Let's protect our earth

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

STATE OF NEW JERSEY

DAM SAFETY MANUAL

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Funds for the development an distribution of this Manual were provided by the Federal Emergency Management Agency (Region II - New York)

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PART I

GUIDELINES FOR DAM

OPERATION AND MAINTENANCE

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ACKNOWLEDGEMENTS

This manual has been made possible as a result of a grant from the Federal Emergency Management Agency. The grant has enabled New Jersey through the Department of Environmental Protection, Division of Water Resources and Department of Law and Public Safety, Division of State Police to improve dam safety in New Jersey. In particular, the Department of Environmental Protection wishes to acknowledge the use of material from the Virginia State Water Control Board, **Safety of Evaluation of Small Earth Dams, Information Bulletin 549.**

FOREWORD

This pamphlet presents a basic discussion of how to evaluate the safety of a small earth dam. Its intent is to inform the dam owner or operator of general aspects of preventive maintenance that he should be aware of and enable him to recognize certain unsafe conditions that may be associated with such structures. Once unsafe conditions are recognized, professional services should be obtained to assess the problem and to take appropriate remedial action. This brief discussion provides general guidance on some of the more common problems, but it is not intended to cover every type of condition, situation, or emergency that could possibly cause a dam to become unsafe or fail.

It should be noted that the condition of a dam depends on many internal and external conditions that may be constantly changing. It is incorrect and unwise to assume that the conditions of a dam at any given time will continue to represent its condition at some time in the future. Only through continued care and evaluation can there be a reasonable chance that unsafe conditions will be detected.

The design of an earth dam is the task of an experienced professional engineer. Likewise the implementation of major remedial measures of a dam generally requires a consultant. The application of trail-and-error "home remedies" to dam problems is not recommended, and such an approach will likely prove to be far more costly than obtaining and acting on professional guidance. The text and plates of this pamphlet are not intended to serve as a design guide either for the construction of new dams or for extensive remedial measures for existing dams. Rather they are intended to serve as a source of information which the owner can use in his regular maintenance and inspection activities and as a general guide as to when professional services are needed to insure the safety of a dam.

The Department has adopted regulations to implement the Safe Dam Act, NJSA 58:4-1 et. seq.. These rules govern the design, construction, inspection, modification and repair of all dams in New Jersey which raise the water height by more than five feet. The primary objective of these rules is the protection of areas below dams from the consequences of their failure. Major factors addressed in these rules include the establishment of design criteria for construction of dams and the development of an inspection program. The inspection schedule for all dams is outlined in the Dam Safety Standards N.J.A.C. 7:20-1.1 and must be used for all dam inspections in New Jersey.

INTRODUCTION

This pamphlet was written to assist dam owners in inspecting and maintaining dams in a safe and stable condition. The focus of any dam safety effort is, of course, safety: the protection and lives and property in the area downstream from the impoundment. Every owner should be aware of the potential hazard that his dam might pose to the downstream area and of the need to properly maintain the dam in such a way as to reduce this hazard as much as possible. The liability for damages resulting from a dam failure rests with the owner of the dam.

A good inspection and maintenance program is important. Dams represent a considerable investment. Replacement costs would be high. Loss of the dam would probably mean the loss of a water source, recreational facility, flood protection, or other assets.

As is the case with buildings, highways, and other works that we construct, dams require an on-going maintenance program to insure their continued useful life. This fact has always been fully appreciated. Often there is a tendency to neglect them once construction is completed.

There are many ways an earth dam can fail. These include but are not limited to sliding, piping (internal erosion of soil particles from the embankment), overtopping during periods of high water, erosion, liquidfaction of earth materials (which may occur when embankment material is poorly drained and loosely compacted), structural failures resulting from excessive seepage or other causes, and failures of the foundation upon which the structure rests. Problems associated with outlets and spillways can also be contributing factors.

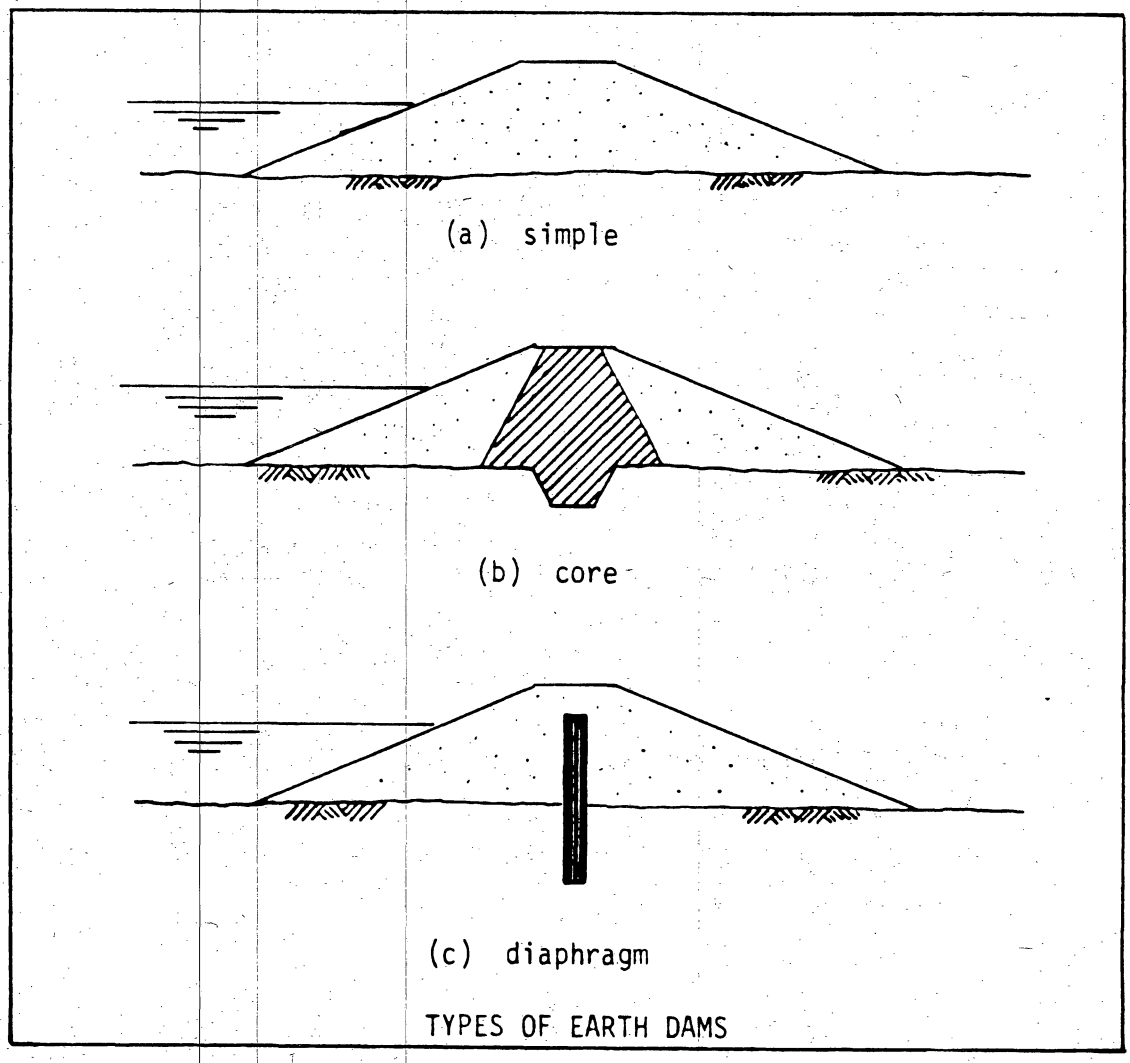
Like most works of man, dams should not be considered to have an unlimited useful life. Ernest E. Wahlstrom, Professor of Geological Sciences at the University of Colorado, states in **Dams, Dam Foundations, and Reservoir Sites:** "The ultimate fate of all dams and reservoirs, unless they are carefully constructed and maintained, is deterioration and failure or filling by sedimentation. Every reservoir that impounds water behind a dam is a real or potential threat to those who live and work in flow channels below it, and, in some locations where earthquake shocks, movements along bedrock faults beneath dams, or collapse of large volumes of earth materials into reservoirs are distinct possibilities, even the most skilled design and continued maintenance may not preclude failures that are disastrous to life and property." So, many events and circumstances can threaten the safety of a dam, including floods, landslides, earthquakes, and-less dramatically but just as surely-neglect and the deterioration which inevitably occurs through neglect.

CHAPTER I

TYPES OF DAMS

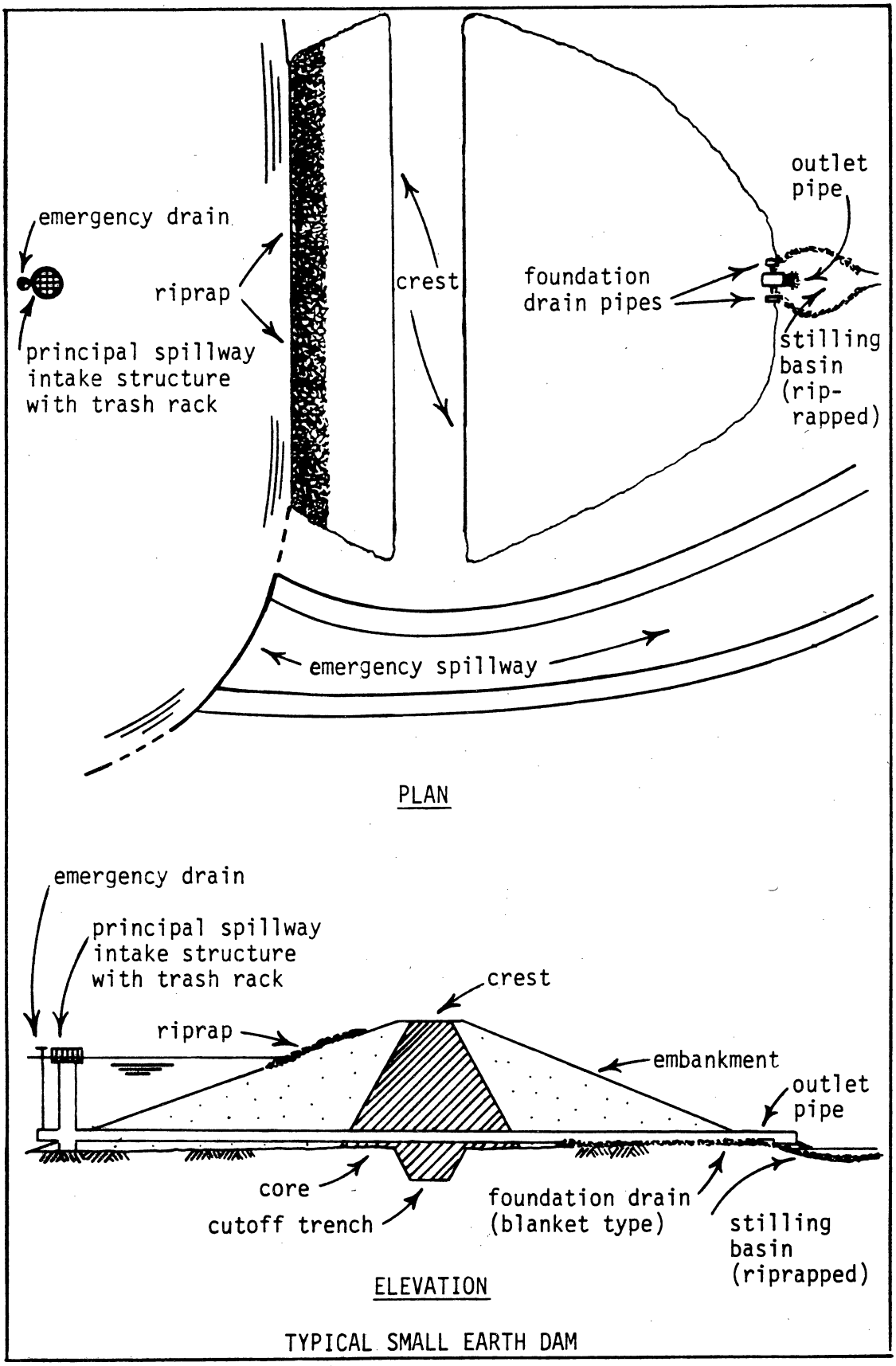
Before discussing some of the procedures for inspecting a dam, it is appropriate to make a few general comments about such structures. In simplest terms, a dam is a barrier constructed across a watercourse for the purpose of storing water. Perhaps the most common type is the earthfill dam, and this pamphlet deals with small dams of this mode of construction. There are also concrete dams (gravity, arch, multi-arch, and buttres types) and dams constructed of masonry, timber, rockfill, steel, and combinations of these materials.

Earth dams may be further classified as simple, core, and diaphragm (Plate No. 1). The simple embankment type consists of reasonably uniform material throughout, sometimes with a blanket of highly impervious material placed on its upstream face. Core embankments employ a central zone or core of carefully chosen material which is less pervious than the rest of the dam. Clay soils are often used for the core, as this type of material is particularly suitable. Diaphragm type dams incorporate a relatively thin section of concrete, steel, or wood-sometimes referred to as a cut-off wall--in the central portion of the embankment, which forms a barrier to the flow of water percolating through the dam. Occasionally an earth dam is constructed with both a central core and a diaphragm.



TYPES OF EARTH DAMS

Source: Virginia State Water Control Board - BWCM PLATE NO. 1



TYPICAL SMALL EARTH DAM

Source: Virginia State Water Control Board - BWCM

PLATE NO. 2

CHAPTER II

A TYPICAL DAM AND ITS PRINCIPAL PARTS

As stated earlier, a dam is essentially a barrier constructed across a watercourse for the purpose of storing water. There are certain features of such structures, such as the principal spillway, which perform vital functions and are common to practically all small earth dams. Understanding the purpose of these is essential to any evaluation of a dam's condition.

Such principal parts include the embankment itself, the principal and emergency spillways, the intake structure, outlet works, and stilling basin. Other common features often but not always found are riprap slope protection and foundation drains. Brief definitions of some of these principal features follow, and others are indicated on Plate No. 2, "Typical Small Earth Dam."

Spillway. A channel or conduit for an impoundment's overflow. The main such outlet is designated as the principal spillway. Usually there is an additional outlet at a somewhat higher elevation, known as the emergency spillway.

Emergency spillway. The purpose of the emergency spillway is to safely pass the charge of major floods, thereby preventing the dam from being overtopped and possibly washed out. Because the ability to handle major floods is so critical to a dam's safety, an adequate emergency spillway is one of the most important features of any dam.

Intake structure. That part of the principal spillway through which water enters.

Outlet works. Pipes or culverts below the spillway crest and generally near the base of the downstream toe of the dam, which serve to release water through the dam.

Stilling basin. A basin or pool area at the toe of a dam into which the outlet works discharge, designed to dissipate the energy of the flow so as to prevent downstream scour or erosion.

Foundation drains. Various types of systems employing pipe, gravel, etc. within an embankment which serve to collect seepage water and move it to a point where it can be safely discharged without deterioration of the dam. Typical foundation drains are shown on Plate No. 3.

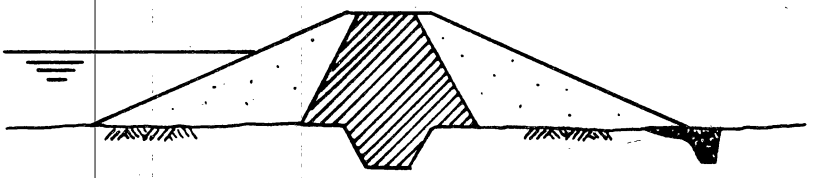
Core. The central portion of a zoned earth dam, composed of impervious material.

Cutoff trench. An excavation in the foundation of a dam for the purpose of construction of a vertical barrier to seepage.

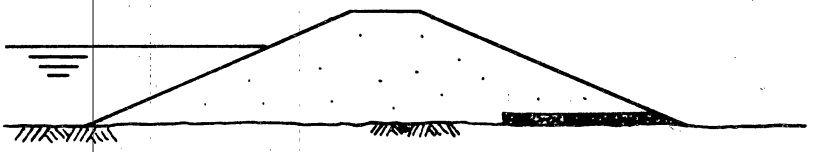
Riprap. A layer, facing, or protective mound of stone in random size pieces, randomly placed to prevent erosion, scour, or sloughing of an embankment or structure.

Trash rack. A screening device located at an intake structure to prevent the entry of debris.

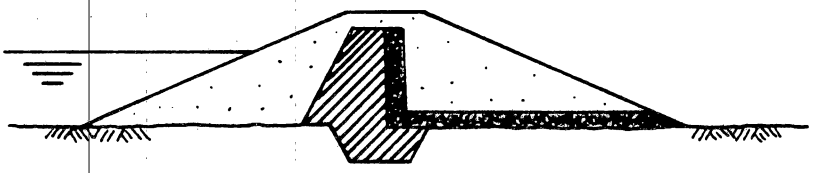
(a) toe drain



(b) toe drain,
clay core



(c) blanket drain



(d) chimney drain,
clay core

FOUNDATION DRAINS

Source: Virginia State Water Control Board - BWCM PLATE NO. 3

CHAPTER III

IS YOU DAM REALLY A HAZARD?

Every dam represents a potential hazard to the area downstream from it, simply because of the inherent amount of destructive energy that would be unleashed if the stored water behind it was suddenly released. Thus a dam is generally classified as to the degree of hazard it poses simply on the basis of its location, without regard to the type of structure or the condition it is in.

I. Hazard class I dams are those whose location is such that in the event of a failure there would be probable loss of life and excessive damage.

II. Hazard class II are those where loss of life is possible and damage would be appreciable.

III. For hazard class III dams no loss of life is expected, and damage would be minimal.

In view of the fact that a dam owner is legally liable for damages resulting from the failure of his dam, it is a good idea for every owner of a dam to pause and consider what lies below it. Several questions need to be asked.

What is the nature of the land use downstream: wooded or agricultural land, scattered homes, roads, villages, urban areas? How many structures are located within a half mile, a mile, several miles of the dam?

How are downstream structures located with regard to the watercourse or floodplain, with respect to both distance from the watercourse or river and elevation above it? Think about the first floor elevation of the homes located downstream. Are they only a few feet above the level of the watercourse, or are they on bluffs high above it and out of danger?

Is the valley below the dam characterized by steep hills forming a narrow gorge, or is there a broad floodplain? This is an important consideration as it determines whether water released in a dam failure would soon spread out and lose its force or whether a destructive wall of water would travel a long distance downstream.

An awareness of the state of development of the downstream area should be a continuing concern, as conditions below a dam often change appreciably over the years. Thus a dam which posed little hazard when constructed may represent a formidable hazard later as the downstream area develops. When this is the case, it is imperative that an emergency warning plan be prepared for the structure, with adequate provision for alerting those in the affected area in the event the dam's safety is threatened.

CHAPTER IV

INSPECTING YOUR DAM

The matter of inspecting your dam should be given the time and consideration it deserves in view of the impoundment's value to you and the possible consequences of its failure. Try to set aside enough time for the project to do a thorough job.

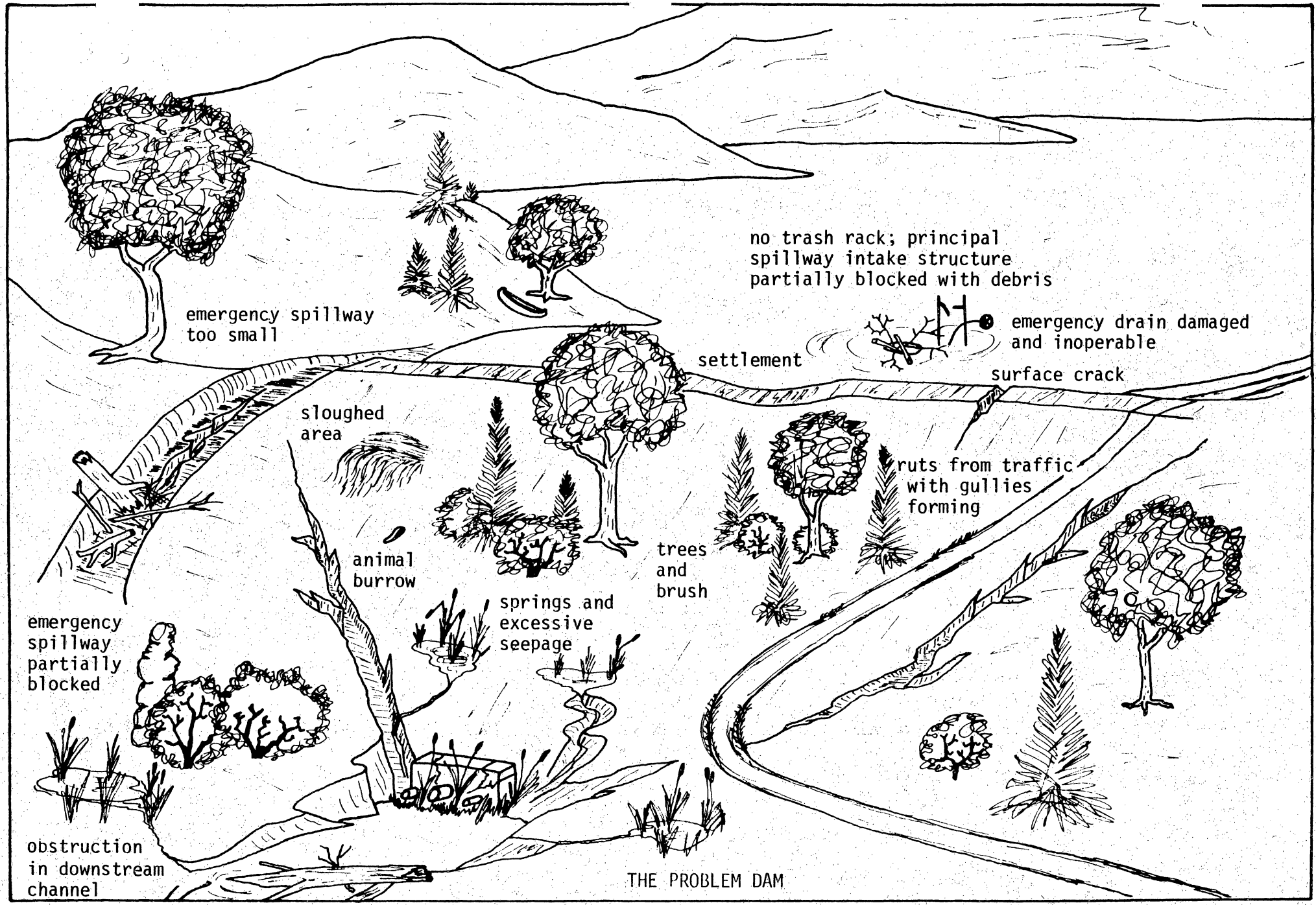
Before taking a close look at the dam itself, it would be a good idea to review all of the material (plans, specifications, construction history, records of operation, repairs, major floods, maintenance, etc.) that you may have on it or can locate. Once assembled, this material should be kept together in one place for future reference.

Sometimes a dam is so overgrown that it is difficult or impossible to evaluate. If this is the case, the underbrush should be cleared off before doing anything else.

The following checklist outlines an approach to the actual inspection. The wording of the questions is general so as to apply to as wide a variety of dams as possible. Walk over the structure, examine it closely, and try to answer the questions. Use the "comments" space to write down additional information or observations, and study the "remarks" and "maintenance tips", related to each topic.

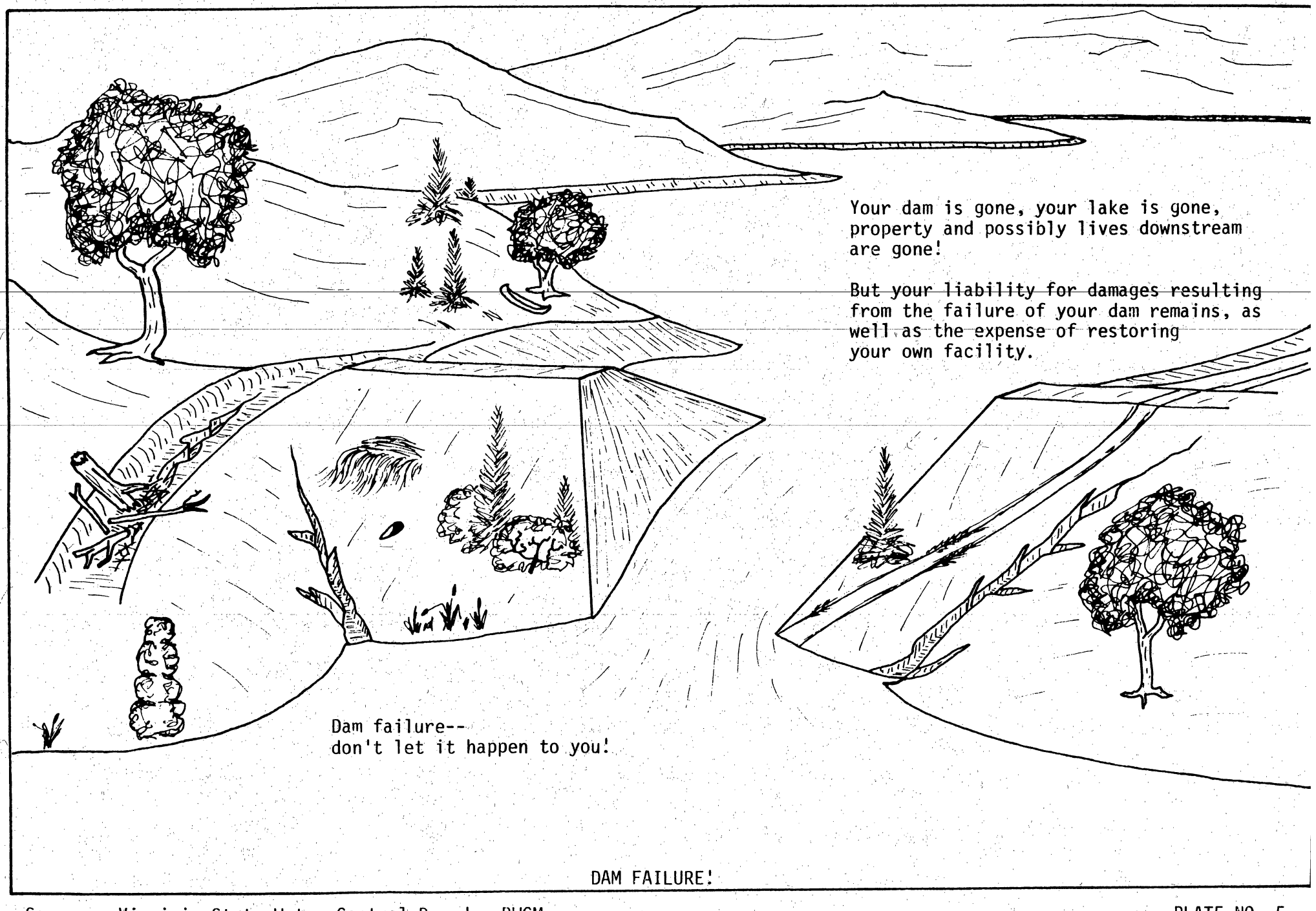
Completing the questionnaire should give you an idea about what areas of your dam require attention. The "Maintenance Priorities" section which follows the checklist will be useful in setting up an ongoing program to take care of these in the order of their importance.

Some of the common problems associated with dams and covered in the checklist are indicated on Plate No.4, "The Problem Dam." Plate No. 5, "Dam Failure", dramatizes the worst possible consequence of neglecting to maintain a dam.



Source: Virginia State Water Control Board - BWCM

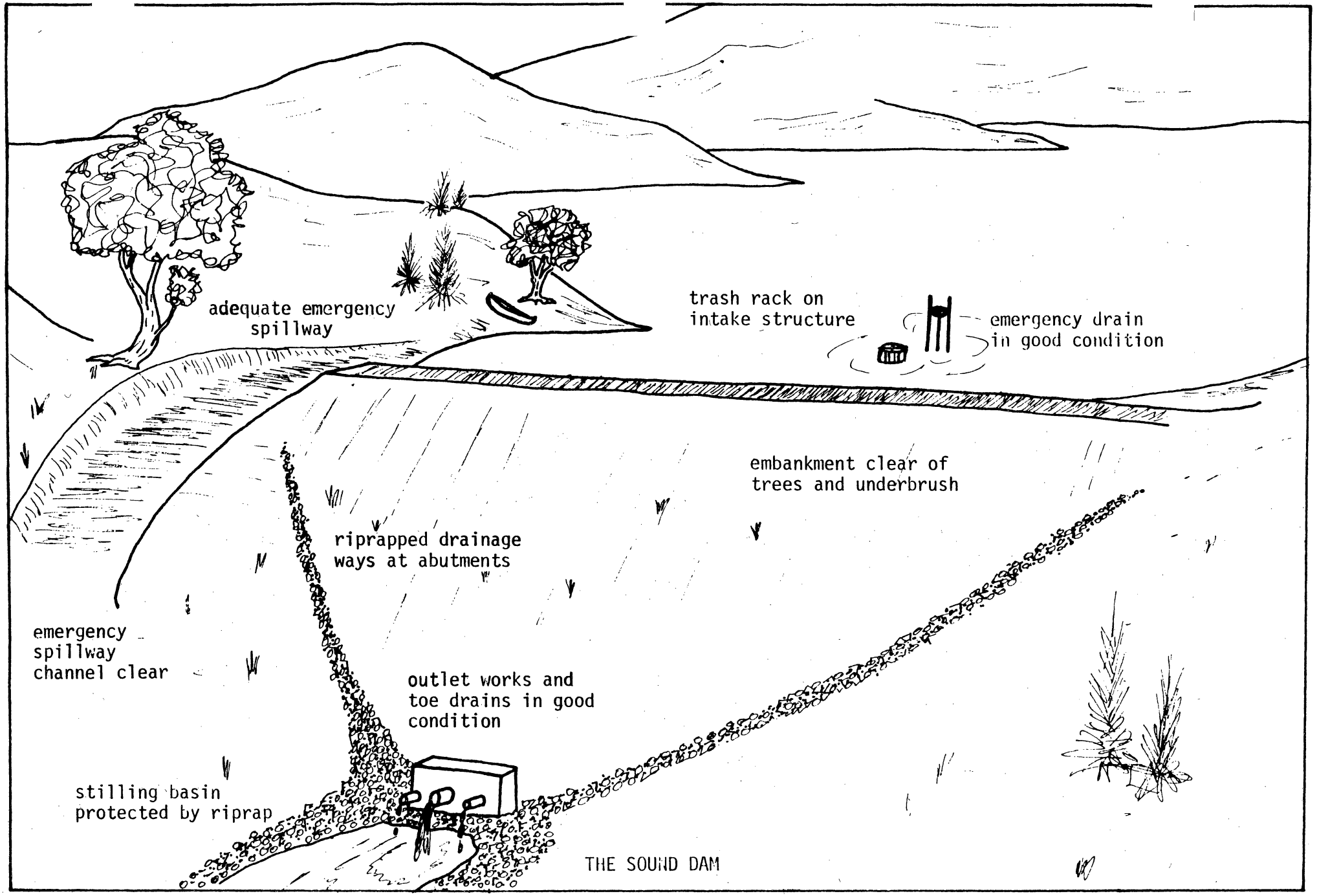
PLATE NO. 4



DAM FAILURE!

Source: Virginia State Water Control Board - BWCM

PLATE NO. 5



Source: Virginia State Water Control Board - BMCM

PLATE NO. 6

CHAPTER V

DAM INSPECTION AND MAINTENANCE CHECKLIST

THE EMBANKMENT

Key things to look for: Any evidence of movement, either within the dam itself, at its ends, or in the material on which it rests. Excessive surface erosion or other damage to the embankment, or excessive seepage. Is the dam overgrown with underbrush or trees?

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Are there any surface cracks?		May indicate movement within the dam.	Should be evaluated by a professional engineer.
☐	☐	Is there any unusual movement or cracking at or beyond the toe?		Dam or its foundation may be unstable.	Should be evaluated by a professional engineer.
☐	☐	Is there erosion on upstream face from wave action or changes in pool level?		If severe or rapid, a serious problem.	If severe and progressive, protect upstream face with riprap or other form of wave protection.
☐	☐	Is there erosion from runoff, either gullies or bare areas?		Erosion of any sort is a problem, as it tends to get worse with time if not corrected.	Improve grass cover; reshape embankment to improve drainage pattern.
☐	☐	Is there erosion from traffic (people, animals, vehicles)?		Any erosion is serious, as it will get worse with time if not corrected.	Try to keep all type of traffic to a reasonable level. Keep vehicles off dam. Stabilize crest roads to prevent rutting. Prohibit recreational vehicle traffic on slopes Keep livestock off dam. Fill in existing ruts or eroded areas and reseed.
☐	☐	Are there any animal burrows?		May provide passageways for water into or through the dam.	Fill burrows with earth or otherwise block entry. Try to keep woodchucks, muskrat and beaver away from the dam.
☐	☐	Are there depressed areas on the dam?		May have resulted from slope failures or settlement, or even piping.	If pronounced or progressive should be evaluated by a professional engineer

THE EMBANKMENT (Continued)

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Is there any evidence of piping? (This condition is evidenced by a muddy flow through the dam and/or the formation of soil deposits beyond the dam and depressions on its slopes.)		Piping is internal erosion within an embankment, or the progressive removal of soil particles adjacent to leaks through a soil mass.	Piping is always a serious condition, which can lead to failure of the dam. A piping condition should be evaluated by a professional engineer.
☐	☐	Does the crest appear to have shifted or settled excessively? (Look for cracks in the embankment and associated structures. Compare alignment with plans if they are available.)		Crest movement may indicate a stability problem. However, some settlement of a new fill, such as an embankment dam, is normal.	Should be evaluated by a professional engineer.
☐	☐	If the upstream face is protected by riprap is in good condition? (Riprap is a layer, facing, or protective mound of stone in random size pieces, randomly placed to prevent erosion, scour, or sloughing of an embankment or structure.)		Effective is lessened if riprap has slipped out of place, has been undermined, or has become overgrown with brush.	Restore riprap as necessary; keep free of trees and bushes.
☐	☐	If there is riprap in discharge channels or in the plunge pool downstream, is it in good condition?		Has riprap stone been displaced or overgrown?	Restore riprap as necessary; keep free of trees and bushes.
☐	☐	If drainage channels at ends of embankment are protected with riprap, is it in good condition?		Drainage along abutments often causes gullying if there is no protection.	Riprap or other forms of slope protection should be restored as necessary.
☐	☐	If there is riprap in miscellaneous areas (on downstream slope, on crest, etc.) is it in good repair?			Restore as necessary.
☐	☐	If there are any drains to collect and remove seepage, are they operating properly?		Check plans for the presence of drains, or search the dam to see if any are present.	Keep drains clear of any blockages and operating properly.
☐	☐	If there are foundation drain outlets, are they clear and flowing?		Foundation drains serve to collect seepage passing through the dam and conduct it away from the embankment.	Open outlets to such drains if they have become covered or damaged.

THE EMBANKMENT (Continued)

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Are there wet spots or areas on the downstream face, at the toe, or beyond the dam? (Such spots are often indicated by a change in color or type of vegetation, such as from grass or cattails.)		Some seepage is normal for an earth dam. Be concerned if it appears to be excessive (a lot of standing water; very soft and marshy areas; evidence of a seepage line high on the downstream face.)	Observe seepage areas periodically to detect changes in the amount of moisture, new flows, or muddy flows. If the upper limit of seepage is fairly high on the downstream face, the dam may be unstable.
☐	☐	Are there seeps or springs with flowing water? Look closely for these at the ends of the dam, around any pipes passing through the embankment, on downstream face, at the toe of the dam and beyond, and at the base of trees on, near, or below the dam.		Flowing seeps or springs may indicate problems, and should be observed periodically for changes in rate of flow or muddy flow. Creation of an impoundment often causes changes in the water table nearby.	Monitor seepage closely for any changes in amount, rate, extent, or clarity. Excessive or turbid seepage, or marked increases in rate of seepage, should be evaluated by a professional engineer.
☐	☐	Is there swamp or marsh type vegetation on downstream face or beyond the dam (cattails, tall grass, etc.)?		Swamp type vegetation indicates the presence of seepage.	Cut frequently to make observation of the area easier. Such growth can hide problems.
☐	☐	Is the dam overgrown with trees and/or underbrush?		One of the most frequent problems, and highly undesirable. Roots may damage the embankment and allow water to pass into or through it. Trees may be uprooted in a storm and breach the dam.	Keep embankment faces free of trees and underbrush by periodic mowing. Remove existing trees and saplings, and establish and maintain a good grass cover on the dam.
☐	☐	Has the dam ever been overtopped by water flowing over it?		Past overtopping may have resulted in erosion of the crest and downstream face of the dam. Overtopping indicates that the emergency spillway is probably too small.	Restore eroded areas or other damage dome to the dam by overtopping. Consider enlarging the emergency spillway, lowering the normal pool level to allow more storage capacity during floods, or perhaps raising the height of the embankment to decrease the possibility of future overtopping.

THE EMBANKMENT (Continued)

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Has there been any modifications of the embankment, such as raising the crest, changing the shape or size of the principal spillway or the emergency spillway, or changing the shape of size of the embankment?		Inappropriate or unsuitable modifications can drastically affect the safety of a dam, even one that may have originally been properly designed and constructed.	Dams that have been appreciably modified since construction should be evaluated for stability by a professional engineer.

THE PRINCIPAL SPILLWAY

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Can water flow into the principal spillway without difficulty, as intended when constructed.		The riser, intake structure, or channel should be free of trash or other blockage.	Install a trash rack if one is not already in place. Periodically clear trash racks of any accumulated debris.
☐	☐	Is outlet pipe or discharge channel clear and open to allow the free passage of the principal spillway discharge?		Flows passing through the spillway should not erode or otherwise damage the dam.	Keep outlet pipe, plunge pool, and all other outlet works clear and in good repair.
☐	☐	Is the primary spillway structure in good condition (check concrete, wood, and metal portions for damage or deterioration)?		Such dam features as the principal spillway require continued maintenance like any other structure.	Repair and maintain as appropriate to insure the continued useful life of the dam.
☐	☐	Does the lake have a drain that can be used to lower it in an emergency?		Lowering a lake may be necessary if the dam begins to develop problems.	Check plans or search dam for emergency drain system.
☐	☐	If there is an emergency drain, is it known to be in working condition? Note: If a drain has not been used for a long time, it may be possible to open it but not close it.		Drain valves and other mechanisms should receive sufficient maintenance to insure that they remain in working order.	Maintain system so that it can be used in an emergency. Normally, the pool behind an embankment dam should not be lowered at a rate of more than 6 inches a day.
☐	☐	If there are other gates, valves, or operating equipment, are these in working condition?		Such devices are vital to the effective and safe operation of the dam.	Repair and restore if necessary, and maintain in an operable condition.

THE EMERGENCY SPILLWAY

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Can water flow into the emergency spillway without difficulty, as intended when constructed?		To be effective, all portions of the spillway channel should be clear and unobstructed.	The approach channel should be kept free of trash, underbrush, or other blockage.
☐	☐	Is the discharge channel clear and open to allow the free passage of the emergency spillway discharge?		Spillway flows must be effectively conducted away from the dam.	Clear as necessary.
☐	☐	Is the emergency spillway constructed in such a way that its flows will not erode other portions of the dam.		A berm is often constructed to keep spillway flows from flowing down the embankment.	Reshape dam if necessary to take care of this problem.
☐	☐	Is the emergency spillway in good condition overall (check for erosion within the channel adequacy of grass cover, etc.)?		Spillway erosion is a common problem.	Restore any erosion gullies or eroded areas. Provide channel protection (riprap, concrete, etc.) if necessary to eliminate recurring erosion problems.

THE RESERVOIR AREA

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Does the nature of the land surrounding the lake or its use present any problems.		Intensive agricultural or development activities in the watershed may precipitate problems associated with surface runoff or other difficulties.	Problems of this nature are often complex and may be beyond the owner's direct control.
☐	☐	Is there any evidence of landslides or instability on the slopes around the reservoir.		A large landslide into a lake can subject a dam to overtopoping or other damage.	Suspected or evident problems of this type should be investigated by a professional engineer or engineering geologist.
☐	☐	Is serious wave erosion occuring along the shoreline?		Some minor erosion along a shoreline is to be expected.	Critical shoreline areas can be protected with vegetation or in some other manner.
☐	☐	Is a lot of sediment entering the impoundment, or has this happened in the past?		This may occur as a result of construction or agricultural activity in the watershed.	Dredging may be required to restore the lake.

DOWNSTREAM CHANNEL

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Is the downstream channel free of obstructions, so that water in a flood will not back up against the toe of the dam?		The channel below a dam is often a neglected area.	Clear downstream channel if necessary.

WATERSHED AREA

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Have there been any major modifications or significant changes in the watershed drainage areas, such as new urban developments (shopping centers, housing projects), clear cutting of woodlands, or other basic changes in land use.		Intensive agricultural or development activities in the watershed may precipitate problems associated with greater surface runoff of other difficulties.	Problems of this nature are often complex and may be beyond the owner's direct control. Appeals to existing regulations dealing with erosion prevention, pollution control, etc. may be helpful.

THE DOWNSTREAM AREA

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	If the dam should fail, would loss of life or extensive property damage be likely?		Consider the number of occupied homes or businesses downstream, their distance from the dam, and their distance from the elevation above the streambed. Consider also potential losses in property and disruption of facilities, i.e., roads, railroads, or utilities.	Personally inspecting the area that would be affected will be useful in determining who needs to be alerted in an emergency. Topographic maps prepared by the U.S. Geological Survey are also useful for this purpose.
☐	☐	Do you have on file the current telephone numbers of any persons living or working in areas downstream from the dam, as well as the telephone numbers of those responsible for facilities that would be affected, such as highways or public utilities.		Prior planning for an emergency is invaluable in terms of mitigating losses. When a dam failure is imminent, it is to lake to begin wondering who is located downstream and how they can be reached.	Any list of phone numbers or other information to be used in an emergency should be checked for accuracy and updated periodically to insure that the information remains current.

THE DOWNSTREAM AREA (Continued)

Yes	No		Comments	Remarks	Maintenance Tip
☐	☐	Do you have on file the current telephone numbers of local authorities who should be informed if the dam is endangered, such as the sheriff, county administrator, or emergency services coordinator?		In an emergency certain functions, such as compelling the evacuation of an area, can be performed only by those with the legal authority to do so.	The Division of Water Resources, State Police and the local Emergency Services Coordinator can offer guidance for preparing an emergency warning plan, if needed. Such a plan should be filed with local authorities.

CHAPTER VI

MAINTENANCE PRIORITIES

Maintenance is an ongoing process which should never be neglected during the life of a dam. If a dam has not received much attention for a long time, there are often a number of areas that require attention. Some of these are more pressing concerns than others. The following outline indicates the relative priority that should be given to certain problems or conditions.

What Needs To Be Done At Once:

The following conditions require immediate attention:

1. Dam is being overtopped or nearly overtopped.

2. Dam is about to be breached (by progressive erosion, slope failures, fallen trees whose root masses have left gaps in the embankment, or by other circumstances.

3. Dam evidences a piping or internal erosion condition.

4. Spillways are blocked or otherwise inoperable.

5. There is evidence of excessive seepage, the embankment appears to be saturated, or the upper edge of the seepage is high up on the downstream face of the dam.

Although the remedy to some critical problems may be obvious (as in clearing a blocked spillway, for instance), the problems listed above generally require the services of a professional engineer familiar with the construction and maintenance of dams to determine the best means of achieving a solution.

What Needs To Be Done Within The Next Year:

1. Removal of all underbrush and trees and establishment of a good grass cover.

2. Restoration and reseeding of eroded areas and gullies as soon as possible.

3. General repairs to spillways, gates, valves, and other features of the dam other than the embankment itself.

4. Establishment of an emergency action and warning plan, in conjunction with the Division of State Police and the Division of Water Resources.

What Needs To Be Done On A Continuing Basis:

1. Routine mowing and general maintenance

2. Periodic observation of all springs and areas of seepage.

3. Periodic inspection of dam (at least annually).

4. Monitoring development which may take place in the downstream area and updating the emergency warning plan to include new homes or other occupied structures within it.

Plate No. 6, "The Sound Dam", illustrates some of the features of a typical well maintained small earth dam. Like other examples in this pamphlet, "The Sound Dam" sketch is not intended to show every feature that may be required on a particular dam, but it should serve to illustrate some of the primary considerations, such as an adequate emergency spillway and the absence of underbrush on the embankment.

CHAPTER VII

DAM HISTORY AND RECORD OF INSPECTIONS

It is a good idea to keep a record of a dam's history, and the following table may be used. Your record of inspections will serve to keep this history current. Also, it is desirable to record a few basic dimensions of the dam.

BASIC DIMENSIONS

Height (measured from downstream toe to top of dam): _____

Elevation of normal pool level (relative to top of dam): _____

Elevation of emergency spillway (Relative to top of dam): _____

Width of crest of dam: _____

Distance across emergency spillway: _____

Upstream slope (for instance, 3 horizontal to 1 vertical, or 3:1): _____

Downstream slope: _____

	DAM HISTORY	DATE
Designed by:		
Constructed by:		
Date of completion:		
Has the dam ever failed, either partially or totally?		
Has the dam ever been rebuilt or modified?		
Has the dam been overtopped by flooding?		
What is the maximum water level observed?		
Other information relevant to dam's history:		

RECORD OF INSPECTIONS

Date	Summary of Findings	Recommendations	Evaluated By	Summary of Actio

CHAPTER VIII

WHERE CAN YOU GET ADDITIONAL HELP?

The Division of Water Resources can offer general guidance on many aspects of dam safety. If also can The Division of Water Resources can offer general guidance onsuggest other agencies that may be able to assist with specific problems, such as the preparation of an emergency warning plan. The Division cannot provide consulting engineering services. The Division's regulatory program with regard to dams is outlined in its Regulations "Dam Safety Standards". Copies are available upon request.

You may wish to do some additional reading on dams and their maintenance, and, of course, more detailed treatment than can be included in this brief pamphlet are available. Many books discuss these matters, and a few basic references are listed in the bibliography at the end of this pamphlet. Of these, **Dams and Public Safety** and **Design of Small Dams** are relatively inexpensive publications by the Bureau of Reclamation, which may be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402. **Dams and Public Safety** presents many case studies of dam failures and has particularly informative chapters on "Kinds of Problems" and "Preventive Remedial Engineering". **Design of Small Dams** contains a wealth of information on the subject, and although technical considerations of dam design are covered in depth, the clarity of the text and the abundance of illustrations give it more than average appeal to general readers.

Standard textbooks and references of water resources, which may be found in engineering school libraries, sometimes contain general discussions of spillways, embankment construction materials, and other subjects which may be of interest to the dam owner. An example of these is **Water Resources Engineering** by Linsley and Franzini. Professor Ernest Wahlstrom's **Dams, Dam Foundations, and Reservoirs** is primarily concerned with the geological aspects of dam location, construction, and maintenance.

The basic types of inspections performed under the four-year National Program for Inspection of Non-Federal Dams are discussed in the U.S. Army Corps of Engineers' publication, "Recommended Guidelines for Safety Inspection of Dams", available at no charge from the Office of the Chief of Engineers, Washington, D.C. 20314.

CHAPTER IX

CONCLUSION

As stated in the Introduction the purpose of this pamphlet is to assist you in inspecting your dam and to make suggestions for a continuing maintenance program to keep it in a safe and stable condition. It is not intended to be a complete checklist for every type of dam, but it should suggest areas with which the dam owner should be concerned.

No dam can ever be declared completely and perpetually safe, as a large volume of water in storage always represents a potential hazard. However, a reasonable amount of care and attention to an impounding structure (assuming that its original design and construction was adequate) can generally make the possibility of a failure fairly remote.

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STATE OF NEW JERSEY

DAM SAFETY MANUAL

PART II

DAM SAFETY STANDARDS

CHAPTER 20
DAM SAFETY STANDARDS

SUBCHAPTER 1. APPLICATION PROCEDURE; DESIGN CRITERIA FOR DAM CONSTRUCTION; DAM INSPECTION PROCEDURE

N.J.A.C. 7:20-1.1 Scope and applicability

The rules in this subchapter were adopted pursuant to the authority of N.J.S.A. 58:4-1 et seq., as amended by the Safe Dam Act of 1981.

1. These rules set forth procedures for application to construct, repair or modify a dam, as defined in N.J.A.C. 7:20-1.2 and set standards for design and maintenance of dams. These rules also establish a dam inspection procedure.

2. Any dam which raises the waters of a stream five feet or less above its usual, mean, low water height falls under the jurisdiction of the Flood Hazard Area Control Act, N.J.S.A. 58:16A-50 et seq.

3. The requirements in this subchapter shall not affect or relate to a dam or reservoir in the pinelands area, as designated by subsection a. of section 10 of P.L. 1979, c.111 (C. 13:18A-11), which will raise the waters of any river or stream less than eight feet above the surface of the ground where the drainage area above the same is less than one square mile in extent and where the water surface created by the dam or reservoir is less than 100 acres in extent except that the commissioner may investigate and take appropriate action regarding any dam or reservoir about which he has a security or safety concern. With respect to dams and reservoirs located on lands utilized for agricultural or horticultural purposes within the pinelands area, the commissioner's actions shall be undertaken after consultation with the Secretary of Agriculture. See N.J.S.A. 58:4-1, P.L. 1985, c.33, §1 and 2.

N.J.A.C. 7:20-1.2 Definitions

"Applicant" means any person making application for a dam permit.

"Dam" means any artificial dike, levee or other barrier, together with appurtenant works, which is constructed for the purpose of impounding water on a permanent or temporary basis, that raises the water level five feet or more above the usual, mean, low water height when measured from the downstream toe-of-dam to the emergency spillway crest or, in the absence of an emergency spillway, the top-of-dam.

"Department" means the New Jersey Department of Environmental Protection.

"Design freeboard" means the minimum freeboard which would exist during passage of the design flood.

"Division" means the Division of Water Resources in the Department of Environmental Protection.

"Environmental impact statement" means a report which describes the real and potential impacts which will or may result from the construction and operation of a proposed dam project, the adverse environmental impacts which cannot be avoided, the steps to be taken to minimize adverse impacts and the alternatives to the project with reasons for the acceptability or unacceptability; and

1. The report shall address real or potential impacts upon ecology, natural resources, historical and archeological resource, recreational resources, aesthetic resources, endangered and non-game species, fisheries and any other identifiable impacts;

2. The report shall include a listing of qualifications of those preparing the report and a reference list of pertinent published information relating to the project, the project site and the surrounding region.

"Formal inspection" means the inspection by a New Jersey licensed professional engineer to reevaluate the safety and integrity of the dam and appurtenant structures to determine if the structure meets current design criteria, including a field inspection and a review of the records on project design, construction and performance.

"Freeboard" means the vertical dimension between the crest of the embankment of a dam (without camber) and the reservoir water surface at the spillway design flood stage.

"Height-of-dam" means the vertical dimension from the lowest point in the original stream bed or natural ground surface at the downstream toe of the dam to the elevation of the top of dam (without camber).

"Informal inspection" means the visual inspection of the dam by the dam owner or operator to detect apparent signs of deterioration or other deficiencies of the dam structure or function.

"Levee" or "dike" means any artificial barrier together with appurtenant works that will divert or restrain the flow of a stream or river.

"One-hundred-year storm" means the storm which is estimated to have a one percent chance, or one chance in 100, of being equalled or exceeded in any one year.

"Outlet" means an opening through which water can be freely discharged from a reservoir for a particular purpose.

"Owner and/or operator" means any person who owns, controls, operates, maintains, manages or proposes to construct a dam.

"Permit or "dam permit" means all approvals required under N.J.S.A. 58:4-1 et seq. for the construction and operation of a dam.

"Person" means any individual, proprietorship, partnership, association, corporation, municipality, county or public agency.

"Pipe conduit" means any hollow tube which conveys water through a dam from a reservoir, either as a spillway or as a drain.

"Probable maximum precipitation" or "(PMP)" means the theoretically greatest depth of precipitation for a given duration that is physically possible, over a given size storm area, at a particular geographic location, at a certain time of year.

"Regular inspection" means the visual inspection of a dam by a New Jersey licensed professional engineer to detect any signs of deterioration in material, developing weaknesses or unsafe hydraulic or structural behavior.

"Reservoir" means any impoundment or any potential impoundment that will be created by a dam, dike or levee.

"Spillway" means a structure other than low flow outlets, over or through which flood flows are discharged.

"Spillway design storm" means the storm upon which the hydraulic capacity of the spillway structure is designed.

N.J.A.C. 7:20-1.3 Permit-by-rule

(a) All dams must be designed, constructed, operated and maintained in compliance with the rules in this subchapter except as set forth below:

1. Owners and operators of Class IV dams (see N.J.A.C. 7:20-1.8, Dam classification) are not required to file documents with nor obtain a permit from the Department, but must meet the following requirements, in addition to those set forth elsewhere in this subchapter:

i. Design must be based upon a spillway design storm that results in rainfall of 50 percent greater than a 24-hour, 100-year, Type II storm (Later technology adopted by the United States Department of Agriculture, Soil Conservation Service may be substituted for the use of the Type II storm.) and

ii. All necessary local approvals must be obtained.

2. Owners and operators of Class III agricultural impoundments, meaning any impoundment used for fish and wildlife, fire control or livestock or crop production and maintenance, where the drainage area is less than one-half square mile in extent, must meet only the following requirements:

i. All necessary local approvals must be obtained;

ii. Design and construction must be supervised by the United States Department of Agriculture, Soil Conservation Service.

3. Applicants for hazard classification in Class III, pursuant to N.J.A.C. 7:20-1.8, may initially submit a preliminary application, including only that information needed to establish Class III hazard classification. Thereafter, some of the documentation and inspection requirements set forth in these rules may be waived by the Department.

(b) The Department may, in its discretion, require the owner or operator of any dam subject to (a) above to obtain a permit and/or to submit any information relating to dam design, construction, operation or maintenance.

(c) The Department may, in its discretion, require the owner or operator of any dam to make modification of the design, construction or operation of the dam in order to comply with the intent of this chapter and the Safe Dam Act, N.J.S.A. 58:4-1 et seq.

7:20-1.4 General requirements and prohibitions

(a) No person may construct or operate a new dam or modify or repair an existing dam without first having obtained a permit from the Department, unless subject to the permit-by-rule provision in N.J.A.C. 7:20-1.3. Where emergency circumstances justify, repairs of a dam may be undertaken prior to obtaining a permit, in accordance with (i) below.

(b) No dam may be approved by the Department where, in the opinion of the Department, there is an unacceptable potential for harm to human health or to human safety.

(c) Backwater created by a dam during a 100-year storm shall be the minimum which is contained within the applicant's property unless written consent is obtained from all potentially affected property owners. Effects on both surface and ground water shall be considered, during normal pool conditions.

(d) No person may construct a dam in any waterway of this state which is a runway for migratory fish, without installing a fish ladder or other approved structure to permit the fish to pass the dam in either direction (see N.J.S.A. 23:5-29.1).

1. This provision is applicable to dams of any size.

2. The Department will determine whether a stream is currently a runway for migratory fish, during the review of the dam permit application. Applicants should consult the Division of Fish, Game and Wildlife in this matter prior to finalizing the application.

(e) Unless otherwise approved by the Department, dam construction shall commence within one year from the date of the permit and be completed within two years from the said date or the permit will become null and void. For good cause shown, the Department may extend the two year construction deadline for a total of no more than five years, one year at a time. Applicants must make written request for an extension, prior to the expiration date of the permit or prior extension.

(f) No action shall be brought against the State or the Department or its agents or employees for the recovery of damages caused by the partial or total failure of any dam or reservoir or through the operation of any dam or reservoir upon the ground that the Department is liable by virtue of any of the following:

1. The approval of the dam or reservoir, or approval of flood handling plans during construction.

2. The issuance or enforcement of orders relative to maintenance or operation of the dam or reservoir.

3. Control, regulation and inspection of the dam or reservoir.

4. Measures taken to protect against failure during an emergency.

(g) The Department may deny any application for a dam permit, based upon its conclusion that the construction or operation of dam will cause an unacceptable threat to or impact on natural or cultural resources or the environment.

(h) Retention and detention basins for storm water management must be constructed in accordance with criteria of the State Storm Water Management Regulations, N.J.A.C. 7:8.

(i) Situations which threaten the public health, safety and welfare and require emergency dam repair will be considered by the Department under the following procedure:

1. Inform the Department by telephone as to the extent of work to be performed, the reason for the emergency and the location of the project.

2. Perform the emergency work upon verbal approval of the Department, which approval shall be verified by the Department in writing within three working days. The Department shall offer guidance and instructions in performing the work.

3. After the work has been completed in accordance with the Department's instructions, a dam permit application and "as built" drawings shall be submitted to the Department for review. A letter shall then be issued by the Department in lieu of a dam permit.

N.J.A.C. 7:20-1.5 General application procedures

(a) The procedures for applying for a dam construction, modification or repair permit and for submitting the supporting engineering documents include the preapplication stage and the application stage, as described below. For Class III dams (see N.J.A.C 7:20-1.8) all required information may be submitted at one time, with such detail as is appropriate to the safe design of the type of structure proposed.

(b) The applicant for a dam permit must use a New Jersey licensed professional engineer to prepare the plans and specifications and to supervise the inspection of the construction.

(c) The Department may require any owner or operator of an existing dam to obtain a permit for repair or modification of the dam and appurtances where:

1. Repair or modification is necessary to insure protection of human health or safety; or

2. Modification is required to comply with the provisions of this chapter, unless the following circumstances exist:

i. Compliance is impracticable; and

ii. Noncompliance poses no unacceptable threat to human health or safety.

(d) Appeal procedures; permit denials

1. An applicant for a dam permit may request in writing an administrative hearing from the Department within 15 days of receipt of the decision by the Department to deny the application.

2. The request for a hearing shall specify in detail the basis for the request, including all issues of fact or law. The Department may attempt to settle the dispute by conducting such proceedings, meetings and conferences as deemed appropriate. Should the efforts to settle the dispute fail and if the Department determines that the matter is a contested case, the Department shall forward the request for a hearing to the Office of Administrative Law, pursuant to the provisions of the Administrative Procedure Act (N.J.S.A. 52:14B-1 et seq.).

N.J.A.C. 7:20-1.6 Preapplication stage

(a) The applicant must submit a written Preliminary Report which must include the following:

1. A general description of the dam and all appurtenances thereto, and the proposed dam classification, pursuant to N.J.A.C. 7:20-1.8. The description shall include the following:

i. A statement of the purpose for which the dam and appurtenances are to be used; and

ii. A description of the potential effects of project construction and operation upon the environment.

2. Maps of the area within one-half mile of the dam and impoundment boundary, showing the following:

i. The location of the proposed dam and all appurtenances, thereto;

ii. The location of all structures;

iii. The county and township;

iv. The boundary of the reservoir;

v. The location of all streets and roads;

vi. The location of all major utilities, i.e. pipe lines and transmission, telegraph, and telephone lines; all minor utilities shall be identified in the immediate vicinity of the dam and impoundment area.

vii. The topography and scale; and

viii. All other structures or facilities affected by the proposed dam, including the area downstream from the dam (State, county, and U.S.G.S. maps and aerial photographs may be used for this purpose).

3. A written report of the surficial conditions (i.e. geology, topography, and culture), based upon a field reconnaissance by the applicant's engineer;

4. Typical cross-sections of the dam, and any dike(s) and levee(s), showing proposed elevations, pool levels and top and bottom widths;

5. Preliminary design data, tentative conclusions and references. The design data shall address hydrologic features such as drainage area and rainfall data, the basis for proposed dam location, the basis for the type of structure and spillway proposed, the soils and geologic engineering criteria and the basis for design and construction;

6. The hydrologic design procedure and the storm durations which are used in the design;

7. All documentation and information related to determining hazard classification; and

8. Other information required by the Department.

(b) Upon review of the pre-application, the Department will notify the applicant of what design criteria will apply.

N.J.A.C. 7:20-1.7 Application stage

(a) The application shall be on forms specified and supplied by the Department and must be accompanied by two copies of the final design report and construction specifications and five sets of all plans, drawings, designs and specifications.

(b) The application shall include a Final Design Report, which must contain the following:

1. A report of the field and laboratory investigation(s) of the foundation soils and/or bedrock, a location map to identify borings and the materials that will comprise the dam and any dikes or levees. Stability and settlement analyses and seepage and underseepage studies are required, unless the applicant can demonstrate to the satisfaction of the Department that these analyses are not necessary.

2. The bases, references, calculations and conclusions relative to hydrologic studies and design of spillway.

3. Structural and hydraulic design studies and calculations. Structural, hydraulic and hydrologic design procedures should be used, as established by one of the following: the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the U.S. Soil Conservation Service and other procedures universally accepted as sound engineering practice.

(c) The application must include all drawings necessary to fully describe the proposal. Drawings must be prepared in accordance with the following:

1. All drawings must be prepared by a New Jersey licensed progessional engineer or land surveyor, as appropriate. Each drawing shall have a title block which meets the requirements of the State Board of Professional Engineers and Land Surveyors.

2. Drawings must clearly show the datum to which elevations shown are referred. The National Geodetic Vertical Datum of 1929 (N.G.V.D.), formerly known as the U.S. Coast & Geodetic Survey datum, should be used wherever possible. If the N.G.V.D. datum is not used, an appropriate conversion equation must be indicated on the drawings.

3. The applicant must submit drawings showing the following information:

i. A general plan of the dam, drawn to an appropriate scale, which must show accurately the position of all essential details, such as the spillway and its point of discharge into the stream, pipes through the dam, inlets, outlets, screen chambers, gate or valve houses, head-races,

the canal mill or power plant, tailraces and downstream bridges which might cause backwater on the dam;

ii. A longitudinal section of the dam and cross-section of the valley at the site of the dam, showing the elevation of the crest of the dam, the elevation of the normal and design storm flow line of the lake or reservoir, the original surface of the ground, the nature and depth of the underlying strata, the probable depth of the excavation for the foundation of the dam and for the cutoff, foundation treatment, elevation of the restored surface of the ground, the location and elevation of all pipes or conduits passing through the dam, the core wall, if any, and the spillway structure;

iii. Typical cross sections, including a maximum section of the dam and of a spillway section which shall meet the following requirements:

(1) Cross sections must show the original surface of the ground, subsurface conditions as disclosed by test pits or borings, the probable depth of excavations for the foundation and for cutoff, the elevations of the top of the dam, the crest of the spillway and the normal flow line or water surface in the reservoir;

(2) For earth dams, the depth of stripping must be shown, as well as the position, material and dimensions of the cutoff or core wall, the width of the crest, the slopes and the nature and dimensions of the slope protection, the position and dimensions of the outlet pipes or conduits and the cutoff to prevent seepage along such structures, the disposition of different classes of embankment material if of varying composition, toe drains and clay blankets;

(3) For concrete or other composite dams, the cross sections shall show all dimensions and shall indicate the position and kinds of material to be included in the structure.

iv. If not clearly indicated on one or more of the drawings listed above, the following details shall be shown on additional detail sheets:

(1) Detail of spillway or overflow, showing the length and depth of opening, together with the width and shape of the crest, grade and shape of the approach and discharge channels, if any, methods of protecting the toe of the dam or end of the discharge channel from erosion and the dimensions of all walls, floors and paving;

(2) Details of the intake and outlet works, showing the location and dimensions of all valves or sluice gates, intakes, screen chambers, racks, outlet towers and gate houses and appurtenances;

(3) For reinforced concrete dams, detailed drawings must also be submitted, showing the size, spacing and arrangement of all reinforcing steel and expansion joints; and

(4) Special drawings shall be submitted showing any special construction features not otherwise shown, such as piling, fishways, aprons, materials used in the core wall, movable dams, tainter gates and mechanical devices, drains and instrumentation.

(d) The application must include specifications, containing the following:

1. General provisions, specifying the rights, duties and responsibilities of the owner, applicant, applicant's engineer and the builder;

2. The estimated project schedule and sequence of work; and

3. Technical provisions, describing carefully and in detail the approved work methods and procedures, standards for equipment and testing, materials to be used and the results to be obtained.

(e) The applicant shall complete all investigations, including the following, prior to submission of the final design report which shall meet the following requirements:

1. The scope and the degree of precision of investigations required for a specific project shall be based on the complexities of the site, the importance of the proposed structure and the hazard created by the proposed structure.

2. The foundation investigation shall consist of borings, test pits, seismic investigations or other subsurface explorations and must be performed so as to accurately define the soil and rock stratigraphy and the ground water conditions to the satisfaction of the Department.

3. Laboratory testing of undisturbed and remolded soil specimens and rock samples may be required by the Department.

4. The applicant must determine the nature and extent of materials which are proposed for use in the structure,(e.g., borrow material, concrete aggregate, riprap stone, filter materials) and their structural properties when incorporated into the proposed structure.

5. Stability analysis and calculations for the proposed structure to ensure safety against failure due to overturning, sliding or overstressing must be submitted and approved by the Department.

6. Topographic surveys must be performed with sufficient accuracy to locate the proposed construction and to define the volume of the storage in the reservoir and the flowage limits. The upstream and downstream area must be investigated in order to delineate the area of potential damage in case of failure or flooding. Locations of baselines, centerlines and other horizontal and vertical control points must be shown on the topographic map of the site.

7. The drainage area must be accurately determined. Both present and projected future land use must be considered in determining the runoff characteristics of the drainage area. The most severe of these two conditions must be used in the design. The hydrologic assumptions and design calculations used in spillway designs shall be specified and shall include:

i. Drainage area size;

ii. Rainfall and runoff data;

iii. Reservoir inflow hydrographs;

iv. Reservoir area-capacity-elevation data;

v. Spillway elevation-discharge data; and

vi. Reservoir flood routings, except as otherwise provided in this subchapter.

(f) All applicants for Class I and II dams (see N.J.A.C. 7:20-1.8) shall prepare and submit an Emergency Action Plan which shall at least include a Dam Breach Analysis, Inundation Maps and Emergency Notification and Evacuation Plans.

(g) The Department may require the submission of an Environmental Impact Statement, as defined in N.J.A.C. 7:26-1.2, by any applicant for a dam permit.

7:20-1.8 Dam classification

(a) The Department will use the following guidelines to classify dams according to hazard. Probable future development of the area downstream from the dam which might be affected by its failure will be considered in determining the hazard classification. The Department may, in its discretion, raise the hazard class of any proposed or existing dam.

1. Class I - High Hazard Potential: This classification includes those dams, the failure of which may cause the probable loss of life or extensive property damage.

i. The existence of normally occupied homes in the area that are susceptible to significant damage in the event of a dam failure will be assumed to mean "probable loss of life".

ii. Extensive property damage means the destructive loss of industrial or commercial facilities, essential public utilities, main highways, railroads or bridges. A dam may be classified as having a high hazard potential based solely on high projected economic loss.

iii. Recreational facilities below a dam, such as a campground or recreation area, may be sufficient reason to classify a dam as having a high hazard potential.

2. Class II - Significant Hazard Potential: This classification includes those dams, the failure of which may cause significant damage to property and project operation, but loss of human life is not envisioned. This classification applies to predominantly rural, agricultural areas, where dam failure may damage isolated homes, major highways or railroads or cause interruption of service of relatively important public utilities.

3. Class III - Low Hazard Potential: This classification includes those dams, the failure of which would cause loss of the dam itself but little or no additional damage to other property. This classification applies to rural or agricultural areas where failure may damage farm buildings other than residences, agricultural lands or non-major roads.

4. Class IV - Small Dams: This classification includes any project which impounds less than 15 acre/feet of water to the top of dam, has less than 10 feet height-of-dam and which has a drainage area above the dam of 150 acres or less in extent. No dam may be included in Class IV if it meets the criteria for Class I or II, but any applicant may request consideration as a Class III dam upon submission of a positive report and demonstration proving low hazard.

7:20-1.9 Design criteria

(a) The minimum design storm used to calculate required spillway capacity must be determined according to the following table:

Hazard	Spillway Design Storm (SDS)
Class I	PMP
Class II	One-half PMP
Class III	24 hour 100 year frequency, Type II storm*
Class IV	24 hour 100 year frequency, Type II storm plus 50%*

*Any later technology adopted by the U.S. Department of Agriculture, Soil Conservation Service may be substituted for the use of the Type II storm.

(b) All Class II and III dams shall, where practicable incorporate in the proposed design, the ability to make modifications necessary to increase the spillway capacity of the facility or other alternative measures if the downstream hazard potential increases.

(c) All dams shall have adequate storage for the design storm or have a spillway system which will safely pass the design storm without endangering the safety of the dam.

(d) Each spillway shall include a satisfactory means of dissipating the energy of flow at its outlet without endangering the safety of the dam.

(e) The capacity of the spillway system shall be equal to the peak inflow of the design flood unless the applicant demonstrates by flood routing procedures that the spillway system has the capacity to safely pass the resulting water flow.

(f) Pipe conduits may be used for the primary (principal) spillway. When so used, the following requirements shall be met:

1. All pipe conduits must convey water at the maximum design velocity without damage to the interior surface;

2. The pipe conduits must be designed so that negative pressures will not occur at any point along the primary (principal) spillway system;

3. Anti-seep collars or other methods approved by the Department must be installed to control seepage along the conduit;

4. Adequate allowances shall be incorporated in the design to compensate for differential settlement and possible elongation of the pipe conduit;

5. An anti-vortex device must be included in the design, unless the applicant can demonstrate that one is not necessary;

6. A trash rack, approved by the Department, shall be installed at the intake to prevent clogging of the pipe conduit; and

7. Should a vegetated or unlined secondary (emergency) spillway approved by the Department be installed, it must be able to pass the design storm without jeopardizing the safety of the structure and that has a predicted average frequency of use less than:

i. Once in 100 years for Class I dams;

ii. Once in 50 years for Class II dams; or

iii. Once in 25 years for Class III and IV dams.

(g) Pipe conduit and spillway requirements are as follows:

1. When used for Class I and Class II dams, pipe conduits shall be of such design as to safely support the total external loads in addition to the total internal hydraulic pressure without leakage. The minimum

allowable inside dimension of the pipe conduit is 30 inches. The type of construction material used must be consistent with the anticipated life of the structure. Corrugated metal pipe shall not be used in new construction relating to Class I or II dams.

2. When used for Class III and IV dams, pipe conduits shall be of such design as to safely support the total external loads. They must be designed to be water tight and meet the following requirements:

i. The minimum allowable inside diameter of the pipe is 18 inches for Class III dams and 12 inches for Class IV dams;

ii. If corrugated metal pipe is used, it must be close-riveted or welded, have watertight connecting bands and be of a minimum gage specified by the manufacturer as safe for a height of fill over the pipe of not less than 35 feet;

iii. If corrugated metal pipe is used, the maximum fill height over the pipe may not exceed 15 feet; and

iv. Cathodic protection for all metal pipes shall be provided.

(h) Drawdown requirements are as follows:

1. Except for excavated impoundments, all dams shall include a device to permit draining the reservoir, as approved by the Department.

2. Valves or sluice gates in pipe conduit drains must be installed upstream of the dam.

3. All pipe conduits used as drawdown drains for all dam classifications shall meet the requirements of (f) and (g) above, except that the minimum allowable inside dimension may be less than 30 inches.

(i) Design references used shall be cited in the information submitted to the Department.

(j) Monitoring devices to permit inspection and assessment of the dam's condition may be required by the Department for use in the inspections during and after completion of construction.

(k) The applicant shall demonstrate to the Department that the riparian rights of downstream property owners will be protected during construction, during the period when the reservoir is being filled and during the life of the dam and reservoir.

(l) Unless the applicant can demonstrate that an alternative slope is acceptable, upstream slopes of an earth dam may be no steeper than three horizontal to one vertical ratio, and downstream slopes may be no steeper than two horizontal to one vertical ratio. Measures are required for protection of upstream slopes against wave action or rapid draw-down

and for protection of the downstream slope against scour or erosion due to high tailwater.

(m) Freeboard requirements are as follows:

1. Sufficient freeboard shall be provided to prevent overtopping of the dam or any dike or levee due to passage of the design flood or due to frost damage, ice damage or wave action.

2. For all dams the minimum elevation of the top of the dam must be:

i. That necessary to pass the design storm with at least one foot of freeboard to the top of dam, or

ii. Two feet higher than the crest elevation of the secondary (emergency) or primary spillway.

3. Where special conditions of severe frost damage, ice damage or wave action may occur, higher elevations than required in (m) 2 i. and ii. above, may be required and should be considered by the applicant.

(n) The Department may require the design and installation of any additional or modified measures by any applicant for a dam permit where appropriate to insure the protection of human health or safety.

7:20-1.10 Construction

(a) Requirements relating to supervision of dam construction are as follows:

1. All applicants shall submit a written description and schedule of the proposed construction, including:

i. The estimated time to complete the construction activities, see N.J.A.C. 7:20-1.4(e);

ii. Where applicable, a description of the means by which stream flow will be diverted around or through the dam site, or otherwise kept from interfering with the work;

iii. The number of inspectors designated for inspection for construction quality control; and

iv. Steps to be taken to minimize erosion and sediment production during construction.

2. The extent and method of inspection for construction quality control must be described and approved by the Department, including an inspection schedule.

3. The diversion facility, as outlined in 1.i above, must remain open and no water may be permanently stored in the reservoir until the permittee demonstrates to the Department that storage of water will neither interfere with construction activities nor create a hazard to life, health or property.

4. The professional engineer responsible for inspecting the construction must submit progress reports to the Department at least once each month, during the construction period.

5. The permittee shall promptly advise the Department of all proposed changes in the approved design, plans or specifications. There may be no change in the approved design, plans or specifications without prior approval of the Department. All approved changes must be recorded on the complete set of as-built plans, required in (a) 6, below. The Department may require the submission of revised designs at any time. Written prior approval from the Department is required for major modifications, which shall include significant changes in scale, use, design, impact, etc. of the project, as initially approved. The Department may require written, prior approval of any proposed modification.

6. A complete set of as-built designs, plans and specifications must be submitted to the Department upon completion of the project.

7. The professional engineer who has inspected the construction shall submit written certification that the structure has been built in conformance with the designs, plans and specifications, and with any changes approved by the Department.

(b) Construction inspection program requirements are as follows:

1. The Department may inspect the dam during construction to insure that it is being built in compliance with the designs, plans and specifications submitted to the Department. Departmental inspections in no way relieve either the permittee or the professional engineer in charge from the responsibility of providing adequate inspection of the work.

2. If, at any time during the progress of the work, the Department finds that the work is not being performed in accordance with the approved designs, plans and specifications and any approved changes, the Department will serve a written notice to that effect on the permittee or his representative. Such notice will state the particulars with which the work has not complied. Additionally, the Department may order the immediate compliance with such designs, plans, specifications, and changes and suspension of all other work until compliance has been effected. If the owner or his representative fails to comply with this order, the permit under which construction is authorized may be revoked or suspended by the Department.

3. Upon receipt of the as-built plans required in subsection (a)6 above and the engineer's certification required in subsection (a) 7 above the Department will inspect the completed construction within 30 days. If the Department finds that construction was completed in accordance with the approved designs, plans, specifications and approved changes, the construction will be approved in writing within 14 days. The approval date shall be the date such approval is sent by the Department.

4. In the 12th month following approval of construction by the Department pursuant to (b) 3 above, the Department will make a final inspection of the construction. A final approval will be given by the Department, if the final inspection shows that the terms of the permit, designs, plans, specifications and approved changes thereof have been met.

7:20-1.11 Dam operating requirements and inspections: new and existing dams

(a) All owners and operators of Class I and II dams shall develop and use an Operational and Maintenance Manual which meets the following requirements:

1. The purpose of this manual is to provide guidance and instruction to project personnel for the proper operation and maintenance of the reservoir and dam.

2. The manual shall be composed of two parts.

i. Part one must include an introduction, project description, project authorizations, project history and list of project contracts.

ii. Part two must contain the operation and maintenance instructions for major project facilities and equipment.

(b) Permittees for Class III dams shall develop and use an Operation and Maintenance Manual in the event that the dam classification is raised.

(c) The owners or operators of all dams which raise the waters of any stream more than 70 feet above its usual mean low-water height or which impound more than 10,000 acre-feet of water shall have a regular inspection peformed annually and formal inspections performed every three years by a New Jersey licensed professional engineer. These inspections must be attended by a professional engineer assigned from the Department. In the year of the formal inspection, regular or informal inspections need not be performed.

(d) Owners or operators of all dams shall have an informal inspection performed on the off-year from the regular inspection (see (f) below).

(e) Owners or operators of dams not covered by (c) above shall have a regular inspection performed once every two years and a formal inspection performed once every six years. In the year of the formal inspection, regular and informal inspections need not be performed.

(f) All dam inspections shall be performed from March through July (Season I) or from August through December (Season II).

(g) All dam inspections shall be performed in compliance with the following schedule:

1. All dams within the counties of Sussex, Morris, Hunterdon, Union and Essex shall have regular inspections performed in Season I of the first year after the effective date of these rules. Informal inspections shall be performed in Season I of the following year.

2. All dams within the counties of Passaic, Warren, Somerset, Bergen and Hudson shall have regular inspections performed in Season II of the first year after the effective date of these rules. Informal inspections shall be performed in Season II of the following year.

3. All dams within the counties of Middlesex, Monmouth, Burlington, Salem and Atlantic shall have regular inspections performed in Season I of the second year after the effective date of these rules. Informal inspections shall be performed in Season I of the first year.

4. All dams within the counties of Mercer, Ocean, Camden, Gloucester, Cumberland, and Cape May shall have regular inspections performed in Season II of the second year after the effective date of these rules. Informal inspections shall be performed in Season II of the first year.

5. Successive regular and informal inspections shall be performed in the opposite inspection season from that of the prior inspection. For example, if a regular inspection is performed in Season I of the first year, the next regular inspection must be performed in Season II of the third year.

(h) All inspections shall be performed in compliance with the following requirements:

1. A written guide provided by the Department for the preparation of a Report on Condition of the dam shall be used for all inspections.

2. Formal and regular dam inspections shall be performed by a licensed New Jersey professional engineer. Except for Class IV dams, the required report shall be submitted to the Department by the engineer within 30 days of completion of the inspection. The report shall indicate the results of the inspection, documenting the conclusions and recommendations. Reports for Class IV dams shall be submitted to the county and/or municipal engineer having jurisdiction over the dam structure.

3. Informal inspections may be performed by the dam owner or operator and, except for Class IV dams, the Report on Condition shall be submitted to the Department within 30 days. Reports for Class IV dams shall be submitted to the county and/or municipal engineer having jurisdiction over the dam structure.

4. The Department may extend the time for submission of the required material for up to 30 days, if the owner or operator justifies the need for such extension.

5. Failure by the permittee to inspect within the required time periods or failure to submit the Report on Condition may result in an order to drain the impoundment under the provisions of the Safe Dam Act (N.J.S.A. 58:4-1 et seq.), and/or any other remedy allowed by law.

(i). For good cause, the Department may require the owner or operator of any dam to perform an inspection of any type at any time.

(j) The owner or operator of all Class I and II dams shall prepare and use an Emergency Action Plan, as described in N.J.A.C. 7:20-1.7(f).

STATE OF NEW JERSEY

DAM SAFETY MANUAL

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

PART III

SAFE DAM ACT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

DIVISION OF WATER RESOURCES

BUREAU OF FLOOD PLAIN MANAGEMENT

LAWS RELATING TO CONSTRUCTION, INSPECTION, REPAIR AND SAFETY OF DAMS AND RESERVOIRS

TITLE 58, CHAPTER 4 OF THE REVISED STATUTES

This act shall be known and may be cited as the "Safe Dam Act." The Commissioner of Environmental Protection shall, by rule, establish a periodic dam safety inspection and reporting procedure, on an annual or longer term basis, for the owner of any dam meeting the criteria contained in R.S. 58:4-1. The owner shall have a professional engineer inspect the dam and prepare and submit a report containing such information as the Commissioner may require, concerning the safety of said dam and appurtenant structures. Every dam which raises the waters of any stream more than 70 feet above its usual mean low-water height or which impounds more than 10,000 acre-feet of water shall be inspected on an annual basis by a professional engineer retained by the owner, in the company of a professional engineer assigned from the Department of Environmental Protection.

58:4-1. No municipality, corporation or person shall, without the consent of the Commissioner of Environmental Protection, hereafter in this chapter designated as the Commissioner, build any reservoir or construct any dam on any river or stream in this State or between this and any other such state which will raise the waters of such river or stream more than five feet above their usual mean low-water height, nor repair, alter or improve existing dams which so raise the water, without such consent, but this shall not affect or relate to a dam or reservoir in the pinelands area, as designated by subsection a. of section 10 of P.L. 1979, c. 111 (C. 13:18A-11), which will raise the waters of any river or stream less than eight feet above the surface of the ground where the drainage area above the same is less than one square mile in extent and where the water surface created by the dam or reservoir is less than 100 acres in extent except that the Commissioner may investigate and take appropriate action regarding any dam or reservoir about which he has a security or safety concern. With respect to dams and reservoirs located on lands utilized for agricultural or horticultural purposes within the pinelands area, the Commissioner's actions shall be undertaken after consultation with the Secretary of Agriculture.

58:4-2. Every municipality, corporation or person, before constructing any reservoir or dam subject to the provisions of this chapter shall apply to the Commissioner for the approval of the plans of such reservoir or dam, which approval the Commissioner may grant with such modifications, limitations or changes as in his judgement may be necessary for the protection of life and property.

58:4-3. Every municipality, corporation or person owning and maintaining or having control of any reservoir or dam shall, upon written request therefor, furnish to the Commissioner as full, true and particular description of the reservoir or dam as may be practicable, and shall, when so requested by the Commissioner cause to be such surveys, plans and drawings of the reservoir or dam as may be necessary to give sufficient information for the determination of its safety as may be required by the Commissioner.

58:4-4. Upon written application by any person owning or representing property liable to be injured or destroyed by the breaking of any reservoir or dam, or upon application by the mayor or governing body of any municipality on account of possible danger of loss of life or of injury to any property within the municipality from the breaking of any reservoir or dam, or without such complaint whenever the Commissioner shall choose, he shall forthwith thoroughly inspect such reservoir or dam.

58:4-5. If, in the judgement of the Commissioner, such reservoir or dam is not sufficiently strong to resist the pressure of water upon it or there is reasonable cause to believe that danger to life or property may be anticipated from the reservoir or dam, or if for any other cause the Commissioner shall determine the reservoir or dam to be unsafe, or improperly maintained he shall determine whether the water in such reservoir or above such dam shall be drawn off in whole or in part, and what altertions, additions and repairs are necessary to be made to the reservoir or dam to make the same safe and properly maintained. The Commissioner shall forthwith in writing order the owner or person having control of the reservoir or dam to cause such alterations, additions and repairs to be made within the time to be limited in the order, and may order the water above the dam or in the reservoir to be drawn off in whole or in part as he may determine. The Commissioner shall have the right to enter upon any and all properties for the purpose of obtaining information about the safety and proper maintenance of any reservoir, dam or appurtenant structures located therein.

58:4-6. If the owner or person having control of any reservoir or dam shall not forthwith comply with any order of the Commissioner made as provided in Section 58:4-5 of this Title or shall not prosecute the work, when commenced,

with reasonable expedition, the Commissioner may direct the Attorney General to proceed in the name of the State to enforce its order in a court of competent jurisdiction. Action may be brought against the person controlling or owning the reservoir or dam, and the court may make such order and judgement in the premises as will effectually secure the persons interested from danger of loss from the breaking of the reservoir or dam complained of. The court may proceed in the action in a summary manner or otherwise. Any person who violates the provisions of this chapter or of any order issued pursuant to this chapter shall be liable to a penalty of not more than $5,000.00 for each offense. If the violation is of a continuing nature, each day during which it continues shall constitute an additional, separate and distinct offense.

58:4-7. Repealed

58:4-8. The Commissioner may, when provided with sufficient funds, employ personnel for the inspection of exisitng reservoirs and dams and the supervision of the erection of new reservoirs and dams in this State or between this and any other state so that said structures may be built with due regard for the safety of property and life which might be endangered by improper construction thereof.

58:4-9. Where a reservoir or dam has been in existence 20 years and the owners of land along the shores above such dam or on such reservoir have made or shall have made permanent improvements on said land or where the shores have become a populated community, depending upon the permanecy of the condition created, and a petition signed by a majority of the landowners along the shore of any pond formed by the reservoir, water or dam protesting against the removal of the reservoir, water or dam has been filed with the Commissioner, the owner or owners of the reservoir or dam shall not, without the consent of the Commissioner, tear down, destroy or abandon the reservoir or dam, or withdraw the water below the usual low-water mark, or maintain such a condition, except for the purpose of necessary repairs.

58:4-10. When a petition has been filed protesting against the removal of any reservoir, water or dam as provided in Section 58:4-9 of this Title the Commissioner shall grant a hearing, upon 20 days notice to all parties interested, and may then establish and fix a permanent low-water mark. Should it appear that the maintenance of such a dam would be an undue burden upon the owner thereof, the landowners interested around the reservoir or above the dam may, in the discretion of the Commissioner, be ordered to pay a part or all of the expenses of maintenance.

STATE OF NEW JERSEY

DAM SAFETY MANUAL

PART IV

DAM EMERGENCY ACTION PLANNING GUIDE

DAM

EMERGENCY ACTION PLANNING

GUIDE

June 1986

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LIST OF ABBREVIATIONS AND ACRONYMS

DABREWS	Dam Breach Warning System
EAP	Emergency Action Plan
ENOS	Emergency Notification System
NJ-DSS	New Jersey Department of Environmental Protection, Division of Water Resources, Bureau of Flood Plain Management, Dam Safety Section
NJ-OEM	New Jersey Office of Emergency Management (or State Office of Emergency Management)
NJSP	New Jersey State Police
NWS	National Weather Service
SOP	Standard Operating Procedure

LIST OF DEFINITIONS

CLASS I DAM - HIGH HAZARD POTENTIAL

This classification includes those dams, the failure of which may cause the probable loss of life or extensive property damage. The existence of normally occupied homes in the area that are susceptible to significant damage in the event of a dam failure will be assumed to mean "probable loss of life". Extensive property damage means the destructive loss of industrial or commercial facilities, essential public utilities, main highways, railroads, or bridges. A dam may be classified as having a high hazard potential based solely on high projected economic loss. Recreational facilities below a dam, such as campground or recreational area, may be sufficient reason to classify a dam as having a high hazard potential.

CLASS II DAM - SIGNIFICANT HAZARD POTENTIAL

This classification includes those dams, the failure of which may cause significant damage to property and project operation, but loss of human life is not envisioned. This classification applies to predominantly rural, agricultural areas, where dam failure may damage isolated homes, major highways or railroads, or cause interruption of service of relatively important public utilities.

EMERGENCY MANAGEMENT SYSTEM

This is the organization of the State, County, and Municipal Offices of Emergency Management along with the public, private, and volunteer organizations they coordinate in response to threatened or actual disasters and major emergencies.

HOTLINE

This is basically a point to point telephone line called "private lines" by the telephone company. The line is contantly "hot" or "ready for communication" between two or more points. You pick-up the telephone receiver and automatically get a "ring" at the other locations (until they answer). The special value of this type of phone service to Emergency Management is the fact that they are wired in such a way that the line is not "lost" to service, if the telephone exchange is overloaded by panic public calls during an emergency.

OBSERVATION

This is defined as the act of observing, looking at, or inspecting a dam utilizing a special checklist for the purpose of determining any conditions that might effect the safety of the dam. The term observation is used for this purpose so as not to be confused with any inspection(s) performed on the dam in accordance with DEP, guidance in N.J.A.C.7:20-1 et. seq.

LIST OF ATTACHMENTS

SECTION 1

DAM EMERGENCY ACTION PLANNING GUIDE

Introduction

One of the basic functions of government is to protect the lives and property of its citizens. Normally, this function is performed in an efficient and effective manner by a multitude of government agencies on a daily basis. In most communities police, fire, emergency medical, health, welfare, public works and other governmental and volunteer organizations have specific duties and responsibilities. However, during an unusual or catastrophic emergency these organizations are required to pool their resources and work together as a team to mitigate the effects of the incident on the community. A coordinated, cooperative, and effective response to an emergency does not just happen, it requires application of the concepts of planning, mitigation, response and recovery. This is what EMERGENCY MANAGEMENT is all about.

In New Jersey, Emergency Management was established by Public Law 1942, Chapter 251, as amended, (originally titled Civil Defense). The Office of Emergency Management is currently established as a Section in the Division of State Police with the Superintendent of State Police appointed as the State Director of Emergency Management. The Supervisor of the Emergency Management Section was appointed as the Deputy State Director.

When a disaster strikes, emergency response begins at the local level. The person responsible for protecting the public from the consequences of these increasingly sophisticated challenges is the Mayor. Under New Jersey Law, (A:9-40.1) the Mayor of each municipality in the State must appoint an Emergency Management Coordinator, a Deputy Emergency Management Coordinator and a local Emergency Management Council (A:9-41). This organization is responsible for the planning, activating, coordinating and the conduct of disaster control operations within the municipality. When an event becomes so serious that local services and resources cannot cope with the problem, assistance is available through mutual assistance from neighboring jurisdictions, from the county and then at the State level. However, a request for aid from other jurisdictions does not relieve the Mayor from the ultimate responsibility of providing for the health, safety and welfare of the residents of the municipality.

The actual breach and failure of a major dam would certainly qualify as a catastrophic emergency. Such an event would require speedy assistance from County and State Emergency Management resources to aid the municipal governments in providing help for the people in the flood path. However, effective emergency response to a dam break cannot occur without careful pre-planning and coordination by those who would be involved. That is the goal of this planning guide.

SECTION 2

WHO MUST PREPARE A PLAN

According to New Jersey Rules (N.J.A.C. 7:20-1 et. seq.) all owners of Class I* and II* Dams will prepare an Emergency Action Plan. This "Emergency Action Plan" (EAP) must be fully coordinated with State, County and Municipal Emergency Management personnel during development stages. Written approval by the State Office of Emergency Management, and the Department of Environmental Protection is required prior to final publication and implementation.

The owner/operator of the dam is responsible for the major portion of the plan referred to as the "Basic Plan". State, County and Municipal Emergency Management Coordinators are responsible for coordinating and insuring the preparation of "Annexes" to go with the "Basic Plan." These Annexes will reflect how primary responsibilities outlined in the Basic Plan will be implemented by the responsible agency. Section 6 reflects the mandatory elements required in each Annex.

The "Basic Plan" (Owner/operator's responsibility) together with the Annexes (State, county and municipal Emergency Management) make up the complete Dam Emergency Action Plan.

* NOTE: Definition of Class I and Class II Dams is found in Definitions List.

SECTION 3

HOW TO BEGIN

The process of preparing a Dam Emergency Action Plan (EAP) can be a complex issue. Therefore, close coordination between owner/operator personnel who will be involved in the planning process and the project officer for the New Jersey Office of Emergency Management (NJ-OEM) is essential for controlling these critical factors. The following steps are recommended to achieve that control and assure a quality plan:

STEP-1

The person owning the dam or the chief executive for the owner/operator should appoint (in writing) a senior supervisor involved in the dams operations as the "EAP Development Supervisor". This person should be given full responsibility for coordinating and directing the preparation of the EAP until ready for final approval.

STEP-2

The appointed "EAP Development Supervisor" should identify and appoint (in writing) an "EAP Planning Group" consisting of those key supervisory personnel involved in various elements of the dam's operations, maintenance, and security. Any other elements that would be involved in a response to an emergency at the dam, but not already included in the group, should have representation.

STEP-3

The "EAP Development Supervisor" and "Planning Group" should become thoroughly familiar with the New Jersey Dam Safety Manual. Especially the requirements and guidance in Part IV, Dam Emergency Action Planning.

STEP-4

The "EAP Development Supervisor" should contact the Dam Safety Officer at the NJ-OEM, to setup the initial planning meeting.

STEP-5

The "EAP Development Supervisor", the "EAP Planning Group", the NJ-OEM Dam Safety Officer and a representative of the DEP Dam Safety Section (NJ-DSS) will prepare a task listing and schedule for completion of the EAP.

NOTE: After Step-5 and the identification of the Counties and Municipalities involved through the inundation study, the EAP development will involve County and Municipal officials (especially Emergency Management Coordinators) as well as the public (through public meetings).

SECTION 4

MANDATORY ELEMENTS IN THE PLAN

Certain elements such as Notification, Warning and Evacuation are an obvious part of an emergency plan. However, the New Jersey Office of Emergency Management (NJ-OEM), in coordinating the preparation of Emergency Action Plans (EAP) for several high hazard dams has developed a list of mandatory elements required in each Emergency Action Plan. These elements are listed in Attachment 4-A, for quick and ready reference. The following paragraphs discusses each of these elements and identifies specific information and detailed guidance required by NJ-OEM/NJ-DSS in each element to obtain Plan approval.

NOTE: These elements are not intended to be an outline or topical division of any specific EAP. Indeed each EAP is expected to be site-specific for the dam/dams it represents. Also, the sequence in which these elements are listed and discussed is not necessarily the order in which they would be covered/appear in the EAP.

AUTHORITY

Each EAP will have an authority element that will reflect:

1. Public Law 1942, Chapter 251, as amended.
2. N.J.S.A. 58:4-1 et. seq, Safe Dam Act
3. N.J.A.C. 7:20-1 et. seq, Dam Safety Standards

Other laws/authorities (Federal, owner/operator, etc.), may be added after the above.

CHECKLISTS

Plans, especially emergency plans, are needed to clearly record operational concepts, procedures, responsibilities and information essential to guide organizations towards their goal or objective. However, under the pressure of time and the weight of "Lives in Danger" during a disaster response, people will forget many details or information reflected in the EAP. Therefore, checklists which briefly identify key/essential steps and actions will be prepared for certain positions/functional areas necessary to insure a timely and correct implementation of the EAP. The following are some suggested positions/functions where checklists may be required:

OBSERVER/INSPECTOR/SECURITY GUARD - A checklist is required to make routine and regular observation / inspections of the dam(s) to determine current safety status.

SECURITY GUARD/DISPATCHER/SHIFT SUPERVISOR - A checklist is required to make the Emergency Notification Call to Owner/operator and the Emergency Management System.

ENGINEER/MAINTENANCE SUPERVISOR - A checklist is required to determine the emergency condition code (status) of the dam.

Attachments 4-B, 4-C, and 4-D are Sample Checklists to be used as a preparation guide.

COMMUNICATIONS

Communications between the dam site, the owner/operator's normal (or emergency) operations center, and the Emergency Management System would be both critical and essential during any dam emergency or threathened disaster. Therefore, owner/operators must insure adequate telephone coverage and radio backup. Refer to comments on the Emergency Notification System for additional information on telephone and radio requirements. These requirements will be coordinated with the dam owner by the NJ-OEM and reflected in an annex to the EAP.

CONCEPT OF OPERATIONS

The basic "concept of operations" for a dam emergency in New Jersey is:

1. The owner/operator will identify any emergency conditions that threaten their dam, notify the the Emergency Management System, and effect emergency repairs.
2. The Emergency Management system will warn the public and direct evacuation necessary for their safety.

Functions making input to or preparing part of the EAP (such as annexes) will identify their own "concept of operations"

for accomplishment of their assigned responsibilities. However, these "concepts" will not conflict with the overall "concept of operations" for the State as identified above.

DAM BREAK ANALYSIS

Dam break analysis or a dam break hydrograph must be accomplished for each dam in conjunction with the preparation of an EAP. Several factors usually have to be evaluated whenever dam failures are postulated. The type of dam and the mechanism which could cause failure require careful consideration if a realistic breach is to be assumed. Size and shape of the breach, time of breach formation, hydraulic head, and storage in the reservoir contribute to the dam failure hydrograph. Most of the methods for estimating dam break hydrographs require the choice of size, shape, and time of dam breach. There are also several available procedures for routing dam failure hydrographs to determine information on areas inundated by the flood as it travels downstream. The routing should cease at a point where real-time flood warning information can be provided on a pre-planned basis.

Many methods for developing the dam failure hydrograph and routing dam break flows downstream are available. Many Federal agencies have developed procedures that are available upon request. They may be obtained from the National Weather Service, Bureau of Reclamation, Soil

Conservation Service, Corps of Engineers, Tennessee Valley Authority, Geological Survey and Federal Emergency Management Agency. Procedures developed by the National Weather Service (NWS) are the most widely used. Simplified NWS procedures are readily available from the nearest FEMA office. However, considerations for using the detailed procedure should be coordinated with NWS.

The Dam break analysis and the inundation maps shall be prepared by a New Jersey licensed professional engineer using methods approved by NJ-DSS. Before preceeding with the breach analysis and inundation mapping the engineer concerned should meet with representatives of the NJ-DSS,

The dam break analysis itself, with all of its computations and data will not be included in the EAP. The inundation map(s) prepared from the analysis results will be included as part of the EAP. (See Inundation Maps, this Section). However, information on the specific method/program used to accomplish the dam break analysis and the basic data parameters on the dam, breach, hydraulic head, reservoir storage, stream flow, and hydraulic computations used in the analysis and inundation mapping will be submitted to NJ-DSS.

DAM AND STORAGE AREA DESCRIPTION

Each EAP will include information on the dam(s) size, type of construction, storage capacity, storage area,

owner/operator, date of construction, location, and purpose. Inclusion of a photograph or drawing of the dam(s) is also required.

EMERGENCY MANAGEMENT SYSTEM

This refers to the New Jersey Office of Emergency Management and the corresponding offices at county and municipal levels along with the public, private, and volunteer organizations they coordinate. This organization is responsible for coordinating/directing all activities necessary to provide for the public safety in the event of an actual or threatened dam disaster. (Reference Public Law 1942, Chapter 251, as amended). Therefore, the specific county and local office of Emergency Management involved with each dam (as based on inundation studies) will be identified in each EAP. Also each emergency management office will prepare an annex to each dam EAP which will reflect their planned response to emergency conditions at that dam. Attachment 4-E identifies the Federal to local emergency management organizational chain.

EMERGENCY NOTIFICATION SYSTEM

The established procedures, involved organizations and required communications equipment all make up the Emergency Notification System for a specific dam (or dam group). This system will be specifically designed for each dam (or group) by the NJ-OEM in conjunction with the owner/operator and the County/Municipal Emergency Management offices involved.

Generally, the system communications equipment will minimally consist of a hotline (see definition list) to a designated warning reception point(s) for the Emergency Management System with a radio back-up.

The owner/operator will use the Emergency Notification System established for their dam to report any emergency conditions when they occur to the Emergency Management System, (see Identification of Emergency Conditions in this section).

EMERGENCY REPAIR ACTIONS

The owner/operator is responsible for prompt, effective emergency repair actions. The EAP will clearly indicate how the owner/operator will implement repair actions.

EMERGENCY REPAIR RESOURCES

Personnel and material resources needed for emergency repairs will be identified and maintained in an annex to the plan. Personnel (names, skills, phone numbers) for damage reduction and repair teams will be identified. Material resources will be identified as to that stockpiled on-site and that which must be obtained off-site. The off-site listing will identify location, name of commercial company, and 24-hour contact phone numbers. Also, equipment required, available, etc., for repairs must be listed. Refer to attachment 4-F for sample formats.

EVACUATION

The process of evacuating the public in each municipal jurisdiction downstream of a threatened dam break is the responsibly of each local Office of Emergency Management. Assistance and coordination will be provided by the State and County Office of Emergency Management. The owner/operator is responsible for evacuating their personnel in the area near the threatened dam break.

The area(s) evacuated will be those which are identified on the inundation maps (prepared from the dam break analysis) as areas which will be flooded. The municipal Emergency Management Coordinator should also select a reasonable area beyond that which is expected to be flooded as an additional margin of safety for the public. Plans for these evacuations will be reflected in each municipal annex to the EAP.

IDENTIFICATION OF EMERGENCY CONDITIONS

The major objective of dam emergency planning is to save lives and minimize damage. The first task in accomplishing this objective is the timely identification of emergency conditions. The NJ-OEM, in order to correlate and standardize the identification of emergency situations at a dam (by the owner/operator) with subsequent emergency response (by the Emergency Management System), has established four emergency conditions of varying severity.

They are:

Dam Breach Condition

A dam breach condition is defined as:

- a dislocation or failure of any reservoir structure, which allows for an expanding, uncontrollable discharge of water through any of the dams, dikes, foundations, or abutments, indicating a breach is occurring.

Required Response: Owner/operator -

SOUND "DAM BREACH" SIGNAL.

Emergency Management System -

EVACUATION, RESCUE AND RECOVERY.

Dam Emergency Condition

A dam emergency condition is defined as one or more of the following situations:

- Water has overtopped any dam or dike, or is expected to overtop within the next hour,
- Any uncontrollable erosion, settlement, or upheaval occurring on the downstream slope or at the toe of the dam,
- and/or any uncontrollable leakage through any dam structure.

Required Response: Owner/operator -

EMERGENCY REPAIRS AND DE-WATERING.

Emergency Management System -

PUBLIC WARNING AND EVACUATION

Dam Warning Condition

Dam warning condition is any event or circumstance which may affect the integrity of the containment structure but is considered controlable. The dam warning condition has the potential of deteriorating to a dam emergency or a dam breach condition. Examples of a dam warning condition are:

- o water level of the reservoir is at an unsafe level below the top of the dam or dike and is rising,
- o any erosion, settlement, or upheaval occurring on the downstream slope or at the toe of the dam and considered to be controllable,
- o and/or any leakage through any dam structure considered to be controllable.

Required Response: Owner/operator -

EMERGENCY REPAIR AND DE-WATERING.

Emergency Management System -

ALERT KEY OFFICIALS, ALERT PUBLIC, REVIEW PLANS, PREPARE FOR EVACUATION.

Dam Advisory Condition

A dam advisory condition is defined as one or any combination of the following situations:

- o instrumentation readings reach a pre-determined numerical limit,
- o bomb threat,
- o a civil disorder near the structure(s),

- o any spring,
- o any sign of piping,
- o any sign of slumping,
- o any sinkhole in the outside area of the dam structure(s),
- o any aircraft accident near the structure(s),
- o any crack,
- o any wet spot or boggy area,
- o any seismic event (regardless of how slight),
- o any obstruction in the spillway,
- o any sign of vandalism at any structure(s),
- o water on the floor of the outlet vaults,
- o and/or any unusual noises or vibrations from the mechanical structures.

Required Response: Owner/Operator -

INVESTIGATION, ASSESSMENT AND RESPONSE AS REQUIRED.

Emergency Management System -

ADVISE KEY OFFICALS.

Regular observation by personnel trained to look for conditions that would effect dam safety/security is the primary key to identifying the conditions established above. The owner/operator is also responsible for notifying the Emergency Management System, upon observing/identifying the condition and for providing regular status reports until the condition is resolved. See information included under

Observations and "Emergency Notification System" for additional guidance

INUNDATION MAPS

Whenever communities or significant numbers of dwellings are located in the flood plain downstream of a dam, an inundation map is needed to develop an adequate evacuation plan. These maps must show an outline of the area covered by the dam break flood in enough detail to identify dwellings and other significant features that are likely to be directly affected. This is generally accomplished by superimposing the flood outline on a existing map. Additional data included on the maps are estimated flood travel time and depth at selected locations. The maps should be of sufficient scale and detail to identify clearly the areas which would be flooded if large flows occur from dam failure, misoperation, or extreme storms. Clarity and simplicity are important. Therefore, the map scale should be such that all important features can be identified. Also, any necessary interpretation instructions will be included with the map.

Generally, an inundation map depicting both the breach and large flood condition should be included in the plan. Although additional conditions could be used, caution must be used to keep the map from becoming cluttered and to keep the plan simple enough to be clear and understandable.

Generalized breach inundation maps may be used in the plan if sufficient for clearly depicting the inundated areas. Generalized maps may need to be supplemented with larger scale and more detailed maps in some areas. The mapping and the number of different flooded areas must be coordinated with NJ-OEM and local officials who are developing evacuation plans. It may be appropriate to supplement the inundation maps with water surface profiles in critical areas.

For detailed maps, it is recommended that the best available maps for evacuation planning be used. The original plotting of the dam failure inundation must be done on topographic maps. After the mapping has been approved, the information will be transferred to street maps for local planning use. The lines delineating the inundated area should be drawn in such thickness or form (solid line, dashed line, dotted line) as to identify the inundation limits as the main features of the map but not bold enough to obliterate features which would be inundated by the flood waters. When plotting inundation limits between cross sections used for the analysis, the lines should reasonably reflect the change in water levels caused by topographic patterns and man-made features.

When inundation lines enter the area of an existing lake or reservoir, they should represent an increase in the water

level of such lake or reservoir. Should this increased water level overtop a dam, the appropriate inundation lines should extend downstream of such dam.

For dams not in series but which affect a common downstream area, it is usually adequate to consider the breach condition for each dam individually unless special conditions would warrant multiple failure considerations. Breach inundation lines of such dams then should consist of a line enveloping the lines for the individual beaches when common areas would be inundated.

When development of the flood plain below some dams is sparse, preparation of inundation maps may not be warranted. Flooding information can be readily provided by vicinity maps with pertinent information at the key locations. Flooding at key locations can be estimated by interpolating data from locations upstream and downstream of their site. Information on depth of flooding and time of travel for floods to reach specific locations must be provided.

OBSERVATION

Without regular observation (see difinitions list) by trained personnel, the safe operation and maintenance of any dam could be compromised. Therefore, owner/operators of Class I Dams will provide for an observation check by a trained person on a daily basis. The observer will use a checklist (approved as part of the EAP) to guide their observations and record the findings. The requirement is

the same for owner/operators of Class II Dams, except the frequency of observation is reduced to once each week. (To be done on a Monday or Tuesday).

OWNER/OPERATOR ORGANIZATION

The EAP will contain sufficient charts/diagrams and written data to describe the owner/operators organizational structure and functioning in relation to operations, maintenance, and response to any emergency conditions at their dam(s).

RESPONSIBILITIES

The following are the assigned minimum responsibilities regarding dam emergencies which will be reflected in the EAP.

Owner/Operator

The Owner/Operator will be responsible for:

- Daily observation of the dam(s) (Class II - weekly),
- identification of any emergency condition,
- notification of authorities (the Emergency Management System as identified in specific plans) and appropriate parties,
- Implementation and direction of emergency dam repairs,

- provision of technical assistance to Emergency Management officials when necessary and within Owner's capability,
- annual review and updating of the EAP,
- daily testing of the Emergency Notification System (ENOS),
- and monthly testing of the Dam Breach Warning System (DABREWS).

Emergency Management - State

The NJ-OEM will:

- assume control and coordination of all emergency actions in accordance with Public Law when appropriate,
- provide assistance to the involved municipalities and counties (when requested and beyond their capabilities) in:
  - controlling access to threatened or flooded areas,
  - providing helicopter assistance for medical evacuation, search and rescue missions,
  - warning the public,
- coordinate specialized assistance as required,
- notify appropriate State agencies,
- notify appropriate counties of any declared emergency condition,
- conduct periodic testing of the EAP,
- and conduct annual review of the EAP.

Emergency Management - County

The County Office of Emergency will be responsible for:

- o passing warning of emergency conditions at a dam to all threatened municipalities,
- o providing assistance to the municipalities in fulfilling their emergency responsiblities,
- o and monitor testing of the Dam Breach Warning System (DABREWS).

Emergency Management - Municipalities

The municipal Office of Emergency Management is responsible for:

- o warning the public of emergency conditions at a dam,
- o implementing and directing required evacuation of threatened areas,
- o establishing Reception Centers for evacuated people,
- o securing and controlling access to evacuated areas,
- o and conducting Rescue and Recovery Operations as required.

STANDARD OPERATING PROCEDURES

Just as a CHECKLIST is required for certain key/essential steps and actions to be taken by various personnel during an emergency, there is also a need for detailed operating procedures. The "Standard Operating Procedure" (SOP's) must

not only make standard the way, time, or sequence an essential task is accomplished, it must contain details on how to accomplish the task. Several functions such as owner/operator personnel responses during specific emergency conditions at the dam are obvious candidates for SOP's (see attachment 4-G for sample). The NJ-OEM will coordinate with the owner/operator during the EAP preparation as to functions or tasks that require SOP's.

TRAINING

Training of personnel involved in the emergency action plan must be conducted to ensure that they are thoroughly familiar with all elements of the plan, SOP's, checklists, and their duties thereunder. Availability, serviceability, and use of equipment needed for response to emergency conditions at the dam must be reviewed regularly with involved personnel. Technically qualified project personnel should be trained in problem detection, evaluation, and appropriate remedial (emergency and non-emergency) measures. This is essential for proper evaluation of developing situations at all levels of resonsibility which, initially, must be based on site observations. A sufficient number of personnel should be trained to assure adequate coverage at all times. The owner/operator's training plan will be included as part of the emergency action plan. Exercises simulating dam failures are excellent training mechanisms for assuring readiness. Cross-training in more than one

responsible position for each individual is advisable in order to provide alternates. A careful record by roster must be kept of training completed and refresher training conducted.

WARNING

Public warning is the responsibility of the Emergency Management System as soon as they have been notified by the dam owner/operator of an emergency condition. The public warning will normally be accomplished by the local emergency management office at each municipality. Methods used to alert and warn the public may vary within each municipality but will generally utilize the following:

1. Sounding of the standard 3 to 5 minute alert signal (steady tone) on all available stationary sirens and other signal devices.
2. Emergency Broadcast (EBS) announcements on local radio stations advising the public of the existing emergency condition with instructions regarding required protective actions (i.e. stay tuned for further information, prepare for possible evacuation, evacuate, etc.).
3. Dispatch of emergency vehicles (police, fire, rescue) equipped with public address speakers into selected areas which would have to be evaucated. These units would sound their vehicle sirens and then make emergency announcements over the vehicle

PA (or else knock on doors). The announcement would usually be a brief alerting as to the emergency with instructions to tune in their EBS radio station. (This method is usually used to warn areas which cannot be alerted by 1. above, or for additional warning coverage for areas in the greatest danger.

In addition to the public warning discussed above, owner/operator's of Class I Dams may be required to install a "Dam Breach Warning System" (DABREWS - SEE NOTE). The intent of this warning system is to provide people with an early life saving warning in the (unlikely but possible) event of a sudden unexpected dam break/breach. Such an event occurring without the usual advance warning signs which provide the opportunity for emergency repairs and a more orderly warning, could result in significant loss of life. (The sudden, unexpected breach of a dam could occur as the result of a major earthquake, aircraft crash, or sabatoge/terrorist activities.) Attachment 4-H reflects the State recommended criteria for installation of this system.

NOTE:

This requirement is currently being reviewed for establishment as a mandatory requirement.

ATTACHMENT 4-A

LIST OF MANDATORY ELEMENTS IN THE EAP

AUTHORITY

CHECKLISTS

COMMUNICATIONS

CONCEPT OF OPERATIONS

DAM BREAK ANALYSIS

DAM, STORAGE AREA, SITE DESCRIPTION

EMERGENCY MANAGEMENT SYSTEM

EMERGENCY NOTIFICATION SYSTEM

EMERGENCY REPAIR ACTIONS

EMERGENCY REPAIR RESOURCES

EVACUATION

IDENTIFICATION OF EMERGENCY CONDITIONS

INUNDATION MAPS

OBSERVATION

OWNER/OPERATOR ORGANIZATION

RESPONSIBILITIES

STANDARD OPERATING PROCEDURES

TRAINING

WARNING

ATTACHMENT 4-B

SAMPLE CHECKLIST

OBSERVATION/RESPONSE CHECK LIST

- ☐ PROFESSIONAL STAFF
- ☐ SECURITY
- ☐ MAINTENANCE

INSPECTOR _____ DATE _____ SHIFT/TIME _____

OBSERVATION	RESPONSE*	LOCATION/STRUCTURE																										REMARKS
		SPRUCE RUN								ROUND VALLEY																		
		DAM								SOUTH DAM					NORTH DAM				DIKE									
		UPSTREAM SLOPE	DOWNSTREAM SLOPE	CREST	DOWNSTREAM TOE	OUTLET TOWER	OUTLET VAULT	SPILLWAY	WEIR	UPSTREAM SLOPE	DOWNSTREAM SLOPE	CREST	DOWNSTREAM TOE	SOUTH INTAKE TOWER	UPSTREAM SLOPE	DOWNSTREAM SLOPE	CREST	DOWNSTREAM TOE	UPSTREAM SLOPE	DOWNSTREAM SLOPE	CREST	DOWNSTREAM TOE	NORTH OUTLET TOWER	NORTH VAULT	SOUTH VAULT	WHITEHOUSE STATION	PUMP STATION	
NORMAL (NO DEFICENCIES)	1																											
NOT INSPECTED	–																											
DAM BREACH	2																											
OVERTOPPING OF DAM CREST	3																											
UNCONTROLLABLE SETTLEMENT, HEAVE OR EROSION	3																											
UNCONTROLLABLE LEAKAGE	3																											
WATER LEVEL 5 FT BELOW CREST & RISING	4																											
CONTROLLABLE SETTLEMENT, HEAVE OR EROSION	4																											
CONTROLLABLE LEAKAGE	4																											
NEW SPRING OR PIPING	5																											
SLUMPING OR HEAVE	5																											
SINKHOLE	5																											
WET SPOT OR BOGGY AREA	5																											
SEISMIC EVENT	6																											
SPILLWAY OBSTRUCTION	5																											
CRACKING	5																											
WATER ON FLOOR OF STRUCTURE	5																											
UNUSUAL NOISE OR VIBRATION	5																											
UNSUBSTANTIATED BOMB THREAT	7																											
CIVIL DISORDER	7																											
AIRCRAFT ACCIDENT	7																											
OTHER	5																											

*RESPONSE: 1– NO ACTION, CONTINUE INSPECTION, 2– CONDITION I , ACTIVATE ENOS, SIRENS,3– CONDITION II , NOTIFY DUTY OFFICER, 4– CONDITION III , NOTIFY DUTY OFFICER, 5– ADVISORY CONDITION, NOTIFY DUTY OFFICER, 6– ADVISORY CONDITION, NOTIFY DUTY OFFICER AND STATE POLICE, INSPECT FACILITY STRUCTURES, 7– ADVISORY CONDITION, NOTIFY DUTY OFFICER, STATE POLICE

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SAMPLE CHECKLIST

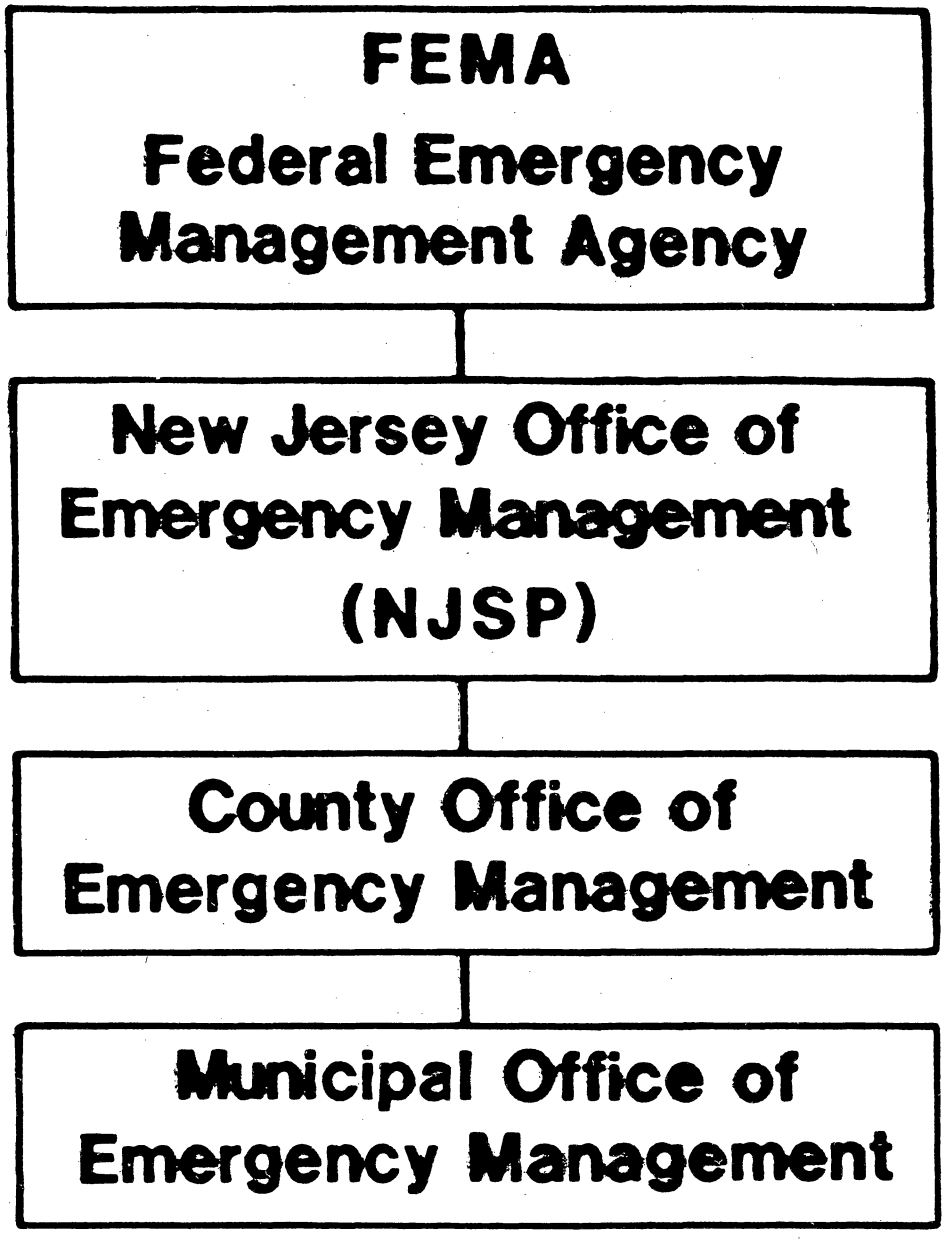
PAGER CHECKLIST

	PERT MEMBER	NOTIFIED	CALLED BACK	TONE WORKING	VOICE WORKING
1	Galley				
2	Chase				
3	Myers				
4	Kroeck				
5	Gross				
6	O'Rourke				
7	Evans				
8	Savidge				
9	Hofmann, C.				
10	Hartl				
11	Buss				
12	Famularo				

EOC ACTIVATION CHECK LIST - OPENING THE OPERATIONS ROOM

NUMBER	ACTION ITEM	COMPLETED
1.	ESTABLISH SIGN-IN ROSTER.	
2.	CHECK EQUIPMENT, SUPPLIES, AND FORMS FOR POSITION SELECTED OR ASSIGNED.	
3.	TURN-ON CALL DIRECTOR BELL SWITCHES.	
4.	OBTAIN TIME CHECK BY DIALING 976-1616. SET OPS ROOM CLOCK ON CORRECT TIME.	
5.	CHECK "BREAK-HUNT" SWITCHES ON BOOTHS 1-8 IN Message Center. (NOTE - 5 AND 6 SHOULD BE DONE BY SAME PERSON).	
6.	OBTAIN CURRENT WEATHER STATUS BY:	
	A. PICK UP WEATHER TELETYPES AT TELE-COMMUNICATIONS.	
	B. CALL NWS FOR THE "EMERGENCY AREA" FORECAST:	
	(1) NYC NWS FOR AREA NORTH OF MERCER AND OCEAN COUNTIES - 212-399-5571/5579.	
	(2) PHILADELPHIA NWS FOR REGION III AND MERCER/OCEAN - 215-597-0845 215-597-3640.	
	C. POST DATA ON WEATHER STATUS BOARD.	
7.	POST ANY SPECIAL MAPS NEEDED.	
8.	SET UP REQUIRED PLANS AND/OR CHECK LISTS.	
9.	POST KNOWN SITUATION ON MAP(S) AS APPROPRIATE.	
10.	SET UP GOVERNOR'S HOT LINE AND POST RADIO IF REQUIRED	
11.	DECLARE THE EOC ACTIVATED BY:	
	A. NOTIFYING TELE-COMMUNICATIONS THAT EOC OPERATION IS ASSUMING CONTROL OF EMERGENCY TELEPHONE LINES (NGS AND 882-4200) AS OF (24 HOUR TIME).	
	B. POSTING EOC ACTIVATION ON THE STAT BOARD AS FOLLOWS:	
	(1) (24 HOUR TIME/DATE) _ LIMITED ACTIVATION OF EOC DECLARED FOR (LIST TYPE) EMERGENCY.	
	(2) (24 HOUR TIME/DATE) _ MAJOR ACTIVATION (PARTIAL MANNING) OF EOC DECLARED FOR (LIST TYPE) EMERGENCY.	

EMERGENCY MANAGEMENT CHAIN



ATTACHMENT 4-F

SAMPLE RESOURCE LIST

TABLE C-2.SUMMARY OF MATERIALS AVAILABLE FROM OFF-SITE PRIVATE CONTRACTORS

LUMBER CONTRACTORS

Co. Name Telephone No.	4 x 4's	1 x 6" sheathing	Location	Approx. Distance to SR	Estimated Travel Time	Transportation Available	24-hour Phone
Amerman 201-369-5511	Yes	Yes	Neshanic	15 miles	30 min	Yes	No
Cal-Lum 201-832-2111	Yes	Yes	Califon	8 miles	15 min	Yes	201-832-2884
Cal-Saw 201-832-2101	Yes	Yes	Califon	8 miles	15 min	Yes	201-832-7812
Conklin 201-852-2922	Yes	Yes	Hackettstown	20 miles	45 min	Yes	No
Country 201-537-2113	Yes	Yes	Hampton	2 miles	10 min	Yes	201-735-5448
Fox 201-735-5178	Yes	Yes	Clinton	3 miles	10 min	Yes	201-735-4224
Hunt-Bldg 201-782-5121	Yes	Yes	Flemington	10 miles	20 minutes	Yes	No
Hunt-Lum 201-735-7137	Yes	Yes	Annandale	1 mile	5 min	Yes	201-735-8131

SAND, GRAVEL, AND RIPRAP CONTRACTORS

Co.Name Telephone No.	Sand	Gravel	Riprap	Location	Approx. Distance to SR	Est. Travel Time	Trans. Avail.	24-hour Phone
Flemington 201-782-2021	Yes	Yes	No	Flemington	13 miles	30 min	Yes	No
Lentine 201-537-2135	Yes	Yes	Yes	Glen Gardner	1/4 mile	5 min	Yes	No
Oldwick 201-439-2131	Yes	Yes	Yes	Oldwick	7 miles	20 min	Yes	No

SAMPLE RESOURCE LIST

TABLE C-3. SPECIFICATIONS FOR ON-SITE EQUIPMENT

TYPE	QUANTITY	Housed at		CAPACITY
		CFOT	SRRV	
Aerial Ladder Truck	1	0	1	38-foot reach
Dump Trucks	4	0	3	5-yard, 8-ton
		1	0	2-yard, 3-ton
Front-end Loaders	3	0	3	M.F. Loader/Backhoe (3/4-yd. Bucket) Case Wheeled Loader (3/4-yd. Bucket) Cae Crawler/Loader (1/2-yd. Bucket)
Generators	3	2	0	(1) Portable 100 Volts (1) 3000 Watt
		1	0	(1) 3500 Watt
Pumps	7	0	4	(3) 150 GPM (1) 600 GPM
		3	0	(2) 140 GPM (1) 200 GPM
Rack Truck	1	0	1	2-1/2 Ton
Speed Loader	1	0	1	3-yd. Dump, 15-ft. Reach, 1/8-yd. Bucket
Tractors	11	0	11	(2) Slope Runners, 55 hp (1) Bug, 18 hp (2) Cubs, 20 hp (1) Kubota, 17 hp (1) Ford, 18 hp (1) Ford, 55 hp (1) International, 63 hp (1) MF, 61 hp (1) Hustler

CFOT: CANAL FIELD OFFICE IN TRENTON
SRRV: SPRUCE RUN/ROUND VALLEY RESERVOIR FACILITIES

TABLE C-4. A SUMMARY OF HEAVY EQUIPMENT AVAILABLE FROM OFF-SITE PRIVATE CONTRACTORS

Co. Name Telephone No.	EQUIPMENT				Loc.	Approx. Dist. to SR	Est. Travel Time	Trans. Avail.	24-Hr. Phone
	Bulldozers	Earthloaders	Backhoes	Dumptrucks					
Apgar 201-735-5248	1	1	1	2	Annandale	4 miles	10 minutes	Yes	735-5750
Aron 201-996-6281	2	0	2	2	Stockton	20 miles	45 minutes	Yes	Same
Barbiche 201-785-5422	2	2	3	5	Flemington	13 miles	30 minutes	Yes	Same
Barkman 201-832-7757	0	0	1	1	Califon	8 miles	15 minutes	Yes	Same
Barry 201-996-6689	0	2	1	1	Milford	8 miles	15 minutes	Yes	Same
Blaufuss 201-832-7751	1	1	2	1	Califon	8 miles	15 minutes	Yes	Same
Franke 201-782-6461	1	1	1	2	Ringoes	18 miles	40 minutes	Yes	Same
Kirk 201-782-6108	1	2	2	2	Flemington	13 miles	30 minutes	Yes	782-0664
Mannon 201-782-4770	4	4	4	7	Flemington	13 miles	30 minutes	Yes	782-6921
Poniatowski 201-782-3514	6	0	5	0	Flemington	12 miles	20 minutes	Yes	No
Williams 201-832-7603	0	0	1	1	Califon	6 miles	15 minutes	Yes	Same
Wright 201-832-7151	1	2	0	1	Glen Gardner	6 miles	15 minutes	Yes	638-8211
Zim 201-537-2531	1	1	1	1	Hampton	5 miles	10 minutes	Yes	Same

CONDITION-SPECIFIC OPERATING PROCEDURES

Condition I

1. Security guard (or public) observes:

   A DISLOCATION OR FAILURE OF ANY RESERVOIR STRUCTURE, WHICH ALLOWS FOR AN EXPANDING UNCONTROLLABLE DISCHARGE OF WATER THROUGH ANY OF THE DAMS, DIKES, FOUNDATIONS, OR ABUTMENTS INDICATING A BREACH IS OCCURRING.

2. If the public has observed a Condition I, the Dispatcher immediately sends the security guard to verify condition.

3. If the security guard observes the Condition I, he immediately notifies the Dispatcher of a Condition I at _____ structure(s).

4. Dispatcher repeats his understanding of Condition I to Security Officer;

   - if Security Officer agrees that this is in fact a Condition I, and
   - if there is no senior person on-site, Dispatcher begins warning procedure.

5. The Dispatcher radio-activates the sirens.

6. The Dispatcher notifies ENOS parties of a Condition I at _____ structure(s).

7. The Dispatcher notifies the Duty Officer.

8. The Dispatcher (under the direction of the Duty Officer) notifies the Primary Emergency Response Team (PERT) by emitting an emergency tone over the pagers.

9. Each member of the PERT will call the Dispatcher.

   a. The Dispatcher will inform them of a Condition I at _____ structure(s).

   b. The Dispatcher will make a list of who has called back and their expected time of arrival at the Site or the Administration Building.

10. The Dispatcher (under the direction of the Duty Officer or senior person on-site) recalls appropriate response teams using the Telediler 32, informing them that there is a Condition I at _____ structure(s) and to report to the Site or the Administration Building as soon as possible.

   - The Dispatcher will keep a list of those who have been called and their expected time of arrival at the Site or the Administration Building.

11. The Duty Officer (or senior person on-site) dismisses non-essential personnel if their presence might impair resolution of the situation.

12. The Duty Officer (or senior person on-site) directs attempts to reduce water head in the affected structure(s).

13. The Duty Officer (or senior person on-site) directs repair operations.

14. Every 15 minutes the Dispatcher (under the direction of the Duty Officer or senior person on-site) reports changes in the situation to ENOS by direct line or by radio.

15. If/When problem is resolved or situation stabilized, the Duty Officer (or senior person on-site) will terminate the emergency warning through ENOS by direct line or by radio.

ATTACHMENT 4-H

CRITERIA FOR DAM BREACH WARNING SYSTEM

o OPERATIONAL CRITERIA

- Signal sound must be unique, distinct and different in sound from that of civil defense and fire sirens.

- Signal devices must be sited to provided warning for all people who live/work within 30 minutes of the flood wave arrival (from the breach - the time line as determined in the dam break analysis and inundation studies).

- There will be a primary and secondary (back-up) method for activation of the signal system.

- Each signal device will have battery back-up for activation in the event of primary power failure.

- Each signal device will have a secure power cut-off switch to turn the devices off in the event of a false or unintentional activation.

- Alternative devices may be approved for small, isolated groups of people.

- Ownership and maintenance responsibilities for the system remain with the dam owner/operator.

o LOCATION CRITERIA

- The signal device should be installed on structures located in, outside of, or at a higher elevation than the area of inundation, typically at an elevation of 50 feet above ground surface.

- The signal device should be located in areas of highest ambient noise and removed from nearby residences where possible.

- The signal device, when possible, should be sited on public buildings or property. They may also be sited on owner/operator property when practical.

o ACOUSTICAL CRITERIA

- The system must be designed to provide for 100 percent notification of the threatened population.

- The minimum audible warning in threatened areas should be 75dB.

- Persons should not be exposed to the sound of an outdoor warning signal exceeding 123dB.

- PROCUREMENT CRITERIA

  - Vendors must demonstrate that their signal device can produce a unique, distinct, and different sound from that of civil defense or fire sirens.

  - Vendors will provide a minimum of three references to customers using their product. One of the references must have used the product a minimum of three years.

SECTION 5

PLAN OUTLINE

GENERAL INFORMATION

The plan outline listed in this section has been developed after considering plan outlines from many other sources including FEMA's Outline for Dam Emergency Action Plans and the general "Emergency Operating Plan", outline used by the Emergency Management System. The use of this outline is required for standardization benefits applicable to management, training, and use. New Jersey Office of Emergency Management (NJ-OEM) will consider wavers regarding use of the outline when justified by unique situations.

OUTLINE

I. INTRODUCTION

- A. Purpose and Scope
- B. Dam - Site Description
- C. Identification of Hazard Area
- D. Authority

II. SITUATIONS AND ASSUMPTIONS

- A. Situations
  - 1. Dam General Condition
  - 2. Other
- B. Assumptions
  - 1. Probable Failure Modes
  - 2. Weather Factors
  - 3. Human Factors

III. CONCEPT OF OPERATIONS

A. General

B. Owner/Operator

C. Other

IV. ORGANIZATION AND RESPONSIBILITIES

A. Organization

1. Owner/Operator

2. Emergency Management

3. Other

B. Responsibilities

1. Owner/Operator

2. Emergency Management

3. other

V. IDENTIFICATION OF EMERGENCY CONDITIONS *

VI. EMERGENCY NOTIFICATION SYSTEM * (2)

VII. EMERGENCY CONTROL ACTIONS * (3) (4)

VIII. EMERGENCY TERMINATION AND RECOVERY

A. Termination

1. Critique

2. After Action Report

B. Recovery

1. Security

2. Damage Assessment

3. Disaster Declaration

IX. TRAINING *

X. ADMINISTRATION OF PLAN

A. Responsible Agencies

B. Distribution

C. Review/Change/Updating Procedures

ANNEXES A to __ (Numbered alphabetically as needed) (6)

APPENDICES 1. to __ (Numbered numerically as needed) (7) (8)

NOTES:

1. Asterisk (*) sections in the Outline were left without recommended sub-divisions to allow greater flexibility in tailoring the material to meet Dam/Site specific needs and owner/operator uniqueness.
2. Details such as specific phone numbers, radio frequencies, additional procedures and other information that might compromise the security and effectiveness of the emergency response will be reflected in the Communications Annex (for limited distribution control).
3. Emergency repair actions and emergency repair resources may be covered in this section, or partly in this section with more detailed information included in Annexes and Attachments.
4. Evacuation actions will be found in specific annexes prepared by the owner/operation and municipal emergency management coordinators for their own areas of responsibility.
5. Checklists and SOP's will be prepared and included as attachments wherever appropriate.
6. Annexes will be prepared by:

    a. Owner/Operator

        (1) Internal Operating Procedures (optional)

(2) Communications

b. Emergency Management

(1) New Jersey - OEM

(2) Each County OEM Involved

(3) Each Municipal OEM Involved

c. Volunteer and Other Agencies

(Which have accepted responsibilities under the plan).

7. The inundation map(s) prepared from the dam break analysis will be appended to the EAP.

8. The map depicting the area covered by the Dam Breach Warning System (DABREWS) will be appended to the EAP.

9. Attachments may be included to any section, annex, or appendix as required. They will be numbered alphabetically (A to ___ as needed) for sections and appendices. Attachments to annexes will be numbered numerically (1 to _____ as needed).

SECTION 6

ANNEXES

GENERAL INFORMATION

Annexes will be prepared by all agencies who have been assigned or accepted responsibilities in the "Basic" Plan. The purpose of the annex is to reflect "how" the agency will implement it's responsibilities. Annexes may also be utilized to reflect sensitive information which (for security and effective response reasons) will be limited in distribution. This type of annex will not be available in copies of the plan distributed outside of the owner/operator and the Emergency Management System (i.e. Public Library). The use of this outline is required for standardization benefits applicable to management, training, and use. The New Jersey Office of Emergency Management (NJ-OEM) will consider wavers regarding use of the outline when justified by unique situations. The topics in the outline apply only to the area and functions falling within the responsibilities and jurisdictions of the agency preparing the annex.

OUTLINE

I. INTRODUCTION

A. Purpose and Scope

B. Dam name, location, direction and distance from agency preparing annex.

C. Identification of Hazard Area (within jurisdiction). (2)

D. Authority (include local ordinances).

II. SITUATIONS AND ASSUMPTIONS

A. Situations

B. Assumptions

III. CONCEPT OF OPERATIONS

A. General

B. Agency

C. Other

IV. ORGANIZATION AND RESPONSIBILITIES

A. Organization

1. Agency

2. Other

B. Responsibilities

V. INTERNAL TASKING (3)

VI. EMERGENCY NOTIFICATION SYSTEM

A. Twenty-four Hour Reception Point

B. Alert/Notification of Key Officials

C. Implementing Public Warning

VII. EMERGENCY RESPONSE ACTIONS

A. General

B. EOC Activation and Operations

C. Public Warning

D. Opening Reception Centers and Shelters

E. Implementing Evacuation

1. Traffic Control Check Points

2. Transportation Assistance

3. Special Assistance Requirements

4. Area Inspection and Security

5. Access Control Check Points

6. Rescue and Recovery Operations

F. Dam Emergency Checklist/SOP's

1. Dam Breach Condition

2. Dam Emergency Condition

3. Dam Warning Condition

4. Dam Advisory Condition

VIII. EMERGENCY TERMINATION AND RECOVERY

A. Termination

1. Critique

2. After Action Report

B. Recovery

1. Security

2. Damage Assessment

3. Disaster Declaration

IX. TRAINING

X. ADMINISTRATION OF ANNEX

A. Responsible Agencies

B. Distribution

C. Review/Change/Updating Procedures

ATTACHMENTS 1 to ___ (numbered numerically as needed and and marked section or sub-section they are supporting).

NOTES:

1. The heading and title of the annex should read/look like the following sample:

   ANNEX A TO WATERFALL DAM EAP

   WASHINGTON TOWNSHIP, WHAT EVER COUNTY.

2. Use street names, landmarks, development names, etc., to clearly identify hazard area that would be flooded/damaged if the dam breached (according to inundation maps).

3. All responsibilities assigned/accepted as reflected in Section IV B, must be tasked or assigned to some department or functioning unit within the agency for action.

SECTION 7

PLAN APPROVAL AND ADMINISTRATION

GENERAL

The owner/operator is responsible for the publication and distribution of the Emergency Action Plan (EAP), including Annexes and Appendices. However, should any contributing agency fail to submit their annex to the owner/operator within the agreed time frame, they will become responsible for publication and distribution (of the annex).

PREPARATION

The complete EAP should be printed on good quality paper with the print large enough for easy reading. The Plan must also be printed with sufficient margins to allow hole punching for filing the Plan in a loose leaf notebook cover. Each page will have the printing date in the lower right hand corner and the page will be numbered so as to identify the section, annex, attachment etc., to which the page belongs.

APPROVAL

All EAP's will be approved by the New Jersey Office of Emergency Management (NJ-OEM) and by the New Jersey Department of Environmental Protection, Division of Water Resources, Bureau of Flood Plain Management, Dam Safety Section (NJ-DSS) for dam break analysis, inundation studies, and owner/operator emergency repair response. The final draft will be submitted in two copies to:

New Jersey State Police
Office of Emergency Management
River Road, Box 7068
West Trenton, New Jersey 08625-0068

Attention: Dam Safety Officer

NJ-OEM will forward one copy to NJ-DSS for their review and approval. When the review (with any required changes) has been completed, NJ-OEM/NJ-DSS will issue the owner/operator an approval page for insertion/printing with the approved plan.

WAIVERS

Request for waivers or changes to any requirement in Part IV of this manual, the Dam Emergency Action Planning Guide, will be submitted to NJ-OEM at the same address shown in the "Approval" paragraph (in this section). The letter requesting the waiver will clearly identify which requirement(s) the waiver is requested for and why the waiver is being sought. Documentation supporting such requests is required.

DISTRIBUTION

The total number of copies for each plan and their distribution will be determined during development by the owner/operator in coordination with NJ-OEM/NJ-DSS.

PLAN REVISIONS

Normally revisions to a plan are required on an annual basis. However, any changes that would have an adverse effect upon emergency response and public safety will be made immediately through a "Change Notice" issued by the responsible agency creating the change as an "Immediate Action Change". The immediate action change notice may request a "Pen and Ink"

correction of the previous material if the change is small and there is space in the area on the page being changed to pen in the new information. When a "pen and ink" change is not feasible, a new printed page for insertion must be provided with the "Immediate Action Change Notice". Please note the "immediate action change notice" for correction is only permitted for immediate changes which would effect emergency response and public safety.

The regular "Annual Revision Change" will always have "new pages" printed for insertion in the plan. The anniversary of the publication date is the required date for the annual revision unless a different date is negotiated with NJ-OEM.

Attachment 7-A show samples of immediate action and annual revision "change notice" cover sheets and changed material pages which will be followed for standardization in maintaining EAP's in New Jersey.

Revisions that are only updating material (i.e. phone numbers, titles, organizational charts, etc.), do not have to be approved by NJ-OEM/NJ-DSS prior to distribution. Revisions changing policy and/or procedures will require review and approval by NJ-OEM/NJ-DSS.

ATTACHMENT 7-A

SAMPLE CHANGE NOTICE

WATERFALL DAM EMERGENCY ACTION PLAN

CHANGE NUMBER 1 April 30, 1986

IMMEDIATE ACTION CHANGE

1. PURPOSE

This change corrects the secondary contact phone number for the State Warning Reception Point, in the Waterfall Dam EAP, Annex C, Attachment 1, Page C-1-1.

2. ACTION

Make the following "Pen and Ink" correction.

LOCATE: State Warning Receiption Point (609) 253-4233.

CHANGE TO: State Warning Receiption Point (201) 253-4233.

3. EFFECTIVE DATE

Immediate upon receipt.

(Signature)
John J. Jones, President
Plenty Water Company

ATTACHMENT 7-A

SAMPLE CHANGE NOTICE

WATERFALL DAM EMERGENCY ACTION PLAN

CHANGE NUMBER 2 May 1, 1986

IMMEDIATE ACTION CHANGE

1. PURPOSE

This changes the Title/name and definition of a dam breach or failure condition in the Waterfall Dam EAP, Section I, page 5.

2. ACTION

(SEE ATTACHED)

REMOVE: Page I-5, dated January 1986.

INSERT: Page I-5, dated May 1986.

3. EFFECTIVE DATE

Immediate upon receipt.

(Signature)
John J. Jones, President
Plenty Water Company

SAMPLE PRINTED CHANGE PAGE

Emergency Management - Municipalities

The municipal Office of Emergency Management is responsible for:

- warning the public of emergency conditions at SR/RV,
- implementing and directing required evacuations of threatened areas,
- establishing Reception Centers for evacuated people,
- securing and controlling access to evacuated areas, and
- conducting Rescue and Recovery Operations as required.

IDENTIFICATION OF EMERGENCY CONDITIONS

The major objective of dam emergency planning is to save lives and minimize damage. The first task in accomplishing this objective is the timely identification of emergency conditions. Procedures for identifying the four emergency conditions of varying severity follow.

DAM BREACH CONDITION

A failure condition is defined as:

- a dislocation or failure of any reservoir structure, which allows for an expanding, uncontrollable discharge of water through any of the dams, dikes, foundations, or abutments, indicating a breach is occurring.

Required Response. Evacuation, rescue, and recovery.

ATTACHMENT 7-A

SAMPLE CHANGE NOTICE

WATERFALL DAM EMERGENCY ACTION PLAN

CHANGE NUMBER 3 June 1, 1986

ANNUAL REVISION

1. PURPOSE

Provides new procedures for emergency repair actions and general updating of outdated/changed names/titles/phone numbers.

2. ACTION *

REMOVE	INSERT
Page I-5 (May 1986)	Page I-5 (June 1986)
Page A-2-1 (January 1986)	Page A-2-1 (June 1986)

3. EFFECTIVE DATE

June 1, 1986

(Signature)
John J. Jones, President
Plenty Water Company

* Paragraph 2 would be as many pages long as was necessary to list all pages being removed and those being inserted.

Emergency Management - Municipalities

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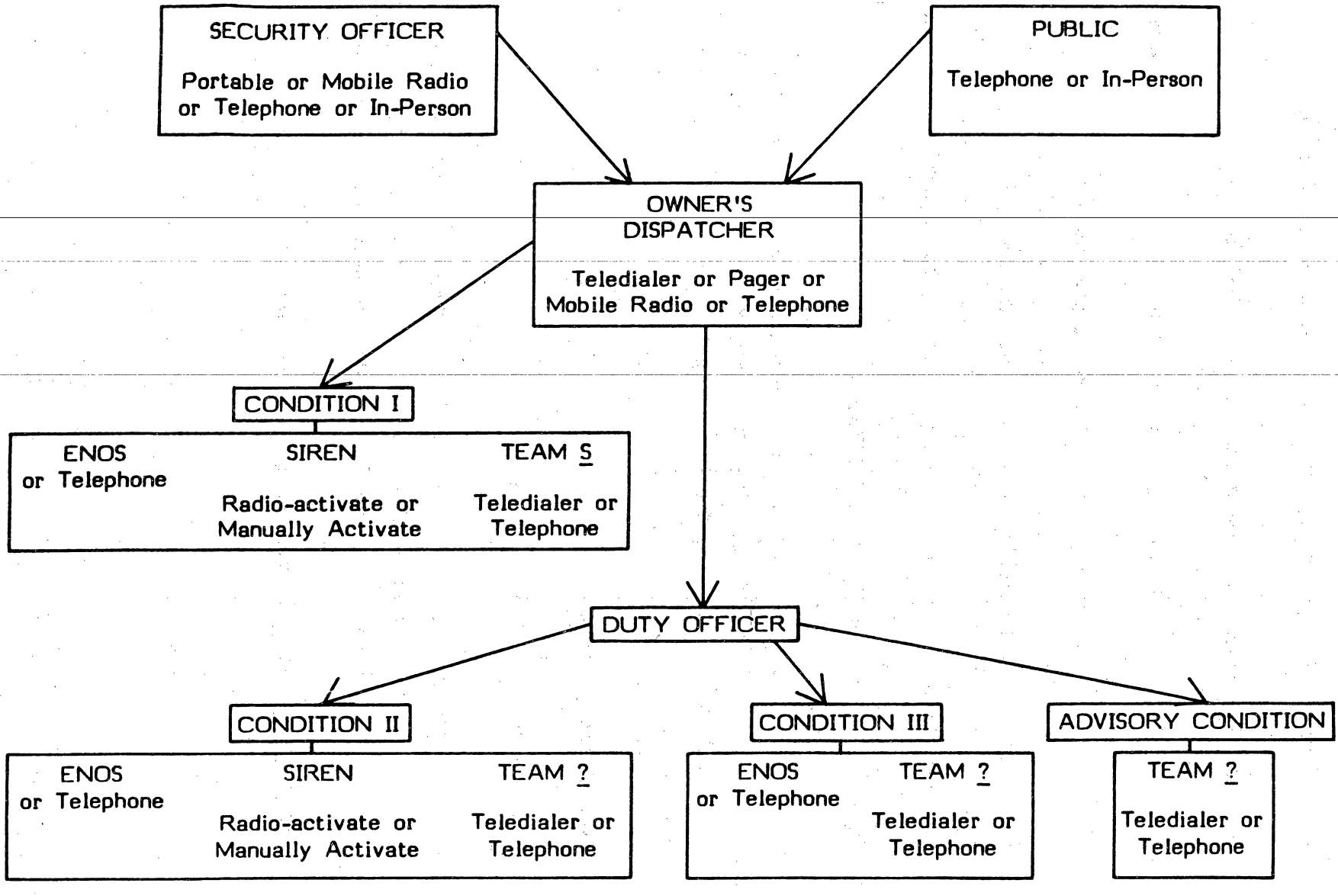
Required Response. Evacuation, rescue, and recovery.

FIGURE A-1. CHAIN OF EVENTS AND COMMUNICATION METHODS UTILIZED



APPENDEX

A

TYPES OF DAMS

AND

WHY DAMS SOMETIMES FAIL

CREDIT FOR COPYRIGHT MATERIAL

TO: NEW JERSEY DAM OWNER/OPERATORS
EMERGENCY MANAGEMENT PERSONNEL
ALL OTHER INTRESTED PERSONS

THE STATE OF NEW JERSEY, OFFICE OF EMERGENCY MANAGEMENT, WISHES TO EXPRESS OUR APPRECIATION TO PROFESSOR GEORGE F. SOWERS AND THE LAW ENGINEERING TESTING COMPANY FOR THEIR GRACIOUS PERMISSION TO REPRINT THE FOLLOWING PRESENTATION ON "TYPES OF DAMS AND WHY DAMS SOMETIMES FAIL." THIS MATERIAL PROVIDES EXCELLENT INFORMATION WHICH ALL OF OUR EMERGENCY MANAGEMENT PERSONNEL NEED TO UNDERSTAND, ESPECIALLY THOSE WHO ARE INVOLVED IN DAM EMERGENCIES.

JJ Craparotta

JOSEPH J, CRAPAROTTA, MAJOR
DEPUTY STATE DIRECTOR
OFFICE OF EMERGENCY MANAGEMENT

TYPES OF DAMS AND WHY DAMS SOMETIMES FAIL

DAM SAFETY WORKSHOP, FEMA REGION II

BY

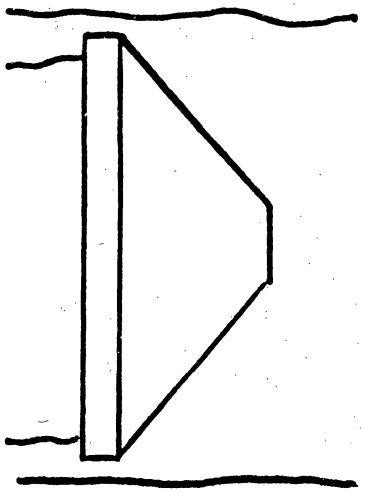
GEORGE F. SOWERS

SENIOR CONSULTANT, LAW ENGINEERING TESTING COMPANY
REGENTS PROFESSOR OF CIVIL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY

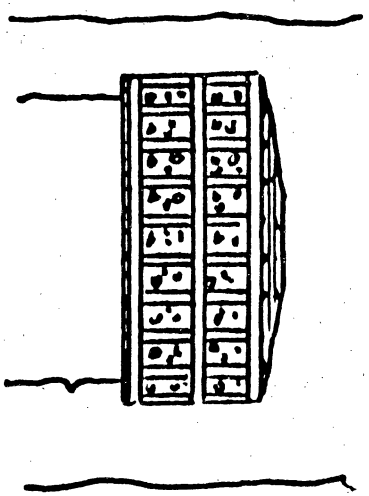
LAW ENGINEERING
TESTING COMPANY

GEORGIA
TECH

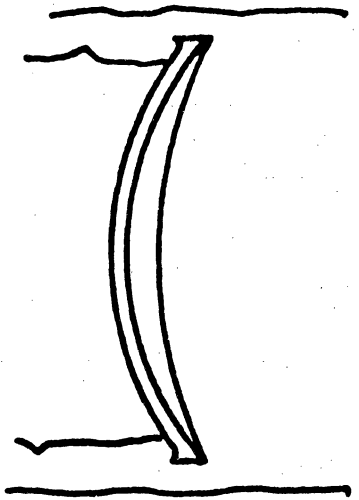
STRUCTURAL DAMS



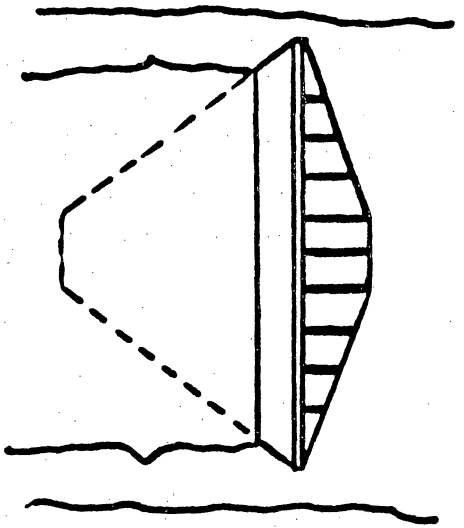
Gravity Masonry-Plan



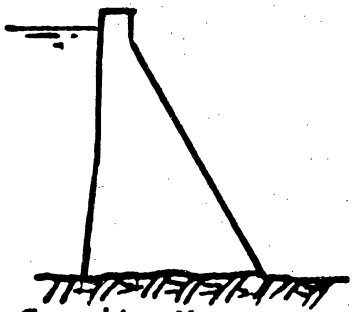
Crib - Plan



Arch-Plan



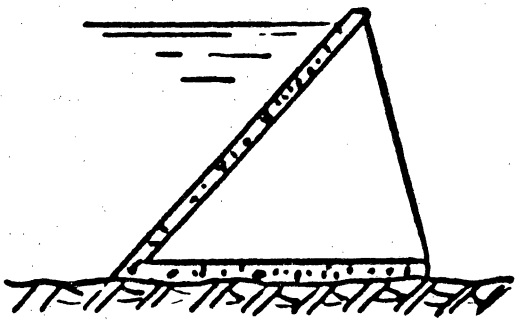
Buttress or Framed Timber-Plan



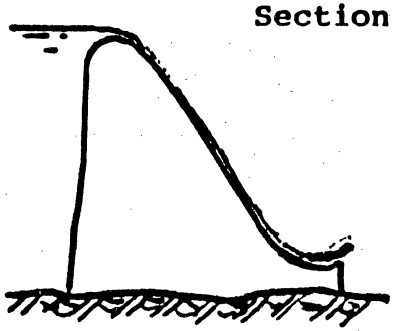
Gravity Masonry-Section

Crib - Section

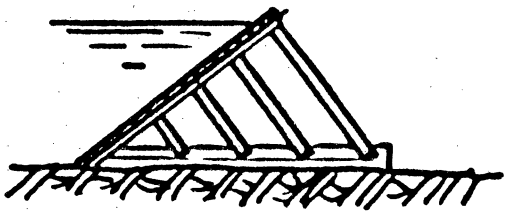
Arch-Section



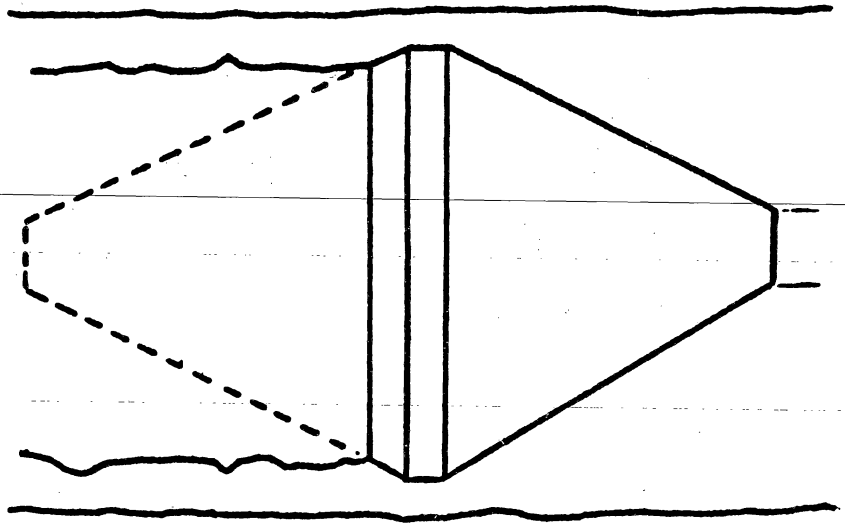
Buttress -Section



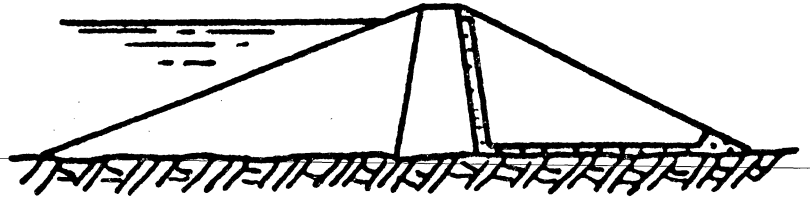
Gravity Masonry-Overflow



Framed Timber - Section

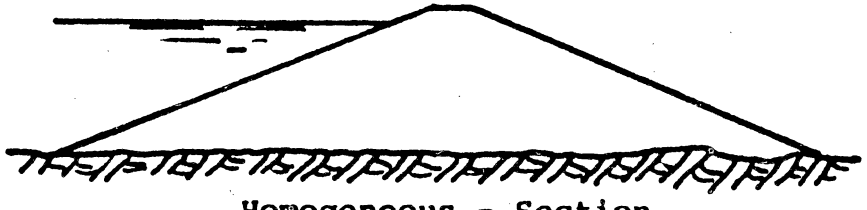


Plan

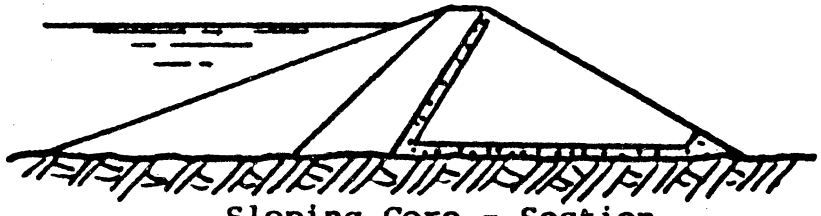


Central Core - Section

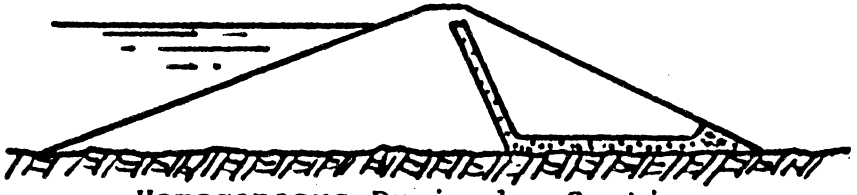
Hydraulic Fill - Section



Homogeneous - Section

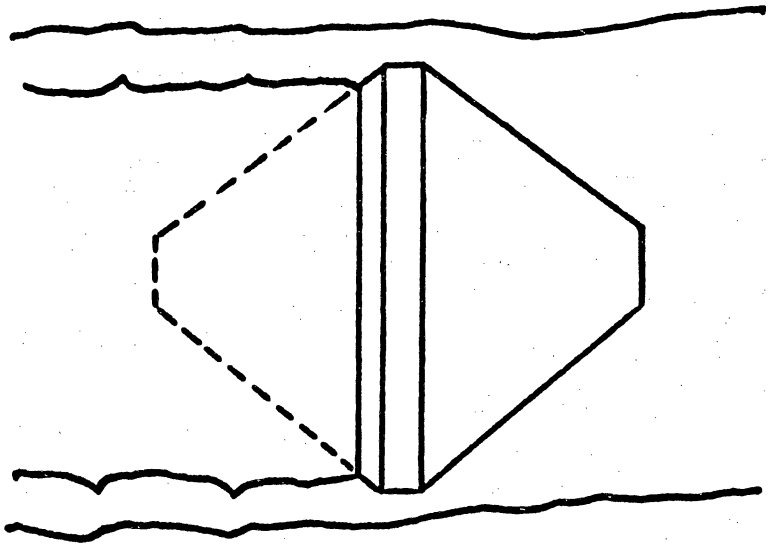


Sloping Core - Section

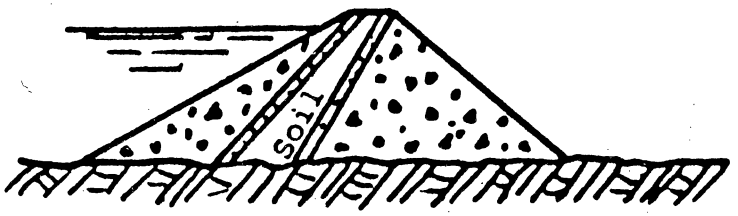


Homogeneous Drained - Section

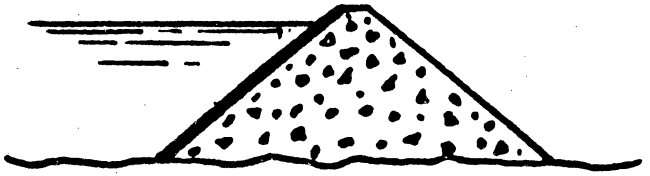
EARTH DAMS



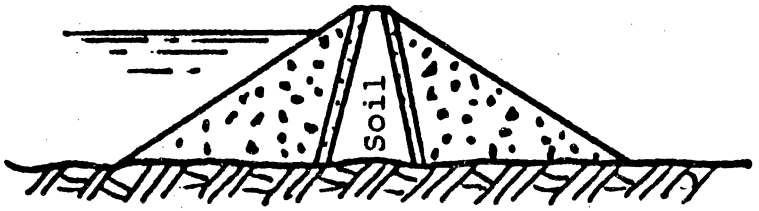
PLAN



Sloping Core - Section

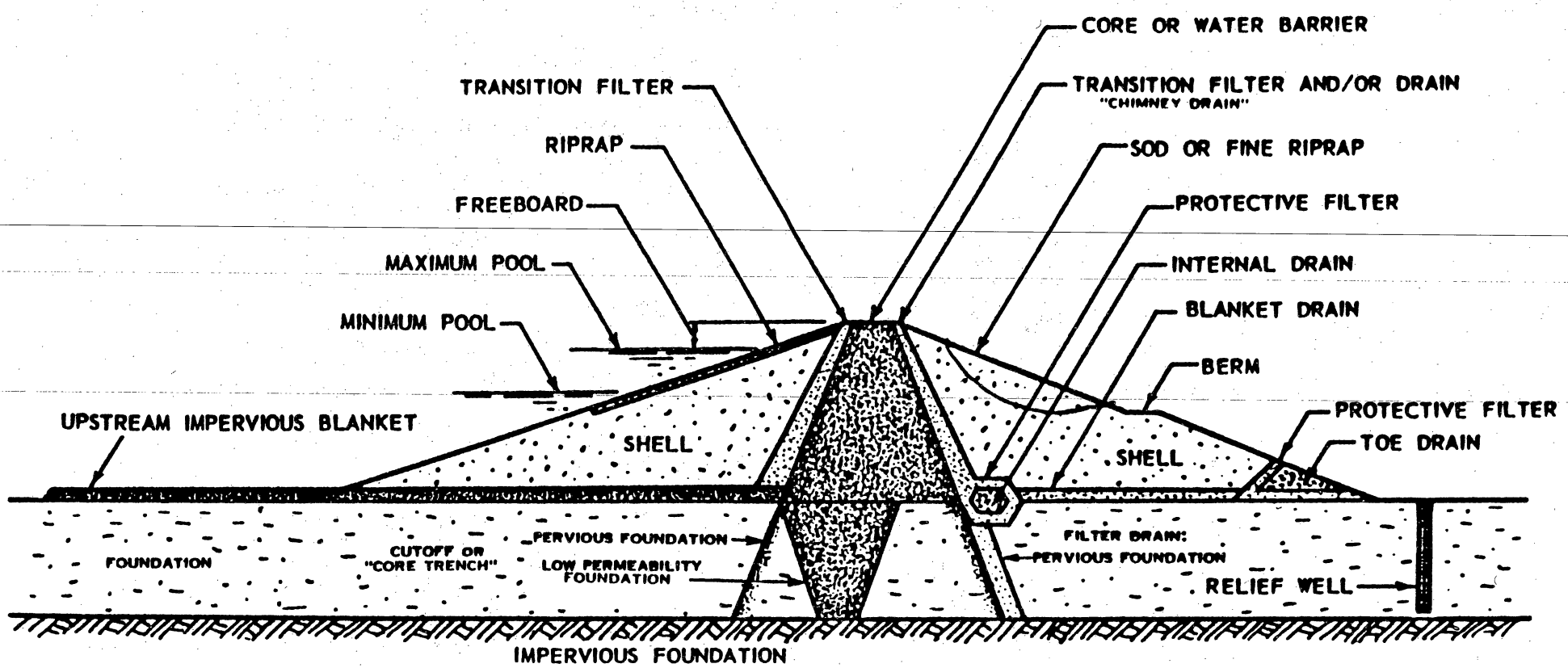


Membrane - Section



Central Core - Section

ROCKFILL DAMS



NOTE: Not all of these components are ordinarily incorporated into any one dam.

PARTS OF AN EARTH DAM

Modes of Dam Failure

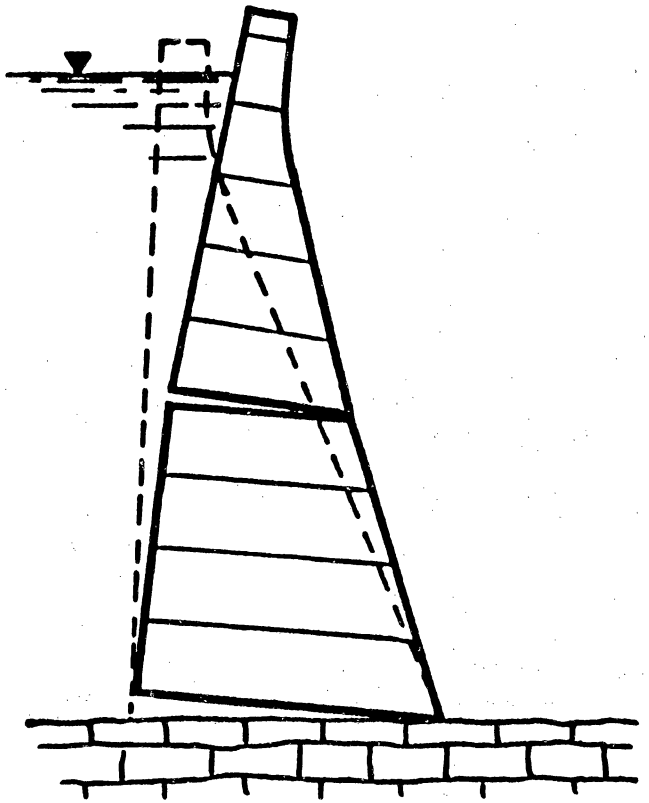
1. Hydraulic
   a. Spillway; Overtopping
   b. Surface Erosion
2. Mechanical: Water Control Systems
3. Seepage
   a. Foundation
   b. Dam
4. Structural
   a. Foundation
   b. Dam

Dam Failure Lessons

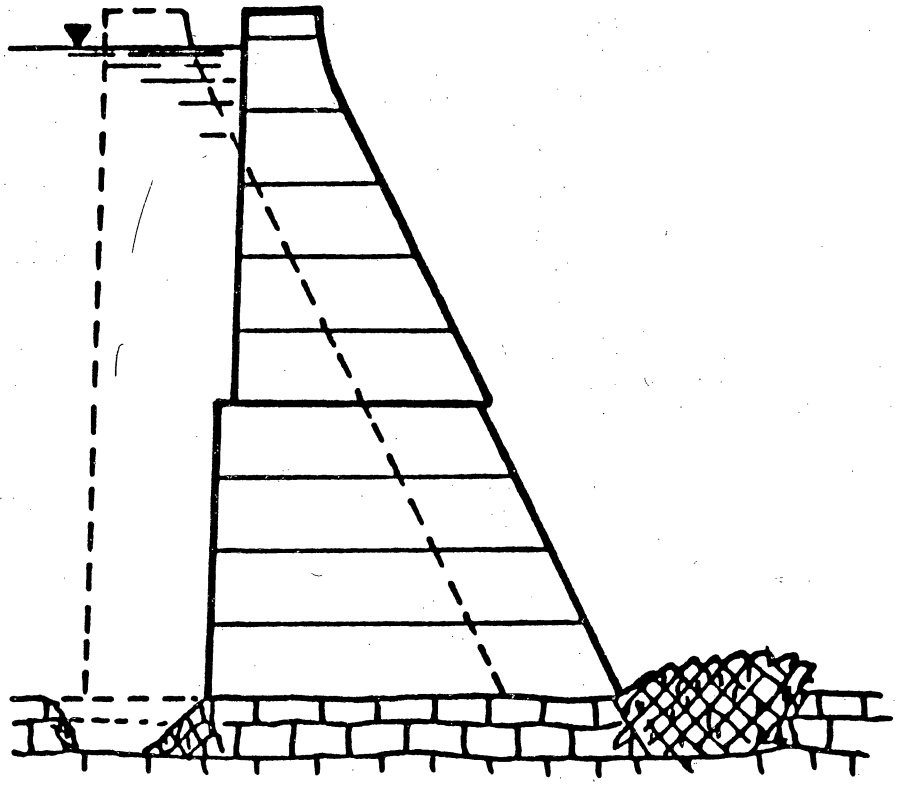
1. Design Deficiencies
   a. Rely on Rules Alone
   b. Uncoordinated Design
   c. Ignore Geologic Discontinuities
   d. Ignore Construction Sequence
2. Construction Deficiencies
   a. Cost-Saving Short Cuts
   b. Limit Field Inspection, Field Testing
   c. Ignore Differences Between Design Criteria and Site Conditions
   d. Limit Design - Construction Communication
3. Operation Deficiencies
   a. No Regular Inspection
   b. No Maintenance
   c. No Downstream Land Use Restriction
   d. No Distress Warning System
   e. No Evacuation Plan

EARTH AND ROCKFILL DAM FAILURES

FORM	CHARACTERISTICS	CAUSES	PREVENTIVE OR CORRECTIVE MEASURES
HYDRAULIC FAILURES (30% of all failures) more in dams under 50 ft			
Overtopping	Flow over embankment, washing out dam	Inadequate spillway capacity	Spillway designed for maximum flood
		Clogging of spillway with debris	Maintenance, trash booms, clean desi
		Insufficient freeboard due to settlement, skimpy design	Allowance for freeboard and settlem design; increase crest height or add flood parapet
Spillway Failure	Erosion of Spillway	Bad Concrete, inadequate hydraulic design	See Above
Wave erosion	Notching of upstream face by waves, currents	Lack of riprap, too small riprap	Properly designed riprap
Toe erosion	Erosion of toe by outlet discharge	Spillway too close to dam	Training Walls
		Inadequate riprap	Properly designed riprap
Gullying	Rainfall erosion of dam face	Lack of sod or poor surface drainage	Sod, fine riprap; surface drains
SEEPAGE FAILURES (40% of all failures)			
Loss of water	Excessive loss of water from reservoir and/or occasionally increased seepage or increased ground water levels near reservoir	Pervious reservoir rim or bottom	Blanket reservoir with compacted clay or chemical admix; grout seams, cavities
		Pervious dam foundation	Use foundation cutoff; grout; upstream blanket
		Pervious dam	Impervious core
		Leaking conduits	Watertight joints; waterstops; grouting
		Settlement cracks in dam	Remove compressible foundation, avoid shar changes in abutment slope, compact soils a high moisture
		Shrinkage cracks in dam	Use low plasticity clays for core, adequat compaction
Seepage e ion or ; ng	Progressive internal erosion of soil from downstream side of dam or foundation backward toward the upstream side to form an open conduit or "pipe". Often leads to a washout of a section of the dam.	Settlement cracks in dam	Remove compressible foundation; avoid shar changes; internal drainage with prot n filters
		Shrinkage cracks in dam	Low plasticity soil; adequate compaction; internal drainage with protective filters
		Pervious seams in foundation	Foundation relief drain with filter; cutof
		Pervious seams, roots, etc. in dam	Construction control; core; internal drain age with protective filter
		Concentration of seepage at face	Toe drain; internal drainage with filter
		Boundary seepage along conduits, walls	Stub cutoff walls, collars; good soil compaction
		Leaking conduits	Watertight joints; waterstops; durable materials
		Animal burrows	Riprap, wire mesh
STRUCTURAL FAILURES (30% of all failures) less in dams under 50 ft			
Foundation slide	Sliding of entire dam, one face, or both faces in opposite directions, with bulging of foundation in the direction of movement	Soft or weak foundation	Flatten slope; employ broad berms; remove weak material; stabilize soil
		Excess water pressure in confined sand or silt seams	Drainage by deep drain trenches with pro tective filters; relief wells
Upstream slope	Slide in upstream face with little or no bulging in foundation below toe	Steep slope	Flatten slope, or employ berm at toe
		Weak embankment soil	Increased compaction; better soil
		Sudden drawdown of pond	Flatten slope; rock berms; operating rul
Downstream slope	Slide in downstream face	Steep slope	Flatten slope, or employ berm at toe
		Weak soil	Increased compaction; better soil
		Loss of soil strength by seepage pressure or saturation by seepage or rainfall	Core; internal drainage with prote filters; surface drainage
Flow slide	Collapse and flow of soil in either upstream or downstream direction	Loose embankment soil of low cohesion triggered by shock, vibration, seepage, or foundation movements	Adequate compaction

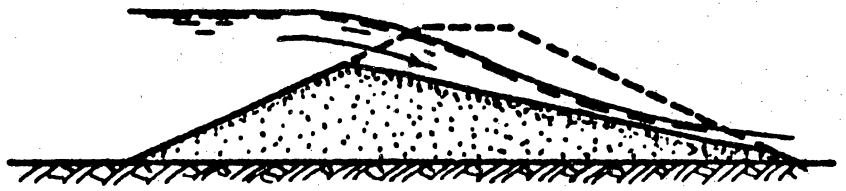


OVERTURNING

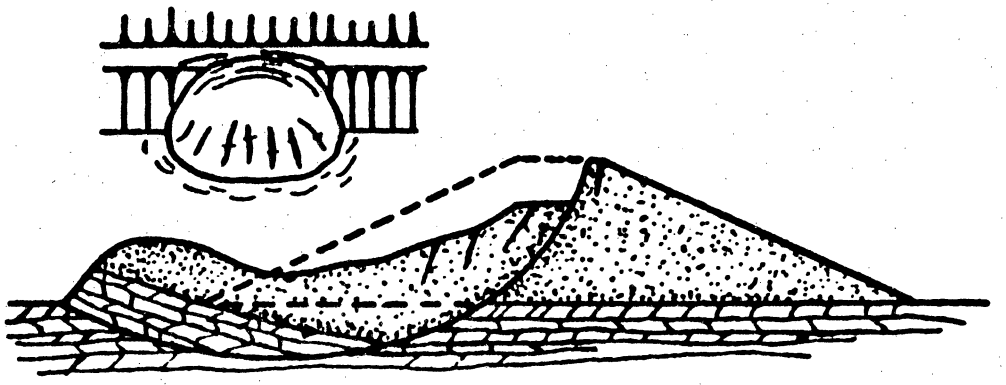


SLIDING

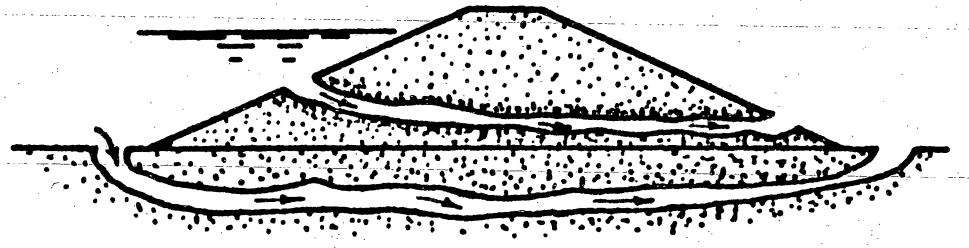
MASONRY DAM STABILITY



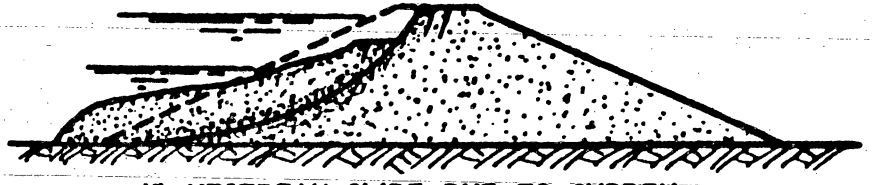
(a) OVERTOPPING WASHING OUT EMBANKMENT



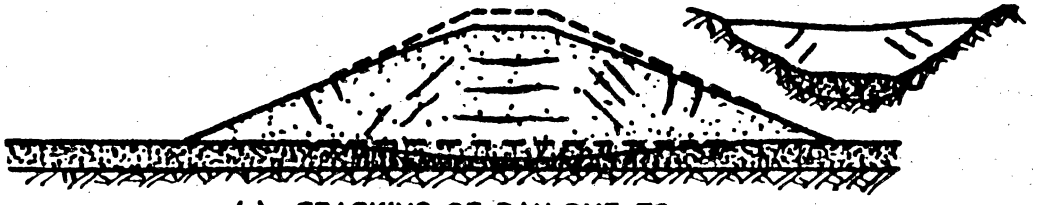
(e) SLIDE DUE TO WEAK FOUNDATION



(b) SEEPAGE EROSION OR PIPING THROUGH THE DAM AND/OR ITS FOUNDATION

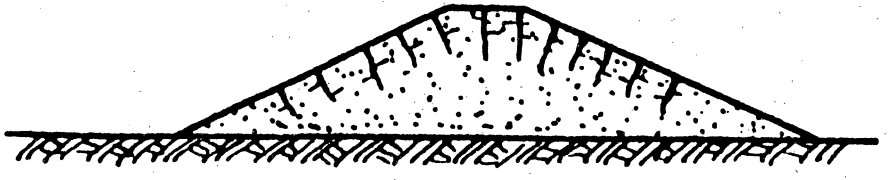


(f) UPSTREAM SLIDE DUE TO SUDDEN DRAWDOWN OF RESERVOIR

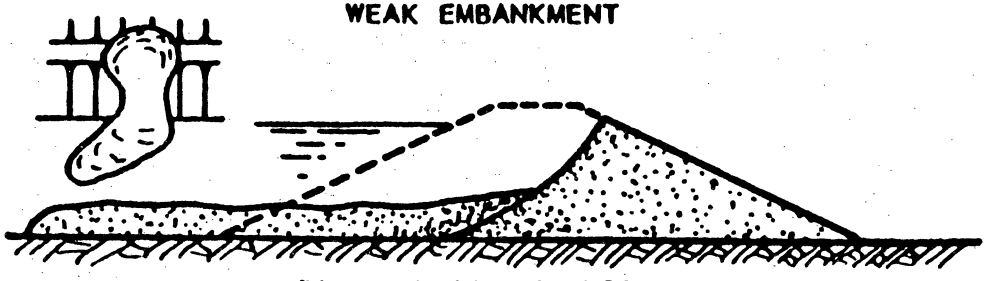


(c) CRACKING OF DAM DUE TO FOUNDATION SETTLEMENT

(g) DOWNSTREAM SLIDE DUE TO WEAK EMBANKMENT



(d) CRACKING OF DAM DUE TO DESICCATION AND SHRINKAGE



(h) FLOW SLIDE IN LOOSE FINE SAND OR SILT

FAILURES OF EARTH DAMS

Inset c shows elevation, insets a, g, h. show plans of fail----

CHECKLIST OF CONDITIONS TO BE NOTED ON REGULAR DAM INSPECTIONS

by

G. F. Sowers, C. Sams, L. D. Wheeless, P. H. Goodling

Consultants, Law Engineering

1. Embankment Dam

   A. Freeboard - pond level

   B. Crest

   * (1) Cracking
   ** (2) Subsidence

   C. Upstream Face

   (1) Cracking: Parallel to crest, upstream-downstream* or arc-shaped*
   ** (2) Surface erosion, gullying
   ** (3) Wave erosion
   (4) Muskrat burrows

   D. Downstream Face

   (1) Vegetation: Overgrowth, requiring cutting, incomplete cover-requiring repair
   (2) Cracking: Arc-shaped*; parallel to crest*; upstream-downstream*
   ** (3) Subsidence
   * (4) Bulging
   ** (5) Erosion, gullies

   (a) Depth
   (b) Moisture on dry days

   ** (6) Damp areas, wet ground vegetation, softspots
   * (7) Boils, seeps, sand or silt trails downhill

   E. Berms and Toe of Dam

   ** (1) Erosion, gullies
   ** (2) Damp areas, rapid growth of wet-type vegetation
   * (3) Seeps, boils, sand cones, sand or silt trails

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* Critical Conditions: Require immediate action
**Potential Trouble: Watch closely

2. Masonry Dam

**A. Alignment of top
B. Condition of masonry

** (1) Spalls, bulges
** (2) Disintegration
** (3) Junction with other structures

C. Seepage

(1) Seeps, surface stains, icicles
** (2) Changes in seeps, surface stains occurring in less than a month

3. Spillways

A. Intake level, indicator systems

* B. Intake structure, gate machinery, Gate C

C. Discharge conduit condition

*D. Seepage or damp areas around conduits

**E. Erosion downstream of conduit

*F. Boils or holes in vicinity of conduit (earth embankments)

*G. Vegetation or blockages of unlined spillway on abutment

H. Training wall: seeps

**I. Chute, flume floor: seeps, *bulges, cracks

4. Abutments and Downstream

** A. Cracks, subsidences, tilting trees

* B. Seeps, boils, sand trails

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* Critical Conditions: Require immediate action
** Potential Trouble: Watch Closely

C. Wet-ground vegetation

D. Drain ditches

(1) Water Flow
(2) Boils, sand or silt trails
(3) Clogging with debris or vegetation

5. Areas of Previous Repairs

A. Effectiveness of Repair

B. Progression of trouble into new area

*Critical Conditions: Require immediate action
**Potential Trouble: Watch Closely