
in Illinois"

Bulletin 71, "Rainfall Frequency Atlas of the
Midwest"

Circular 172, "Frequency Distributions of Heavy
Rainstorms in Illinois"

Circular 173, "Time Distributions of Heavy
Rainstorms in Illinois"

Illinois WRC Research Report No. 107, "Criteria
for Shore Protection Against Wind Generated Waves
for Lakes and Ponds in Illinois"

Report of Investigation 65, "Model Test Results of Circular, Square, and Rectangular Forms of Drop-Inlet Entrance to Closed-Conduit Spillways"

Report of Investigation 67, "Hydraulic Jump Type Stilling Basins for Froude Number 2.5 to 4.5"

SWS contract Report 258, "Derivation and Regionalization of Unit Hydrograph Parameters for Illinois (Dam Safety Program) "

United States Geological Survey

"Equations for Estimating Clark Unit-Hydrograph Parameters for Small Rural Watersheds in Illinois", WRI 00-4184, 2000

"Technique For Estimating Flood-Peak Discharges and Frequencies on Rural Streams in Illinois", WRI 87-4707, 1987.

"Effects of Urbanization on the Magnitude and Frequency of Floods in Northeastern Illinois", WRI-79-36, 1979.

"River Mileages and Drainage Areas for Illinois Streams", Volumes 1 and 2, WRI 79-110, 1979.

"Time of Concentration and Storage Coefficient Values for Illinois Streams", WRI 82-13, 1982.

"A Technique for Estimating Time of Concentration and Storage Coefficient Values for Illinois Streams", WRI 82-22, 1982.

"Water Resources Data for Illinois"

"Investigation of Techniques to Estimate Rainfall-Loss Parameters for Illinois", WRI 87 4151, 1989.

Federal Highway Administration

Hydraulic Engineering Circulars:

No. 5 -"Hydraulic Charts for the Selection of Highway Culverts".

No. 10 -"Capacity Charts for the Hydraulic Design of Highway Culverts".

No. 13 - "Hydraulic Design of Improved Inlets for Culverts".

No. 14 - "Hydraulic Design of Energy Dissipators for Culverts & Channels".

No. 15 - "Design of Stable Channels with Flexible Linings".

Hydraulic Design Series No. 1 - "Hydraulics of Bridge Waterways".

Hydraulic Design Series No. 3 - "Design Charts for Open-Channel Flow".

V. STRUCTURAL AND GEOTECHNICAL
INVESTIGATIONS AND DESIGN

A. Geotechnical Investigations

For all dams an investigation of the foundation and abutment soils or bedrock and the borrow materials that are to be used to construct the dam should be made. The foundation and abutments investigation should consist of borings, test pits and other subsurface exploration necessary to clearly define the existing conditions. The appropriate field and laboratory tests to be made should be based on the magnitude and type of the dam, as well as the characteristics of the foundation deposits, abutments, and materials available for use in the embankment. Some of the common tests made are Standard Penetration Tests (N-Values), unconfined compressive strength (q_u) tests, direct shear tests, triaxial tests, water content tests, Atterberg-limit tests, particle size analysis tests, Standard Proctor moisture-density relations, permeability tests, consolidation tests, and dispersion tests. Soils should be at least classified according to the Unified Soil Classification System.

In general, for embankment dams greater than 30 feet in height, the foundation and embankment soil shear strengths for the unconsolidated-undrained (Q), consolidated-undrained (R), and consolidated-drained (S or \bar{R}) conditions are to be based on actual test data from the dam site. One half the unconfined compressive strength ($q_u/2$) is usually adequate for the unconsolidated-undrained (Q) condition.

For embankments 30 feet or less in height, at least the unconfined compressive strengths (q_u) and the standard Penetration Test (N-Values) of the soils are to be determined from actual test data, unless unusual foundation

conditions exist which require a more thorough investigation. It is recommended that the R and S or \bar{R} condition soil strengths also be determined from actual test data from the dam site.

B. Earth and Rockfill Embankments -- Structural Stability.

The embankment and foundation should be analyzed for stability against failure from sliding, sloughing, or rotation along potential failure surfaces using a phi value of "0". The following loading conditions should be investigated:

Case	Loading Condition	Minimum Factor of Safety	
		w/o Seismic Forces	w/ Seismic Forces
I	End of Construction	1.3*	N/A
II	Steady Seepage	1.5**	1.0
III	Sudden Drawdown	1.2***	N/A

* For embankments over 50 feet high on relatively weak foundations, use a minimum factor of safety of 1.4.

** The submitted design will be reviewed for an effective stress condition. A review using S or \bar{R} with $c=0$ will also be performed. Where the analysis relies on the cohesion component to meet the minimum factor of safety, an analysis of the soil chemistry may be required.

*** The factor of safety should not be less than 1.5 when the drawdown rate and pore water pressures developed from flow nets are used in the stability analyses.

Computations of factors of safety for various loading conditions and shear strengths are readily made using computer programs. Several computer programs are available for the completion of the analysis including those developed by the federal agencies and many universities.

Seismic activity should be considered in the design of all dams in Illinois. The Peak Ground Acceleration values for 2% probability of exceedance in 50 years is shown in Appendix 1. Dams located in an area with a peak acceleration greater than 20%g must have a seismic stability

analysis using equivalent static load methods included in the application submittal package. The values found in Appendix 1 should be the minimum coefficient. Dynamic analysis methods should also be considered for dams in areas of high seismic activity.

So that earth embankment side slopes can be easily maintained and/or mowed, it is recommended that the downstream slope be no steeper than 3:1. Crown vetch or similar types of ground cover should not be planted on the slopes of earth embankments because it severely restricts the ability to inspect the slopes for sloughing, erosion, seepage, animal holes or excessive settlement.

C. Earth Embankments -- Seepage.

Adequate analyses should be made of anticipated seepage rates and pressures through the embankment, foundation and abutments. The analyses should show that the seepage flow through the embankment, foundation and abutments will be controlled so that no internal erosion takes place and no sloughing takes place in the area where the seepage emerges.

D. Earth Embankments -- Conduits.

Conduits through earth embankments are to be a pressure type conduit, such as reinforced concrete pressure pipe or cast-in-place reinforced concrete. However, non-pressure type conduits properly detailed may be allowed for Class III dams, 30 feet or less in height. Reinforced concrete pipe should meet one of the following specifications:

- (A) ASTM C 361
- (B) AWWA C 300
- (C) AWWA C 301
- (D) AWWA C 302

Reinforced concrete pipe should be supported on a concrete bedding or cradle, and reinforced where spreading might be a factor. The pipe joints should incorporate a rubber gasket set in a positive groove as described in the above specifications which will prevent its displacement from either internal or external pressure under the required joint extensibility.

Conduits other than the reinforced concrete pipes listed above may be used. For those designs the application should fully document that the proposed conduit will provide performance equal or superior to reinforced concrete pressure pipe.

It is recommended that all conduits which pass through an embankment have a filter constructed at the downstream end of the conduit to control any seepage along the conduit regardless of whether anti-seep collars are used.

E. Concrete Dams and Structures.

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. Loadings to be considered in the 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. A gravity structure should be capable of resisting all overturning forces.

The analysis of concrete stresses should be based on in situ properties of the concrete and foundation. Tensile stresses in unreinforced concrete are 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.

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 investigation should be made along all potential sliding paths. The shear-friction safety factor is obtained by dividing the resistance, including the applicable downstream passive wedge if appropriate, by the summation of horizontal service loads. 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. Designs based on Corps of Engineers, Bureau of Reclamation, or Natural Resources Conservation Service criteria are generally acceptable.

F. Concrete Design.

The loadings, allowable stresses, load factors, and safety factors for the design of concrete structures should be those appropriate for hydraulic structures. Concrete design should be in accordance with the applicable sections of the latest edition of the "Building Code Requirements for

Reinforced Concrete" (ACI 318); however, because hydraulic structures are subjected to a relatively severe environment and unknown loading conditions, due consideration should be given to the allowable stresses or "Z" values used so that adequate crack control is achieved. Working stress and strength designs should be based on 28-day concrete strengths not less than 3000 psi.

The following minimum clear cover of main reinforcement should be used:

Structures exposed to weather, or backfill,
or submerged and can be made accessible
Bar Size Nos. 5 and less - - - - - 1 1/2"

Structures exposed to weather, or backfill,
or submerged and can be made accessible
Bar Size Nos. 6 through 18 - - - - - 2"

Structures submerged and cannot be made accessible
All Bar Sizes - - - - - 2 1/2"

Concrete cast against and permanently exposed
to earth or rock
All Bar Sizes - - - - - 3"

All concrete construction, contraction, and expansion joints subject to hydrostatic pressure should be protected by the use of waterstops or other means.

G. Steel Design.

Structural steel design should be based on the applicable sections of the latest edition of the American Institute of Steel Construction (AISC) specifications. The applicable sections of the latest edition of the Standard Specifications for Highway Bridges adopted by the American Association of State Highway and Transportation Officials (AASHTO) are acceptable, as well as designs prepared using Corps of Engineers, Natural Resources Conservation Service or Bureau of Reclamation specifications.

H. Spillways and Energy Dissipators.

The range of spillways and energy dissipator types which can be used on a dam project is very large. If a standard design is used, reference to the standard used is acceptable for the structural design documentation. If a non-standard design is proposed, the structural design computations submitted should be based on the commonly accepted principles of structural analysis and design.

Underdrains and/or anchors should be considered in the design of chute spillways.

I. Filters and Drains.

When filters and/or drainage blankets are required because of a significant difference between the gradation of the material to be protected and the material of the drain, they should be designed to provide for the controlled flow of the water while precluding the movement of embankment and filter materials. Examples of situations where filters may be required are zoned embankments, rockfill dams, pipe underdrain systems, and chimney drains and drainage blanket systems. Typical filter design criteria are shown in the Bureau of Reclamation's "Design of Small Dams" and "Earth Manual".

J. Geosynthetics.

Geosynthetics may be used in dams as filters, drains and impermeable membranes. An important aspect of the use of geosynthetics is the choice of the appropriate material and opening size. The use of geosynthetics at many construction sites are not as sensitive to this correct choice as at dams. Generalized use of geosynthetics does not assure their performance or acceptability. Detailed analysis must be completed to assure adequate constructability and functionality exists.

Geosynthetic materials are commonly used in filter and drain applications. The geosynthetic often replaces several layers of a granular design. Caution should be used in the adoption of standards developed for other engineered solutions. The assumptions and performance standards may not be consistent with those required for dam safety.

K. Riprap.

Riprap should be designed for its expected use and anticipated water velocities. All riprap should be placed on a properly designed bedding to prevent the loss of the underlying base material, unless the gradation of the underlying base material is such that it will not infiltrate through the riprap. Properly designed geosynthetic materials can be used to provide the bedding. For most riprap gradations a sand layer is required between the riprap and a geosynthetic material to prevent damage to the material during construction.

L. Geotechnical and Structural References.

The following references are a representative sample of publications available which are related to dam design, construction and safety, but are not intended to be all inclusive of dam technology.

General

"Designing with Geosynthetics", Koerner

"Earth and Earth-Rock Dams", Sherard, Woodward, Gizienski, and Clevenger. (Wiley)

"Soil Mechanics in Engineering Practice", Terzaghi and Peck. (Wiley)

"Foundation Engineering", Peck, Hanson and Thornburn. (Wiley)

"Seepage, Drainage & Flow Nets", Cedergren. (Wiley)

"Foundation Engineering Handbook", Edited by Winterkorn and Fang. (Van Nostrand Reinhold)

"Soil Testing For Engineers", Lambe. (Wiley)

"Stability Analysis of Earth Slopes", Huang. (Van Nostrand Reinhold)

"Special Procedures for Testing Soil and Rock for Engineering Purposes", Special Technical Publication No. 479, ASTM.

Proceedings - Research Conference on Shear Strength of Cohesive Soils, ASCE, 1960.

Proceedings - Stability and Performance of Slopes and Embankments, ASCE, 1966.

Bureau of Reclamation

"Design of Small Dams"

"Design of Gravity Dams"

"Design of Arch Dams"

"Earth Manual"

"Hydraulic Design of Stilling Basins and Energy Dissipators", Engineering Monograph No. 25.

"Stilling Basin Performance; An Aid in Determining Riprap Sizes", Hydraulic Laboratory Report No. HYD-409.

"Concrete Manual"

"Design Standards No. 3" - Canals and Related Structures

Corps of Engineers

"National Program of Inspection of Dams", Volume I, Appendix D, "Recommended Guidelines for Safety Inspection of Dams"

"Shore Protection Manual," Volumes 1-3

Engineering Manuals (EM):

1110-2-1601, Hydraulic Design of Flood Control Channels

1110-2-1901, Soil Mechanics Design-Seepage Control

1110-2-1902, Stability of Earth and Rockfill Dams

1110-2-1906, Laboratory Soils Testing

1110-2-1908, Instrumentation of Earth and Rockfill Dams

1110-2-1911, Construction Control for Earth and Rockfill Dams

1110-1-2101, Working Stresses For Structural Design

1110-2-2200, Gravity Dam Design

1110-2-2300, Earth and Rockfill Dams General Design and Construction Considerations

1110-2-2400, Structural Design of Spillways and Outlet Works

1110-2-2702, Design of Spillway Tainter Gates

1110-2-4300, Instrumentation for Measurement of
Structural Behavior of Concrete Gravity Structures

Engineering Technical Letters (ETL):

1110-2-222, Slope Protection Design for
Embankments in Reservoirs

Hydraulic Design Criteria (HDC):

712-1, Stone Stability, Velocity vs. Stone
Diameter

Natural Resources Conservation Service

National Engineering Handbook:

Section 6 - Structural Design

Section 11 - Drop Spillways

Section 14 - Chute Spillways

Technical Releases (TR):

18, Computation of Joint Extensibility
Requirements

30, Structural Design of Standard Covered Risers

52, A Guide for the Design and Layout of Earth
Emergency Spillways

54, Structural Design of SAF Stilling Basins

60, Earth Dams and Reservoirs

67, Reinforced Concrete Strength Design

69, Riprap for Slope Protection Against Wave
Action

Design Note (DN)

6, Riprap Lined Plunge Pool for Cantilevered
Outlet

Soil Mechanics Note (SMN)

1, Tentative Guides for Determining the Gradation
of Filter Materials

Mining Safety and Health Administration

"Engineering and Design Manual, Coal Refuse Disposal Facilities", 1975.

Illinois Department of Transportation

"Soils Manual"

Illinois State Geological Survey

Bulletin 94, Pleistocene Stratigraphy of Illinois

Bulletin 95, Handbook of Illinois Stratigraphy

Circular 490, Glacial Drift in Illinois:
Thickness and Character

American Society of Civil Engineers

"Current Trends in Design and Construction of Embankment Dams", Wilson and Marsal, 1979. (ASCE)

Federal Highway Administration

Hydraulic Engineering Circular

No. 14, Hydraulic Design of Energy Dissipators for Culverts and Channels

No. 15, Design of Stable Channels with Flexible Linings

VI.

OPERATION PLAN

A documented plan of operation for normal conditions, flood events, and emergency conditions is required. This plan should include availability of the damtender, means of communication between the damtender and his supervising authority, method of gate operation (manual, automatic or remote control), a list of the names, addresses, and telephone numbers of people and agencies to contact during normal and emergency conditions, and a list of standing instructions for normal, flood, and emergency conditions. The actions to be taken at the dam during an emergency condition are a portion of the emergency action plan for the dam which is described in a following section.

A copy of the operation plan should be provided to the damtender and kept at the project site. An example operation and maintenance plan is included as Appendix A. This example is for the purpose of providing generalized guidance in the development of the specific plans for the dam being designed and is not a required format.

VII.

MAINTENANCE PLAN

A maintenance plan must be submitted which includes a listing of the equipment and manpower necessary and a time schedule for performing routine inspections and the inspections required in the "Rules for Construction and Maintenance of Dams". This plan should, at a minimum, address the following items: prevention of the growth of trees and brush on the embankment, on the abutment, on the downstream area a minimum distance of one-half the height of the dam or 20 ft. from the toe of the embankment whichever is greater, and within the spillway system; maintenance of adequate vegetation to prevent erosion of the embankment and earth spillway and the method by which the vegetation will be maintained to allow adequate visual inspection of the embankments, spillways, and crest of the dam; removal of debris or other deleterious materials from the spillway systems; inspections as necessary to insure that all gates, orifices, dissipators and other appurtenances and all mechanical and electrical equipment that affect the operation of the dam and reservoir are kept in good repair and working order; and a time schedule for test operation of all spillway and outlet gates or other equipment that must operate to pass flood flows. The OWR document entitled "Guidelines and Forms for Inspection of Illinois Dams" also

provides a generalized listing of the items to be inspected and therefore the items that need to be considered in the development of the maintenance plan. The maintenance plan should be specific to the dam.

A copy of the maintenance plan should be provided to the damtender and kept at the project site. A detailed record of all maintenance is required, including dates and results of routine inspections, and complete information on all maintenance, rehabilitation, and improvements. This record should also include data on the structural behavior of the dam embankment and spillway system for all major flood and seismic events.

An example operation and maintenance plan is included as Appendix A. This example is for the purpose of providing generalized guidance in the development of the specific plans for the dam being designed and is not a required format.

VIII.

EMERGENCY ACTION PLAN

An emergency action plan is a formal document which identifies potential emergency conditions at a dam and specifies the procedures to be taken by various entities in response to the noted emergency. The plan should address: accidents at the dam which could affect the operation of the dam or present a hazard to areas downstream of the dam; impending flood conditions even though the dam may not be in danger; and the potential failure of the dam. The inundation mapping prepared as a portion of the dam breach analyses should be included in this plan.

Emergency action plans are necessary to provide early warning and notification of an emergency. Emergency action plans must be site specific. The plan for a dam must address not only the specific characteristics of the dam but also the capabilities and resources of the dam owner and the emergency responders. Due to its need to be unique, an example plan is deliberately not included in these guidelines. An appropriate format for the development of an emergency action plan is available in the document entitled "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners," prepared by the Interagency Committee on Dam Safety and the Federal Emergency Management Agency (FEMA-64).

OWR and the Illinois Emergency Management Agency offer a course on the development of emergency action plans for dams. Contact OWR's Division of Resource Management for schedule information.

IX. DAM REMOVALS AND ABANDONMENTS

This section provides guidance regarding the removal of dams and the abandonment of slurry disposal or similar material impoundment dams. However, both removal and abandonment usually result in the dam ultimately being eliminated from the Office of Water Resources regulatory purview.

Abandonment may differ from removal of a dam in that abandonment may leave the embankment intact. Dams which are typically considered for abandonment include slurry disposal, dredge disposal and fly ash disposal impoundment dams. The principles noted for the abandonment of these dams should be applicable to the abandonment of other similar structures.

B. INVESTIGATIONS AND EVALUATIONS FOR REMOVAL OF DAMS

The removal of a dam requires careful planning and design. The size, height, reservoir impounding capacity, upstream and downstream channel conditions, existing reservoir sediment deposits, degree of hazard in case of failure, as well as any other considerations which might be peculiar to a particular dam, all have impacts on the removal process.

A method to remove or reduce the stored water prior to initiating the breach of the dam must be determined. When available, use of the dam's dewatering structures would generally be the appropriate method of drawdown. For dams without dewatering structures, the installation of siphons or pumps may be an appropriate method. Items to consider in determining the drawdown rate should normally include the capacity of the dewatering structure, the flow into the reservoir from the tributary areas, the downstream channel's bank full flow capacity, and the affects of the speed of a reservoir drawdown on the embankment and shoreline.

The method to be used for the breach of the dam can vary from typical excavation with earth moving equipment for embankment dams to controlled blasting for concrete dams. The time necessary to accomplish the breach and the flows which may enter the reservoir during that time should be considered in determining the method.

The size of the breach, width and depth, needs to be large enough that a potential failure of the remaining portion of the dam and resultant release of stored water does not cause a significant increase in downstream water surface elevations. To prevent downstream damage, an assessment of water surface elevations at the breach is used as a means to establish the necessary breach size for flows up to and including the 100-year frequency flood. For configurations where the breach opening will be to the invert elevation of the channel at the downstream toe, a backwater analysis from the downstream channel and floodplain cross section to a natural channel and floodplain cross section located upstream of the dam can be used for the assessment. If a comparison of the increase in water surface elevations for the "with the dam" condition including the breach to the "without the entire dam" condition shows the increase to be less than 1 ft. in a rural area or 0.5 ft. in an urban area, the opening is considered to have a negligible backwater effect. For configurations where the breach opening will not be to the downstream channel invert (which is typical of sites for which a drop structure at the elevation of the sediment level in the reservoir is proposed), the water surface elevation comparison should be for a cross section at the upstream toe of the dam for the "with the dam" condition including the breach to the "without the entire dam" condition.

Sediment control during and after the breach must be considered for the removal of a dam. For the configuration where the breach opening will be to the invert elevation of the channel at the downstream toe and a structure to control the headcutting of the channel through the sediment is not proposed, the re-establishment of a channel in the reservoir bed to match the channel downstream of the dam is typically proposed. For the configuration where a structure is proposed to control the headcutting or to make the bottom of the breach at the top of the sediment in the reservoir, the structure and the distance through the breach opening to the downstream channel should be designed and constructed to be stable for flow conditions up to and including the 100-year frequency flood. Erosion control and re-establishment of an appropriate vegetative cover in the reservoir bed are also items which are necessary and are usually based on the conditions at the site and the final configuration of the area. For some low head run-of-the-river concrete dams for which there is significant continual flow in the river and an accumulation of sediment upstream of the dam, the creation of sediment basins downstream of the breached dam where the sediment will be removed on a regular basis may be necessary to limit the movement of sediment further downstream.

B. INVESTIGATIONS AND EVALUATIONS FOR ABANDONMENT OF DAMS

Upon the end of the useful life of a disposal impoundment it is often necessary for the owner of such a structure to reclaim and abandon it. This reclamation and abandonment is most frequently associated with slurry disposal at mining operations, reservoir sediment disposal at lake or river dredging operations, and ash disposal at power plants. Often this process is assumed by the owner to remove the associated dam structure from the dam safety regulatory jurisdiction. This assumption is usually based on the belief that the hardened surface of the impounded refuse material is characteristic of the entire volume of impounded material. However, studies have indicated that while this material may solidify on the surface after a period of time, a portion of the material below the surface remains fluid for an extended period of time. Thus, if the dam were to fail, the remaining fluid material could escape, possibly causing loss of life and/or significant property damage. Therefore, dams used in conjunction with disposal operations cannot be removed from Illinois dam safety regulation until it has been verified that the existing impounded material is not flowable and appropriate measures have been taken to prevent it from becoming flowable by recharging or seismic activity.

The following guidelines have been written in an attempt to provide general information regarding the methods of testing, analyses and computations which must be completed and submitted with an application for permit to support an owner's request for abandonment of a disposal impoundment dam.

An evaluation regarding a request to permit abandonment of a disposal impoundment structure will be based on the documentation and data addressing four issues: 1) the classification of the existing condition of the impounded material with respect to its fluid nature; 2) the liquefaction potential of the impounded material and the related stability of the containing dam; 3) the final surface configuration for the impoundment including the potential for resaturation of the impounded material, especially from any surface water impounding characteristics and the erosion potential of the surface material; and 4) the establishment of a follow-up inspection schedule to ensure the proposed plans have been effective and the submittal of record drawings.

1. Existing Impounded Material

The existing material which has been impounded must be analyzed and classified with respect to its fluid nature. To establish the characteristics of the material, actual field samples must be obtained, tested and evaluated. Testing and analyses, as appropriate, should be completed to determine such parameters as liquid limit, water content, yield shear strength, permeability, viscosity, particle grain size distribution, confining pressure and void ratio of the material. Piezometers or other observational devices may also be used to assist in the evaluation and classification process.

If the existing impounded material is found to be of a non-fluid nature then the liquefaction potential must be evaluated as described in Section 2. If the liquefaction potential is found to be low, then a plan to prevent resaturation as discussed in Section 3 would need to be developed.

If the existing impounded material is found to be of a fluid nature and abandonment is desired then design of an appropriate method to dewater the material must be developed. Additionally, a plan to prevent future resaturation of the impounded material must also be completed. To ensure a continued non-fluid state is maintained it is suggested that observational devices such as piezometers be installed and monitored for a period of not less than one year after initial dewatering has been completed. Upon completion of dewatering procedures the existing impounded material must be evaluated with respect to liquefaction potential (as discussed in Section 2).

2. Liquefaction Potential

The impounded material within a disposal impoundment dam must be evaluated to determine if the material is susceptible to liquefaction. If necessary, a computer model capable of analyzing the dynamic effects should be used.

If the material is found to be susceptible to liquefaction then no abandonment would be permitted unless plans for modifications to eliminate the liquefaction potential were completed and approved.

If the material is not susceptible to liquefaction the abandonment procedures may be permitted providing that the issues of Sections 1, 3 and 4 have been appropriately addressed and the containing embankment

is shown (by submitting appropriate support documentation) to be stable under static conditions.

3. Resaturation Potential

To prevent resaturation, water should not be permitted to pond on the surface of the slurry material or any cover material. Elimination of any existing surface impoundment on the slurry material will be required. Plans to prevent any future surface water impounding capability and the prevention of erosion on the final surface material should be required.

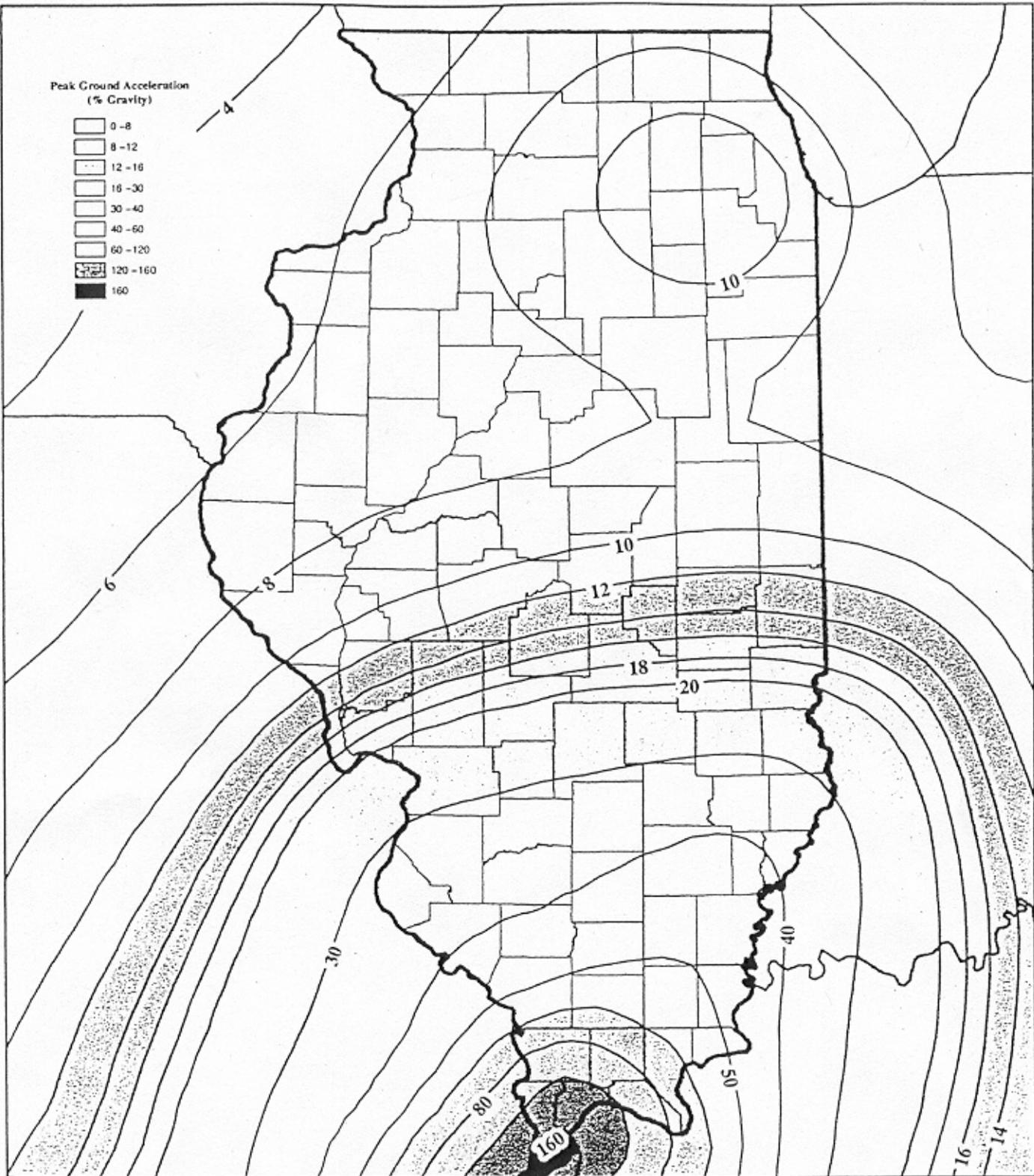
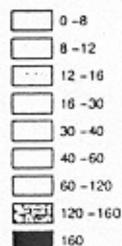
4. Final Inspection and Record Drawings

A final inspection and report by a professional engineer must be completed and submitted to the Office of Water Resources one year after the completion of the abandonment modifications to the dam. This inspection will evaluate and report the effectiveness of the abandonment designs. Record drawings should be submitted along with the final inspection report.

APPENDICES

APPENDIX NO. 1

Peak Ground Acceleration
(% Gravity)



Peak Ground Acceleration (Percent Gravity) Two Percent Probability of Exceedance in 50 Years

Source: US Geological Survey
National Seismic Hazard Mapping Project
(Open-file Report 97-431) November, 1996

Office of
Water Resources
October 4, 2002



APPENDIX NO. 2

OPERATION AND MAINTENANCE MANUAL

UNKNOWN CREEK DAM

WHEREVER, ILLINOIS

WHICHEVER COUNTY

DATE

OPERATION AND MAINTENANCE MANUAL
UNKNOWN CREEK DAM
WHEREVER, ILLINOIS

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APPENDICES

Appendix A	Operation and Maintenance Inspection Checklist
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PLATES

Plate 1	Vicinity Map
Plate 2	Location map
Plate 3	Plan View of Dam
Plate 4	Typical Section Through Principal Spillway
Plate 5	Profile of Dam

SECTION 1

GENERAL

This operation and maintenance manual, (hereafter referred to as O&M manual), outlines objectives, proposed policies, responsibilities, and procedures for City of Wherever personnel who are responsible for the management of the Unknown Creek Dam.

REASONS FOR DEVELOPMENT AND DISSEMINATION OF THE O&M MANUAL

The Rivers, Lakes and Streams Act, (615 ILCS 5) Paragraph 23a includes the statement "The Department is authorized to carry out inspections of any dam within the State, and to establish standards and issue permits for the safe construction of new dams and the reconstruction, repair, operation and maintenance of all existing dams." (emphasis added).

Part 3702 of the 17 Illinois Administrative Code, Chapter I entitled the "Construction and Maintenance of Dams" details the requirements to obtain a permit for the construction, operation, and maintenance of a dam. Section 3702.40 b) includes the following statements:

"4) An applicant for a Class I or II dam shall submit an operational plan specifying the method and schedule for the operation of the dam and the routine operating procedures to keep the dam in good working order, including an emergency warning plan." and

"5) As a condition of each permit, the dam owner shall submit a maintenance plan detailing the procedures and schedules to be followed to maintain the dam and its appurtenances in a reasonable state of repair."

Thus it is a requirement of all dam owners who have dams which fall under the jurisdiction of the Illinois Department of Natural Resources to operate and maintain them safely.

As a dam owner the City of Wherever is responsible for the safety of the public and for maintaining the structures within the City's jurisdiction for both safety and economy. The overall public interest is served by providing a document to serve as a basis for the safe and economical operation and maintenance of the dam during both emergency and day-to-day conditions.

GENERAL RESPONSIBILITIES CONCERNING DAMS

Specific information should be included either here or throughout the O&M plan. The following comments are noted for general guidance for development of the O&M plan.

City Council

The City Council should annually provide sufficient funding to safely maintain and operate the dam. The estimated annual funding requirements as of the date of this plan is \$ _____. The City Council should also provide sufficient authority to personnel within city government to assure the performance of critical functions during emergencies.

Street Department

The Street Department may have specific responsibilities which should be outlined in the O&M plan. The responsibilities might include mowing of the dam; removal of debris from the spillways; placing needed rip rap; and providing trucks and other equipment, personnel, and material during emergency actions.

Water Department

The Water Department may have specific responsibilities which should be outlined in the O&M plan. The responsibilities might include the overall responsibility for the dam such as making emergency action decisions; inspecting the dam; operating and maintaining the dam's gates, valves, and electrical system; and providing equipment, personnel, and material during emergency actions.

Emergency Services and Disaster Agency

The city's Emergency Services and Disaster Agency should review, and revise if necessary, the Emergency Action Plan for the dam prior to the plan being submitted for permit approval. The Agency should be responsible to keep the information in the Emergency Action Plan for the dam current. It should coordinate with other agencies (local, county, state, federal) the responses to an emergency at the dam.

SECTION 2

DEFINITIONS

Abutment - That part of the valley side or concrete walls against which the dam is constructed. Right and left abutments are those on respective sides of an observer when viewed looking downstream. (Illustration 1 depicts the principal parts of a "typical" earthen dam and its appurtenant works.)

Appurtenant Works - The structures or machinery auxiliary to dams which are built to operate and maintain dams; such as outlet works, spillways, gates, valves, channels, etc.

Boil - A stream of water discharging from the ground surface downstream of the dam carrying with it a volume of soil which is distributed around the hole formed by the discharging water.

Berm - A horizontal step or bench in the sloping profile of an embankment dam.

Breach - A break, gap, or opening (failure) in a dam which releases impoundment water.

Concrete Block - An erosion protection method using interlocking concrete blocks, usually with openings that are filled with soil and grass.

Core - A zone of material of low permeability in an earthen dam.

Dam - A barrier built for impounding or diverting the flow of water.

Dike (Levee) - An embankment or structure built alongside a river to prevent high water from flooding bordering land.

Drain, Layer or Blanket - A layer of pervious material in a dam to facilitate the drainage of the embankment including such items as a toe drain, a weephole, and a chimney drain.

Drawdown - The resultant lowering of water surface level due to the controlled release of water from the impoundment.

Embankment - Fill material, usually earth or rock, placed with sloping sides.

Earthen Dam - Any dam constructed of excavated natural materials.

Emergency Action Plan - A predetermined plan of action to be taken to reduce the potential for property damage and loss of lives.

Failure - An incident resulting in the uncontrolled release of water from a dam.

Freeboard - The vertical distance between a stated water level and the top of a dam. (See Illustration 1.)

Gate or Valve - In general, a device in which a leaf or member is moved across the waterway to control or stop the flow.

Groin - The junction of the upstream or downstream face of the dam with the valley wall.

Maintenance - The upkeep, involving labor and materials, necessary for efficient operation of dams and their appurtenant works.

Operation - The administration, management, and performance needed to operate the dam and appurtenant works.

Operation and Maintenance Inspection - Inspections conducted by the dam operator. These inspections are frequent visual "walk-around" inspections of the dam surface and appurtenant works.

Outlet - An opening through which water can freely discharge for a particular purpose from an impoundment.

Phreatic Surface - The upper surface of saturation in an embankment.

Piping - The progressive development of internal erosion by seepage, appearing downstream as a hole or seam, discharging water that contains soil particles.

Riprap - A layer of large stones, broken rock or precast blocks placed in a random fashion usually on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel as a protection against current, wave and ice action.

Silt/Sediment - Soil particles and debris in an impoundment.

Slump/Slide Area - A portion of earth embankment which moves downslope, sometimes suddenly, often with cracks developing.

Spillway System - A structure or structures over or through which flows are discharged. If the flow is controlled by gates, it is considered a controlled spillway. If the elevation of the spillway crest is the only control of the flows, it is considered an uncontrolled spillway.

Emergency Spillway - A spillway designed to operate very infrequently, only during exceptionally large floods, usually constructed of materials expected to erode slowly.

Principal Spillway - The main spillway which controls both normal and flood flows and is constructed of non-erodible materials.

Auxiliary Spillway - A spillway which works in conjunction with the principal spillway to control flood flows and is constructed of non-erodible materials.

Stilling Basin - A basin constructed to dissipate the energy of fast flowing water, such as from a spillway, and to protect the stream bed from erosion.

Toe of Embankment - The junction of the face of the dam with the ground surface in the floodplain upstream or downstream of the dam.

Trash Rack - A structure of metal or concrete bars located in the waterway at an intake to prevent the entry of floating or submerged debris.

SECTION 3

INFORMATION ABOUT THE DAM

LOCATION

The Unknown Creek Dam is located in the southeast part of Wherever in the northwest part of Whichecker County, Illinois. The dam is located on Unknown Creek in the southeast quarter of Section 4, Township 21 North, Range 9 East of the 4th Principal Meridian. Plate 1 shows the general vicinity of the dam within the State of Illinois, and Plate 2 is a location map.

DESCRIPTION OF DAM AND APPURTENANCES

The Unknown Creek Dam is an earth embankment structure approximately 31 feet high and 1480 feet long. The top of dam elevation is 740.8 and both faces of the dam slope at 3 horizontal to 1 vertical.

The appurtenant works consist of a 24 inch diameter concrete low flow pipe principal spillway, a reinforced concrete drop inlet auxiliary spillway with a dewatering gate, and an earth cut emergency spillway. The 24 inch diameter low flow pipe with a trash rack at its entrance and the drop inlet spillway both discharge through a 60 inch diameter concrete pipe into a reinforced concrete stilling basin at the downstream toe. The emergency spillway is located at the left abutment of the dam. (Left and right orientation is based on looking in the downstream direction.) The emergency spillway is a 150 foot wide earth cut with a concrete wall crest control section.

The principal and auxiliary spillway system is designed to pass the 100-year frequency storm with about 5.4 feet of freeboard, that is, without the emergency spillway functioning. The emergency spillway is designed to function for any storm event greater than the 100-year frequency storm. The combined spillway capacities are capable of passing 50 percent of the Probable Maximum Flood (PMF) with 2.9 feet of freeboard and 100 percent of the PMF with 1.3 feet of freeboard.

Plate 3 shows a plan view of the dam. Plate 4 shows a cross section of the dam embankment at the principal spillway. Plate 5 shows a profile of the dam.

SIZE CLASSIFICATION

With a maximum height of 31 feet and a maximum storage capacity of approximately 198 acre-feet, the dam is in the small size category.

HAZARD CLASSIFICATION

The Unknown Creek Dam is classified as a CLASS I, HIGH HAZARD POTENTIAL dam because of the high probability that, in the event of a dam failure, loss of life and/or property downstream of the dam would be substantial.

PURPOSE OF DAM

The dam serves to form a dry detention reservoir for the control of flooding on the Unknown Creek which flows through the southeastern part of Wherever.

PERTINENT DATA

Pertinent data about the dam, appurtenant works, and reservoir is presented in Table 1. Plates 3 through 5 show plans, sections and details of the dam and appurtenant works.

TABLE 1
PERTINENT DATA

DRAINAGE AREA	Square Miles	0.92
DAM		
Type	Earth Embankment	
Elevation, Top of Dam	Feet-NGVD	740.8
Height Above Streambed	Feet	31
Upstream Slope	Horiz:Vert	3:1
Downstream Slope	Horiz:Vert	3:1
Length, Crest	Feet	1480
Top Width	Feet	16
Streambed Elevation	Feet-NGVD	709.8
RESERVOIR		
Normal Pool Storage	Acre-Feet	0
Elevation, PMF Pool	Feet-NGVD	739.5
Storage, PMF Pool	Acre-Feet	
177		
Length, PMF Pool	Miles	0.3
Storage, Top of Dam	Acre-Feet	198

TABLE I
(continued)

PRINCIPAL SPILLWAY		
Type	Uncontrolled flow through concrete pipe	
Size	Inch Diameter	24
Elevation, Inlet Invert	Feet-NGVD	714.0
Elevation, Outlet Invert	Feet-NGVD	713.5
Length	Feet	20
AUXILIARY SPILLWAY		
Type	Uncontrolled Drop Inlet	
Size	Feet	5' X 5'
Elevation, Crest	Feet-NGVD	733.5
Length, Crest	Feet	16.5
DEWATERING GATE		
Type	Unseating head type sluice gate with cast iron flange frame and bronze seat facings	
	Manufacturer :	
	Model No. :	
Size	Feet	3' X 3'
Inlet Invert Elevation	Feet-NGVD	725.0
OUTLET CONDUIT		
Type	Concrete Pipe	
Size	Inch Diameter	60
Elevation, Inlet Invert	Feet-NGVD	713.5
Elevation, Outlet Invert	Feet-NGVD	712.0
Length	Feet	124
STILLING BASIN		
Type	Impact	
Elevation, Floor		Feet-NGVD
	709.75	
Elevation, End Sill	Feet-NGVD	712.
Width	Feet	13.5
EMERGENCY SPILLWAY		
Type	Earth Cut Channel (grass lined)	
Control Section	Concrete Wall	
Elevation, Crest	Feet-NGVD	735.5
Length, Crest (Bed Width)	Feet	150
Width, Crest	Feet	1
Side Slopes	Horiz:Vert	3:1

Notes: (1) NGVD is referred to as the National Geodetic Vertical Datum, 1929.

SECTION 4

OPERATION ACTIVITIES

TYPES OF DAM INSPECTIONS

The inspection program includes two types of dam inspections. The first is regularly conducted by the Dam Operator and is referred to as an Operation and Maintenance Inspection. The second type of inspection, referred to as the Engineering Inspection, is conducted by a qualified engineering consulting firm approved by the City of Wherever, (all engineering inspection reports must be signed and sealed by an Illinois Registered Professional Engineer).

Operation and Maintenance Inspection:

Occasional "walk-around" inspections of the dam and appurtenant works are to be made by the Dam Operator. During these inspections, a checklist of items to be maintained and items to be observed should be recorded. Appendix A provides an example of the Operation and Maintenance Inspection Checklist to be utilized for these inspections. Illustration 2 identifies some potential problem indicators at a "typical" earthen dam.

Frequency: Monthly and during and after unusual events such as heavy rainfall or an earthquake.

Inspection Items: During each inspection the following items should be noted in particular:

(1) Water Level - A staff gage which can be easily seen when the reservoir is full should be installed or painted on the drop inlet. Maximum reservoir levels as a result of heavy rainfall should be recorded.

(2) Earth Embankment - Walk the crest, abutments, groins, side slopes, downstream toe and upstream toe or at the waterline of the dam concentrating on surface erosion, seepage, cracks, settlements, slumps, slides, and animal burrows. These are described as follows:

Surface Erosion - Removal of vegetative cover by water action or pedestrian or vehicle usage forming deep ruts or gullies.

Seepage - The passage of water through and/or underneath the earth embankment abutment and natural groundline or at the contact between the embankment and outlet works can be indicated by cattails or other wet environmental vegetation, erosion channelization, or slumping on the embankment face.

Cracks - Deep cracks usually indicate the movement of the dam and/or the foundation and can be in either the longitudinal (along the length of the dam) or transverse (across the dam) directions. Cracking can be an indicator of the beginning of slumps. Shallow cracks may develop during the summer when the surface soils of the embankment become severely dried and are usually of no concern in regard to the safety of the dam.

Settlement - Settlement is indicated by depressions or low spots and can be signs of consolidation of the dam or foundation or the loss of material beneath the settlement area.

Slumps/Slides - Slow or sudden movements of the earth embankment slope on either face toward the toe of the dam.

If seepage indicates the presence of soil particles, or if deep cracks, settlement, slumps, or slides are noticed, a qualified engineer should be contacted immediately for consultation.

Animal Burrows - Animal burrows result in a loss of earth embankment material and can provide seepage paths for water through the embankment.

(3) Vegetation - Grass should be a thick vigorous growth to stabilize embankment soils and prevent erosion from occurring. Note the height of the grass; if greater than 1 foot, a mowing of the area should be scheduled before the next inspection. There should be NO trees on the earth embankment and NONE within a minimum of 20 feet of the embankment toes or concrete structures. There should be NO trees in the emergency spillway.

(4) Trash Racks - Check to make sure that the trash racks are unobstructed, operating well, and allowing for the free flow of water.

(5) Drop Inlet Spillway - Check for any debris or other obstructions around the inlet crest and at the bottom of the drop inlet which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete, and seepage, cracking, breaking, or spalling of the concrete. Check the vent pipes for overall condition and alignment and to ensure that the pipes are clear and unobstructed. (Do not place your hand or any tool near the inlet of the vent pipe if flows are passing over the crest of the auxiliary spillway as suction through the vent pipe may be occurring.)

(6) Outlet Works - Check for any debris or other obstructions within the impact basin which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete, and seepage, cracking, breaking, or spalling of the concrete. Check to make sure weepholes are clear and operating properly. Check for any erosion occurring at the embankment/structure junction.

(7) Concrete Block and Rip Rap - Check to make sure that the blocks and rip rap are remaining in a uniform position. Freeze/thaw action or flow over the blocks or rip rap may tend to lift or fracture them, thus requiring replacement or leveling to maintain the necessary level of protection. NO trees or woody vegetation should be growing through the blocks or rip rap.

(8) Mechanical Equipment - Check for any debris or other obstructions around the dewatering gate which may block or restrict the free flow of water. Operate the gate from the fully closed to the fully open position taking note of the physical and operating conditions of the system. Lubricate the stem, stem guides, wedges and hoisting mechanism a minimum of two (2) times a year. NOTE: Except in emergencies, the drawdown of water using the dewatering gate should be limited to 0.5 foot per day to

minimize upstream slope stability problems.
(Refer to Appendix D for operation and maintenance of the sluice gate.)

(9) Fences - Check for damage, accumulated debris, operation of gates and locks, and adequacy of locations (this may change with time as people access the area or development occurs in the area).

(10) Drains - The change in location or amount of flows discharging from the toe drain should be recorded. If a significant change has occurred, a qualified engineer should be contacted for consultation.

(11) Emergency Spillway - Check for settlement or cracking of the crest control wall. Check for any logs, tree or brush growth, and other debris in the spillway, upstream and downstream areas which may restrict the flow of water.

(12) Downstream Floodplain - Check the floodplain downstream of the dam for a distance of at least 100 feet for signs of seepage or boils.

Records: A log book of activities occurring at the dam is to be kept current by the Dam Operator. The log book should be reviewed during the Engineering Inspection and may be helpful during budget preparations. This book should contain at least the following documentation:

- (1) Completed operation and maintenance inspection checklists
- (2) Additional visual observations
- (3) A list of maintenance performed
- (4) A list of any unusual occurrences at the dam
- (5) A copy of the engineering inspection reports

Engineering Inspection:

The engineering inspection is to be conducted by a qualified engineering consulting firm approved by the City of Wherever. The inspection will provide a thorough evaluation of the condition of the dam and appurtenances. Appendix B is an example of the inspection report form which is to be utilized for these inspections.

Frequency: The Unknown Creek Dam is classified as a CLASS I, HIGH HAZARD POTENTIAL dam. Class I dams are to be inspected annually.

Inspection Items: The engineer will thoroughly inspect the items noted under Operation and Maintenance Inspection in addition to the following items:

(1) Principal and Auxiliary Spillways - Check for signs of seepage, structural cracking or spalling of concrete, misalignment of pipe, joint separation or differential settlement.

(2) Emergency Spillway - Check for signs of structural cracking or spalling of the concrete crest control wall. Check for signs of degradation of the embankment on the right of the emergency spillway to assure that emergency spillway flows do not attack the left downstream dam groin.

Records: The Dam Inspection Report form, Appendix B, will be completed by the inspecting engineer and will be signed and sealed by an Illinois Registered Professional Engineer. This report will document problem areas and deficiencies; recommend remedial actions for problem areas; and establish time requirements for dealing with the problems. The original report will be retained in the City of Wherever's Unknown Creek Dam file and a copy of the report will be submitted to the Illinois Department of Natural Resources, Office of Water Resources.

REVIEW OF EMERGENCY ACTION PLAN

The emergency action plan should be reviewed annually to assure that all contacts, addresses, telephone numbers, etc. are current. Changes to the plan should be made as appropriate but only with the concurrence of the Wherever office of the Emergency Services and Disaster Agency and of the Department of Natural Resources, Office of Water Resources. Copies of any revisions should also be forwarded to all personnel that have the plan.

SECTION 5

MAINTENANCE ACTIVITIES

Timely repairs are a must after problem areas have been identified. The dam operator is to perform the work required to correct items noted in the operation and maintenance and engineering inspections. Such items include mowing, seeding, tree and brush removal, painting, greasing, replacing riprap, repairing fences and locks, clearing debris, etc. Common maintenance items are pictured in Illustration 2. The maintenance activities specified in the following sections are minimum requirements. NOTE: NO alterations or repairs to structural elements should be made without the assistance of a qualified engineer and the concurrence of the Illinois Department of Natural Resources, Office of Water Resources.

Debris: Remove all trash, logs and other debris which may obstruct flow into the principal spillway pipe, drop inlet, and emergency spillway or block passage from their discharge channels.

Concrete Block and Rip Rap: Replace or level blocks and rip rap as needed to provide adequate protection against erosion.

Vegetation Control:

(1) A good grass cover on the embankment should be maintained by seeding, fertilizing and mulching areas which are refilled, barren, or thinly vegetated. Seeding mixtures used for maintenance reseeding shall result in a cover compatible with adjacent cover. The seeding mixture used at the time of the dam's construction was

(2) Grassed areas such as the embankment, the emergency spillway, and areas beyond the embankment toes for a distance of at least 20 feet should be mowed at least twice annually and at any time the height of the grass exceeds 1 foot.

(3) All eroded areas should be filled and compacted, reseeded, fertilized and mulched to establish a thick erosion resistant cover.

(4) All trees and brush on the dam embankment should be removed to prevent development of a root system which could provide seepage paths. Herbicides utilized for tree and brush control are discussed in Appendix C.

(5) The emergency spillway area should be kept clear of weeds, brush and trees.

(6) All trees and brush should be removed from the outlet channel to a distance of approximately 100 feet downstream from the stilling basin.

(7) All brush and trees should be removed to a distance of approximately 20 feet beyond both toes of the dam.

Animal Damage: Rodent holes should be filled with compacted clayey dirt and reseeded. If rodents become a nuisance, an effective rodent control program as approved by the Illinois Department of Natural Resources District Wildlife Biologist should be implemented.

Concrete: Spalled and cracked areas on concrete structures should be patched to guard against any further deterioration of the structure. Concrete construction joints should be filled with a suitable joint filler such as a bituminous sealant to protect against weathering.

Drains: All drains and weepholes should be kept open and functional by cleaning them of silt and debris.

Painting: All metal work, fencing, railing, etc. should be properly prepared and repainted as necessary to protect against rusting.

Signs: All warning signs and staff gages should be maintained (repaired, painted, or replaced) as needed.

Vent Pipes: All obstructions should be cleared from the vent pipes.

Sedimentation: Sedimentation of this reservoir is estimated to occur at the rate of approximately 1 ac-ft per year, which is about 1.1% of the initial reservoir storage at the crest of the drop inlet. As sediment accumulates in the reservoir less storage is available for the control of flood waters from the watershed. Efforts should be made to work with the U.S. Department of Agriculture, Natural Resources Conservation Service and the upstream land owners to minimize the sediment being transported to the reservoir. A location for the placement of the sediment removed from the reservoir (if upstream of the dam, above the top of the dam) should be determined.

Mechanical Equipment: The hoisting mechanism, stem and guides, wedges, nuts and bolts should be cleaned and lubricated at least two (2) times per year. (Refer to Appendix D for operation and maintenance of the sluice gate.)

APPENDIX A

OPERATION AND MAINTENANCE INSPECTION CHECKLIST

OPERATION AND MAINTENANCE INSPECTION CHECKLIST

Dam Name : _____
 Date and Time of Inspection : _____
 Name of Inspector : _____
 Reservoir Elevation : _____

<u>ITEM</u>	<u>NO</u>	<u>YES</u>	<u>IF YES</u>
Surface Cracks	___	___	Contact Superintendent
Slump or Slide on the upstream or downstream face	___	___	Contact Superintendent
Erosion from runoff, wave action or traffic	___	___	Repair and stabilize
Embankment, abutment or spillway seepage	___	___	Contact Superintendent
Seepage or flows of muddy water	___	___	Contact Superintendent and ESDA
Uneven settlement	___	___	Contact Superintendent
Uneven concrete blocks	___	___	Level and stabilize
Trees, brush or burrow holes on the embankment	___	___	Remove trees and brush, fill holes
Spillways or trash racks blocked	___	___	Clear immediately
Exposed metal is rusty	___	___	Clean and paint
Concrete deterioration or cracks	___	___	Contact Superintendent
Pipe joint separation	___	___	Contact Superintendent
Scour	___	___	Contact Superintendent
Vent pipe blocked	___	___	If no flow over drop inlet, clear
Height of Grass ___ inches			If more than 1 foot, schedule mowing

Comments : _____

APPENDIX B

ENGINEERING INSPECTION FORM

(See OWR document entitled "Guidelines and Forms for Inspection of Illinois Dams")

APPENDIX C

HERBICIDES

HERBICIDES

Site personnel should check with the Illinois Department of Natural Resources, Regional Fisheries Biologist and the Regional Wildlife Biologist before using any herbicide. Read the product label prior to use and follow the use directions and precautions accordingly.

On March 1, 1979 the U.S. Environmental Protection Agency (U.S.E.P.A.) halted the use of the herbicide 2, 4, 5-T in parks and recreation areas. The use of silvex (2, 4, 5-TP) around water has also been banned.

The Agronomy Department at the University of Illinois and the Aquatic Biology Section of the Department of Natural Resources, Office of Scientific Research and Analysis indicate that the herbicides containing the 2, 4-D or 2, 4-DP are legal for use in parks and recreation areas and effective for controlling brush and woody growth. Some examples of approved herbicides are:

- 1) Tordon RTU by DOW Chemical. (Can be obtained with blue dye.)
- 2) WEEDONE 170 by Union Carbide
- 3) WEEDONE, 2, 4-DP by Union Carbide
- 4) A 1% to 2% solution of ROUNDUP
- 5) Garlon by DOW Chemical
- 6) Banvel by Sandoz

Your distributor may carry brand name herbicides other than those listed above. Be certain that the product does not contain the ingredients 2, 4, 5-T or 2, 4, 5-TP. An example of an unacceptable product is ESTERON 2, 4, 5 by DOW Chemical.

APPENDIX D

OPERATION AND MAINTENANCE OF SLUICE GATE

MAINTENANCE

The maintenance on a sluice gate is minimal but very important. The gate, itself, requires no periodic maintenance or lubrication. It is critical that the operating stems be periodically cleaned and greased. Manufacturers recommend that stems be cleaned and greased at least once every six months. Dirty grease or lack of grease will increase the operating force necessary to open or close the gate and will accelerate the wear in the stem nut. Manufacturers of sluice gates recommend the following lubricants for this use:

- Lubriplate Lithium Base No. 630AA or AAA
- Texaco Multi-Fax Heavy Duty No. 2
- Conoco All Purpose Superlube
- Shell Alvania No. 1 or No. 2 EP
- Mobilox Grease No. 2 EP
- Valvoline Val-Lith No. 2 EP

At least once a year, all grease fittings on manual floor stands should be lubricated with a small amount of heavy duty grease designed to remain pliable and not dry out over long periods and wide temperature ranges. For best results the floor stand should be greased when being operated. For the first three or four turns of the crank, grease should be applied to each fitting after each turn. This will insure adequate lubrication of all parts. Over lubrication is not possible. Manufacturers recommend the following lubricants for this application:

- Mobilgrease Special
- Mobilplex No. 45

The exposed non-operating surfaces of the gate, stem guides, and hoisting mechanism should be cleaned and painted as conditions require or permit. All machined corrosion-resistant metal faces must be thoroughly protected during the cleaning and painting.

OPERATION

There isn't a sluice gate manufacturer who will guarantee a leak-proof gate. AWWA Specifications maintain that leakage for a seating head gate should not exceed 0.1 gpm per foot of perimeter. For unseating head gates with heads of up to 20 ft., the specifications indicate that leakage should not exceed 0.2 gpm per foot of perimeter.

As an example: a 24-inch diameter circular opening gate would have a circumference of 6.25 ft. If an unseating head gate operates under a head of 20 ft. the allowable leakage would be 1.26 gpm. That is, the gate could pass 1.26 gpm without requiring adjustment. When there is excessive leakage through the gate seating surfaces, the wedges should be re-adjusted per the manufacturer's instructions. These adjustments should not be attempted without adequate instruction, help, tools, replacement parts, and safety equipment.

Sluice gates are designed and constructed to operate satisfactorily under the design operating conditions. Care should be taken in the operation of the gate to assure that the design operating conditions are not exceeded. If, in the operation of the gate, an obstruction is met, either in the opening or closing direction, the obstruction must be removed, before continuing the operation of the gate. Excessive force must never be placed on the gate or gate stem by the operator in an effort to move the gate further. Manual operators are designed so that the maximum pull on the crank need not exceed 40 pounds when the gates are opened or closed against the specified operating head. If a problem arises in the operation of the gate, the operator should consult the Superintendent and a determination will be made as to the corrective action to be taken.

Prior to opening a sluice gate, the following checklist activities should be performed:

- (1) Gate, wedges, stem, stem guides and hoist mechanism inspected.
- (2) All sand, stones, and other debris cleaned from the top of the gate, wedges, and stem guides.
- (3) Stem and stem guides cleaned and lubricated.
- (4) Guides cleaned and lubricated.
- (5) Hoisting mechanism lubricated.

When operating the gate, record the number of turns of the crank to open the gate. Repeat the number of turns to close the gate. After closure, check the gate for leakage. If leakage is "excessive" or greater than prior to opening, the wedges may need adjusting. Do not force the crank to attempt to close the gate. If any problems are encountered, the Superintendent should be notified immediately.

PLATES

(Specific plates or figures appropriate for the dam should be included here.)

APPENDIX NO. 3

EMERGENCY ACTION PLAN

UNKNOWN CREEK DAM

WHEREVER, ILLINOIS

WHICHEVER COUNTY

DATE

EMERGENCY ACTION PLAN
UNKNOWN CREEK DAM
WHEREVER, ILLINOIS

TITLE

PAGE

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PLATES

Plates 1-5	Dam Breach Inundation Maps
Plate 6	Granular Blanket "Inverted Filter"
Plate 7	Boil Ring

EMERGENCY ACTION PLAN
UNKNOWN CREEK DAM

(The information that follows identifies the procedures to be followed in the event of a heavy rainfall or a dam failure. An example of a complete plan is specifically not included. OWR and the Illinois Emergency Management Agency offer a course on the preparation of emergency action plans for dams. Guidance on the development of a plan can be obtained in the document entitled "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners," prepared by the Interagency Committee on Dam Safety and the Federal Emergency Management Agency (FEMA-64). The plan should be coordinated with emergency services personnel prior to submittal to OWR for permitting of the dam construction. Some of the items which relate to actions to be taken at the dam are included for consideration and guidance.)

EMERGENCY DETECTION, EVALUATION AND ACTIONS

The following section explains some of the problems which may occur at a dam, how to make a rapid evaluation of the problem, and what action should be taken in response to the problem. This section presents only generalized information for the dam operator to aid in a first response to a problem. Any suspected problem should be reported and assistance from a qualified engineer should be obtained as soon as possible.

This section will be placed in the following format:

PROBLEM

INDICATOR

HOW TO EVALUATE PROBLEM

ACTION TO BE TAKEN

SEEPAGE

Wet area, on downstream embankment slope or any other area downstream of the embankment, with very little or no surface water or very minor seeps.

This condition may be caused by infiltration of rain water which is not serious, or may be the start of a serious seepage problem which would be indicated by a quick change to one of the conditions below.

No immediate action required; note location for future comparison.

Same wet area as above with moderate seeps of clear or relatively clear water and rate of flow not increasing.

Measure the flow periodically and note any changes in clarity.

No immediate action required; note location, flow rate, and clarity for future comparison. During reservoir flood stages the seepage area should be watched for any changes.

Same wet area as above with moderate seeps of clear or relatively clear water and rate of flow increasing.

Measure the flow periodically and note any changes in clarity. Inspect the downstream area for any new seeps.

Contact a qualified engineer for an immediate inspection. Observe the condition constantly for any further changes in flow rate or clarity unless notified otherwise by the engineer.

Piping (seepage with the removal of material from the foundation or the embankment) with moderate to active flows of cloudy to muddy water.

If the water is cloudy to muddy and the rate of flow is increasing, this condition could lead to failure of the dam.

Immediate action is necessary. Open the dewatering gate completely. If no whirlpool is noted on the upstream side of the dam, place an "Inverted Filter" over the seepage area on the downstream side of the dam (see Plate 6). The filter should consist of a 3 to 5 ft. thick blanket of material graded from coarse sand and pea gravel at the bottom to 3-inch stone at the top. If needed, use larger stones on the top of the filter. Use filter cloth at the bottom of the filter if available. Do not try to "plug" or stop the flow of water from this location. Try to reduce the movement of material using this filter while allowing the flow to pass through it. Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5).

If, along with the piping, there is an upstream swirl (whirlpool) caused by water entering through the abutments of embankment, failure may be imminent.

Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5), open the dewatering gate completely, and attempt to construct the inverted filter over the seepage area on the downstream side of the dam as noted above. The thickness of the section will generally be greater than 5 ft. Plugging of the upstream entrance of the "pipe" should also be attempted using large rock or anything else that is available (rolls of fencing, bed springs, cars, large hay bales, etc.). If the large material placed in the hole appears to have reduced the

flow, follow with progressively smaller material in an attempt to seal the entrance.

Boils (soil particles deposited around a water exit forming a cone, varying from a few inches in diameter spaced 2 to 3 ft. apart to isolated locations several feet in diameter in the floodplain downstream of the dam) may show the same types of flow as noted above.

Evaluation of the problem is the same as noted above for the various flow conditions, i.e., clear and constant, clear and increasing, and cloudy or muddy and increasing.

Actions to be taken are essentially the same as those noted above. An additional method to try to control the movement of material from a boil is the construction of a boil ring or ring dike. An example of a boil ring is shown in Plate 7. In placing the ring it must be remembered that the work is not being done to stop the flow of water but rather to stop the movement of material. When the ring reaches an elevation where the water that is discharging from the ring is flowing clear the work should stop and the flows monitored for changes.

RESERVOIR WHIRLPOOL

Water flowing in a swirling motion in an area on the upstream side of the dam.

During high reservoir stages when the drop inlet is completely submerged, debris may come together above the drop inlet and due to flows at the inlet move in a rotating motion. If there is no evident downstream exit of "piping" as noted above and the rotating debris is over the drop inlet, then it can be assumed that there is no piping failure. If the whirlpool is over a section of the embankment or abutment, the situation is critical and failure of the dam may be imminent.

Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5). Take the actions noted above under "piping".

SLIDE

Movement of a portion of the embankment, either the upstream or downstream slope, toward the toe of the dam.

Various degrees of severity of a slide require different responses. The first condition is that the slide does not pass through the crest and does not extend into the embankment more than 5 ft., measured perpendicular to the slope.

For this condition, a qualified engineer should be consulted before any repairs are initiated to determine the cause of the slide and to recommend any modifications to prevent future slides. The downstream side of the dam should be watched for the emergence of any water either through the slide or opposite the slide. If discharging water is noted, the area the slide should be treated as a seepage location and monitored as noted above.

The second condition is that the slide passes through the crest and that the reservoir elevation is more than 10 ft. below the lowered crest.

Use the same actions as noted above and notify the Emergency Services and Disaster Agency of the situation so they may be prepared to act if the condition worsens.

The third condition is that the slide passes through the crest and the reservoir elevation is less than 10 ft. below the lowered crest.

This condition is critical and failure of the dam should be considered imminent. Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5). Armor the crest of the lowered portion of the embankment and try to restore the lost freeboard. If seepage is also occurring, take the appropriate actions as noted above.

CRACKS

Cracks in the embankment can occur either in the longitudinal (along the length of the dam) or transverse (across the dam from upstream to downstream) direction.

Some cracking of the surface soils may occur when they become dry. This cracking is to be expected and no further action is required.

Longitudinal cracking can indicate the beginning of a slide or be an uneven settlement of the embankment.

Monitor the crack for future changes and contact a qualified engineer for assistance in the evaluation of the crack and recommended repairs.

Transverse cracking can indicate uneven settlement or the loss of support below the crack. Such cracks usually occur over an outlet conduit, near the abutments, or in the taller portion of the embankment.

If the crack does not extend completely across the dam and the reservoir elevation is more than 10 feet below the base of the crack, monitor the crack for future changes and contact a qualified engineer for assistance in the evaluation of the

crack and recommended repairs. If the crack extends across the dam and the reservoir level is less than 10 feet below the base of the crack, both the upstream and downstream sides of the dam should be protected with a plug and inverted filter (as noted above under seepage) and the Emergency Services and Disaster Agency should be notified of the situation so they may be prepared to act if the condition worsens.

BURROW HOLES

Holes in the embankment, varying in size from about 1 inch to 1 foot in diameter, caused by animals.

If the holes do not extend through the embankment the situation is usually not serious. Some animal holes will have soil pushed out around the hole in a circular fashion which may look like a boil (crayfish or crawdad). Watch for the movement of water and soil particles from these holes to determine whether they are boils.

Backfill as deeply as possible with impervious material. If rodents become a nuisance, an effective rodent control program, as approved by the Illinois Department of Natural Resources District Wildlife Biologist, should be implemented.

RESPONSIBILITIES

[This section should clearly specify responsibilities that are specific to this dam. General guidance for the positions noted for the City of Wherever are included but should be revised as appropriate for the dam and owner.]

PREPAREDNESS

Visual inspections of the dam and its appurtenances will be made on a routine basis per the schedule noted below. Items that will be monitored are those noted for the operation and maintenance inspection and are noted here again. The O&M inspection checklist should be completed for each inspection.

Inspection Items: During each inspection the following items should be noted in particular:

- (1) Water Level - A staff gage which can be easily seen when the reservoir is full should be installed or painted on the drop inlet.

Maximum reservoir levels as a result of heavy rainfall should be recorded.

(2) Earth Embankment - Walk the crest, abutments, groins, side slopes, downstream toe and upstream toe or at the waterline of the dam concentrating on surface erosion, seepage, cracks, settlements, slumps, slides, and animal burrows. These are described as follows:

Surface Erosion - Removal of vegetative cover by water action or pedestrian or vehicle usage forming deep ruts or gullies.

Seepage - The passage of water through and/or underneath the earth embankment abutment and natural groundline or at the contact between the embankment and outlet works can be indicated by cattails or other wet environmental vegetation, erosion channelization, or slumping on the embankment face.

Cracks - Deep cracks usually indicate the movement of the dam and/or the foundation and can be in either the longitudinal (along the length of the dam) or transverse (across the dam) directions. Cracking can be an indicator of the beginning of slumps. Shallow cracks may develop during the summer when the surface soils of the embankment become severely dried and are usually of no concern in regard to the safety of the dam.

Settlement - Settlement is indicated by depressions or low spots and can be signs of consolidation of the dam or foundation or the loss of material beneath the settlement area.

Slumps/Slides - Slow or sudden movements of the earth embankment slope on either face toward the toe of the dam.

If seepage indicates the presence of soil particles, or if deep cracks, settlement, slumps, or slides are noticed, a qualified engineer should be contacted immediately for consultation.

Animal Burrows - Animal burrows result in a loss of earth embankment material and can provide seepage paths for water through the embankment.

(3) Vegetation - Grass should be a thick vigorous growth to stabilize embankment soils and prevent erosion from occurring. Note the height of the grass, if greater than 1 foot, a mowing of the area should be scheduled before the next inspection. There should be NO trees on the earth embankment and NONE within a minimum of 20 feet of the embankment toes or concrete structures. There should be NO trees in the emergency spillway.

(4) Trash Racks - Check to make sure that the trash racks are unobstructed, operating well and allowing for the free flow of water.

(5) Drop Inlet Spillway - Check for any debris or other obstructions around the inlet crest and at the bottom of the drop inlet which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete and seepage, cracking, breaking, or spalling of the concrete. Check the vent pipes for overall condition and alignment and to ensure that the pipes are clear and unobstructed. (Do not place your hand or any tool near the inlet of the vent pipe if flows are passing over the crest of the auxiliary spillway as suction through the vent pipe may be occurring.)

(6) Outlet Works - Check for any debris or other obstructions within the impact basin which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete and seepage, cracking, breaking, or spalling of the concrete. Check to make sure weepholes are clear and operating properly. Check for any erosion occurring at the embankment/structure junction.

(7) Concrete Block and Rip Rap - Check to make sure that the blocks and rip rap are remaining in a uniform position. Freeze/thaw action or flow over the blocks or rip rap may tend to lift or fracture them, thus requiring replacement or leveling to maintain the necessary level of protection. NO trees or woody vegetation should be growing through the blocks or rip rap.

(8) Mechanical Equipment - Check for any debris or other obstructions around the dewatering gate which may block or restrict the free flow of water. Operate the gate from the fully closed to the fully open position taking note of the physical and operating conditions of the system. Lubricate the stem, stem guides, wedges and hoisting mechanism a minimum of two (2) times a year. NOTE: Except in emergencies, the drawdown of water using the dewatering gate should be limited to 0.5 foot per day to minimize upstream slope stability problems. (Refer to Appendix D for operation and maintenance of the sluice gate.)

(9) Fences - Check for damage, accumulated debris, operation of gates and locks, and adequacy of locations (this may change with time as people access the area or development occurs in the area).

(10) Drains - The change in location or amount of flows discharging from the toe drain should be recorded. If a significant change has occurred, a qualified engineer should be contacted for consultation.

(11) Emergency Spillway - Check for settlement or cracking of the crest control wall. Check for any logs, tree or brush growth, and other debris in the spillway, upstream and downstream areas which may restrict the flow of water.

(12) Downstream Floodplain - Check the floodplain downstream of the dam for a distance of at least 100 feet for signs of seepage or boils.

Areas downstream of the dam may experience flooding due to local runoff at times when the reservoir water level is low. However, high reservoir levels are an indicator of potential downstream flooding and are used in this plan to provide steps for various actions to be taken. The following schedule of inspections and evacuation procedures will be followed:

(1) Normal Conditions Surveillance

Under normal water level elevations (up to elevation 732.0) the embankment and appurtenant structures will be observed by the dam operator on a monthly basis.

(2) "Unusual" Storm Conditions

During and immediately following unusual storm and flood events (reservoir level equal to or greater than elevation 732.0) the dam operator will make visual inspections of the dam and its appurtenances at a minimum of every hour if it is currently raining and every 12 hours if it is not raining. Flooding in some areas downstream of the dam may occur for heavy rainfall events occurring in a short period of time. As reservoir levels increase above this elevation larger areas of flooding downstream of the dam may occur.

The dam operator is responsible to notify the Emergency Services and Disaster Agency (ESDA) in Wherever when the reservoir levels exceed elevation 732.0. The ESDA office will be responsible for notifying individuals and coordinating their evacuation and return in the event an emergency occurs.

If the reservoir level reaches elevation 734.0, the dam and appurtenances will be inspected at 1-hour intervals if it is currently raining and at 8-hour intervals if it is not raining.

If the reservoir level reaches elevation 735.5 and it is currently raining, the dam operator is responsible to notify ESDA. The dam and appurtenances will be inspected continuously if it is currently raining and at 4-hour intervals when the rain has stopped.

If the reservoir level reaches elevation 736.0 and it is currently raining, the dam operator is responsible to notify ESDA. The dam and appurtenances will be inspected continuously until the reservoir level falls to elevation 735.0 and the rain has stopped.

When the reservoir level reaches elevation 736.5 and it is currently raining, the dam operator is responsible to notify ESDA to evacuate all residents within the dam breach wave area (see Plates 1-5). The dam and appurtenances will be inspected continuously until the reservoir level falls to elevation 735.0 and the rain has stopped.

ESDA will not allow residents to return to the flood wave area until: 1) the lake level is below elevation 735.0, 2) the dam and appurtenances have been inspected by an engineer to determine if damage has occurred, and 3) all damages indicating a weakened condition of the dam have been remedied.

If there is no inflow to the reservoir the estimated time for the reservoir level to drop from the crest of the emergency spillway

(735.5) to the crest of the drop inlet (733.5) is 4.5 hours. With no inflow, the estimated time for the reservoir level to drop from the crest of the drop inlet (733.5) to the flow line of the low flow pipe (714.0) is 20 hours. If the low flow pipe or drop inlet are not allowing the reservoir level to drop due to debris accumulation or damage, the dewatering gate should be opened or portable pumps should be used to lower the reservoir level. The lower reservoir level will allow for the removal of debris, the repair of damage, and the re-establishment of storage in the reservoir.

EQUIPMENT AND MATERIALS LOCATIONS

The following equipment and materials are available at these sites:

Backhoe
Location, Contact Person, Tel. No.

Dump Truck
Location, Contact Person, Tel. No.

Grader
Location, Contact Person, Tel. No.

Crawler Tractor
Location, Contact Person, Tel. No.

Sand Bags
Location, Contact Person, Tel. No.

Sand
Location, Contact Person, Tel. No.

Gravel
Location, Contact Person, Tel. No.

Riprap
Location, Contact Person, Tel. No.

Pumps
Location, Contact Person, Tel. No.

PLATES

(Specific plates or figures appropriate for the dam should be included here.)