STANDARD OPERATING PLAN

FOREWORD

The Standard Operating Plan (SOP) is intended as a private document to be shared by the dam owner/operator and Utah Dam Safety.

Utah Dam Safety, under direction of the State Engineer, has the responsibility to inspect dams throughout the state. Many of the problems encountered are directly related to poor maintenance or improper operation of the dam. The objective in formulating an SOP is to provide the greatest possible assurance of the safety of the dam and continuous operation of the reservoir. An effective plan provides all the information and instructions necessary to allow the dam owner and/or operator to perform all actions required to operate the dam safely. Among the items addressed are the operation of valves and headgates, periodic inspection of the dam, monitoring the dam's performance, recording and interpreting the results of the inspection and monitoring, and performance of all required maintenance.

This document is a guide and may be used as a template to write a Standard Operating Plan, but is not exclusive. An SOP can be written in any format that suits the Owner but needs to comply with the Utah Administrative Code R655-12-4.

Utah Dam Safety published the "Utah Dam Safety Guide to Routine Maintenance of Dams". This publication provides guidance on how to integrate the SOP with day-to-day operation and maintenance. Both this SOP development document and the routine maintenance guide are intended as general guidelines and consideration should be made for site-specific conditions at each dam. Additional assistance from an experienced consulting engineer may be helpful. Supplementary guidance and site-specific detail is available from Utah Dam Safety.

This document was originally prepared by Matthew C. Lindon in 1991 and was revised in 2019.

David K. Marble, P.E.
Assistant Utah State Engineer / Dam Safety
March 2019

STANDARD OPERATING PLAN

CHAPTER 0.0

PREFACE - INSTRUCTIONS FOR PREPARING SOP'S

0.1 PURPOSE

Standard Operating Plans are prepared to establish operating instructions for each dam in the state of Utah in accordance with Utah Code, Section 73-5a-402. The purpose is to ensure adherence to approved operating procedures over long periods of time and during changes in operating personnel. The instructions also permit persons knowledgeable in reservoir operation, but unfamiliar with the conditions of a particular dam, to operate the dam and reservoir during an emergency situation and at times when regular operators cannot perform their normal duties.

As a minimum, the SOP should contain all information and instructions necessary for operators to perform their duties. By preparing and using an operating plan, the dam owner and/or shareholders can expect these **benefits**:

- Assuring the safety of the dam and continuous operation of the reservoir
- Avoiding the waste of stored water by having it under control at all times
- Minimizing the need for costly repairs
- Extending the useful life of the structure

Assembling the required information and writing the operating plan is the responsibility of the dam owner. The information provided here is meant to act as a guide to assist the owner in preparing their operating plan. Additional assistance from an experienced consulting engineer may be helpful.

Because of the variation in size and complexity of dams in Utah, the SOP section headings to be included and the detail required will vary. In addition, some SOP's unusual dam and reservoir conditions may require more topical headings than previously listed. Nevertheless, the suggested contents can be adapted readily for use at all dams and reservoirs. This guide includes a complete SOP checklist as an aid. It is suggested that appendix A be reproduced and used as an outline in formatting the SOP.

0.2 CONTENTS

Preface 0.0 - Instructions for Preparing SOP's - Summarizes information and instructions that an SOP encompasses.

Chapter 1.0 - SOP Preliminary Pages and Communications Directory - Includes communications, responsibilities, and precautionary measures to be observed.

Chapter 2.0 - General Information - Contains information and instructions concerning administration of the dam, and SOP distribution and its revisions.

Chapter 3.0 – Electrical, Mechanical, Structural and Dam Instrumentation - Contains detailed descriptions and instructions for operation and maintenance of the dam and its appurtenant structures, instrumentation and equipment.

Chapter 4.0 - Reservoir Operations - Contains detailed instructions and information on all aspects of reservoir operation.

Chapter 5.0 - Appendixes - Contains SOP checklist, copies of selected supporting documents that complete the SOP.

0.3 EDITORIAL SUGGESTIONS

Each SOP should give clear, concise, and complete instructions since it is the manual used to operate and maintain the dam during normal and emergency conditions. A responsible person knowledgeable in reservoir operation, but unfamiliar with the operation and maintenance of a particular dam, should be able to read the SOP instructions and successfully and safely operate and maintain the dam, its structural appurtenances, and related equipment.

It is recommended to supplement step-by-step instructions in the SOP by using posted operating instructions, marked photographs, color-coding, and numbering to identify valves and switches mentioned in the operating instructions for the spillway, outlet works, and service equipment. Using these aids considerably simplifies the operating instructions and reduces the margin for error.

Some suggestions to **improve the quality** and to aid in the SOP draft composition are:

- Begin each major section on a new page
- Print **only** on one side of the paper
- Insert colored dividers in front of the SOP, Communications Directory, each chapter, and appendix
- Write clear, concise, complete sentences and paragraphs. Remember, the operator may be in a **crisis** situation and require operating information immediately
- Use lists rather than narrative to outline instructions and information whenever possible
- Reference all included drawings, figures, photographs, etc., included in the appendix, **at least** once in the text
- State the exact location of dam operator's copy - at the dam - under SOP Distribution (e.g., in office at dam operator's house, in desk at gatehouse, etc.)
- Use exact title of dam operating personnel throughout (e.g., dam tender, reservoir superintendent, ditch rider, power plant foreman)
- Avoid indefinite words (e.g., regular intervals, frequent, periodically)

Preparation of a dam and reservoir SOP requires a detailed review and analyses of the operation and maintenance procedures. Because this entails appreciable time and effort, effective management dictates the desirability of making certain reviews and studies before or simultaneously with the Emergency Action Plan - (EAP) preparation.

STANDARD OPERATING PLAN

CHAPTER 1.0

SOP PRELIMINARY PAGES AND COMMUNICATIONS DIRECTORY

1.1 SOP PRELIMINARY PAGES

1.1.1 Cover

The SOP and its Supporting Documents should be bound with fasteners to facilitate revisions. Covers should be a heavy, flexible, durable material, sized to match the chapter dividers. To help identify the SOP when shelved, the spine of the document should be labeled with “Standard Operating Plan (SOP)” and include the dam name and the five digit dam number (i.e., UT#####).

It is desirable to use an aerial photo of the dam and reservoir either on the cover or preferably as a front piece.

1.1.2 Title Page

The SOP should have a **title page** showing:

Name of Reservoir/Dam	Operating Entity
Dam Number	Date Published
Project and County	Regulating Entities

1.1.3 Letter of Transmittal

To control the location of each SOP copy, the letter of transmittal also should list the complete initial SOP Distribution. Subsequent letters of transmittal of official copies also should be inserted at this location in the SOP.

1.1.4 SOP Revision Sheet

The SOP revision sheet should be transmitted with the revised pages of the SOP. The revision sheet should be inserted after the letter of transmittal. This provides a quick, convenient method for checking that each copy is up to date. The sheet includes the revision number, date, and instructions whether to replace or add specific page numbers, drawings, etc. The revision number and date must be shown on the bottom of each revised page.

1.1.5 Certification of SOP Review by Operating Personnel

This SOP **subsection** contains the following:

- Receipt and initial review of SOP and SOP revisions
- Review of SOP at least on an annual basis
- Certification of SOP Review by Operating Personnel

1.1.6 Verification of SOP by Dam Safety Inspection Team

This SOP subsection provides procedures to be used by the Dam Safety Inspection team for all visits to the dam. The examination team is required to **verify** that:

- The current SOP is on hand and all revisions have been inserted.
- The Operating Log conforms to SOP requirements as described in the SOP Guide.
- The operating procedures observed during the review are in accordance with the SOP.
- The SOP Supporting Documents pertinent to the operation of the dam are available to the operating personnel.

Recommendations to correct any of the above items will be made in the Dam Safety Inspection Report.

1.1.7 SOP Preface

The SOP preface states the **purpose**; the following is a suggested statement:

> "SOP's for dams and reservoirs are prepared to establish in one primary controlled document (with associated supporting documents) the complete, accurate, current, structure-oriented operating instructions for each dam and reservoir and its related structures. The SOP purpose is to ensure adherence to approved operating procedures over long periods of time and during changes in operating personnel. The instructions also will permit responsible persons who are knowledgeable in reservoir operation, but are unfamiliar with the conditions at a particular dam, to operate the dam and reservoir during emergency situations and at such times when the normal duties of the regular operator cannot be performed.
>
> The SOP is prepared primarily for the use of operating personnel located at or nearest to the dam and their immediate supervisors who are assigned the responsibility for the operation and maintenance of the dam. This SOP CONTAINS, AS A MINIMUM, ALL INFORMATION AND INSTRUCTIONS NECESSARY FOR OPERATING PERSONNEL TO PERFORM THEIR DUTIES. Operating procedures shall not deviate from those stated in the SOP without appropriate authorization and shall be reviewed by qualified Dam Safety personnel."

1.1.8 Items of Special Importance

Any precautions, specific noteworthy directives, or construction and design problems at the specific dam should be noted in this subsection.

1.1.9 Table of Contents

The SOP contents lists all chapters, section headings, and page numbers (including the Communications Directory).

It is desirable that SOP drawings, charts, maps, and photos be numbered numerically as figures (exhibits within an appendix) and shall be referenced and similarly listed.

Most full-page tables, figures (exhibits), particularly those that are folded, should be assembled at the back of the SOP. Historical and current as-constructed drawings are to be included and used in preparing the SOP. In some cases, where a number of drawings are included in the SOP, it may be desirable to bind them into a separate appendix. Each Appendix should be labeled with a brief content title (i.e., Appendix A – Location and Access Map, Appendix B – Photographs, etc.).

1.2 EMERGENCY AND UNUSUAL CONDITIONS

1.2.1 General

Identify events which could happen or a condition which could develop that normally is not encountered in routine operations and that could reach emergency status and endanger the facility.

Refer also to the Standard Operating Plan Checklist and the Emergency Action Plan.

1.2.2 Communications Systems

Briefly describe communications systems available at the dam.

1.2.3 Telephone Report of Emergency or Unusual Conditions

Records of all phone or radio reports of emergency or unusual conditions and facility failure shall be maintained at all stages of the communications network.

Records at all levels are to be maintained to provide a continuing record of emergency activities at a facility for future reference and safety analyses of the structure.

1.3 SOP COMMUNICATIONS DIRECTORY

The SOP Communications Directory section should contain specific communication contact for all levels of responsibility, as well as any other pertinent Federal, State, Local, or private entities, emergency assistance agencies, public utilities, and any cooperators that the personnel and the supervisory office may need

to contact in case of an emergency.

Persons to be contacted should be **listed by**:

- Name
- Title
- Location
- Office and phone number
- mobile phone number
- Backup numbers (if necessary)

The Communications Directory should be prepared as a complete and separate document that can be reproduced.

Do not include phone numbers or names in the SOP text. To avoid revising the pages, use official titles. In the text, reference should be made to the Communications Directory at the beginning of the SOP for current phone numbers. When changes occur, a few sheets will need to be revised in the Communications Directory.

STANDARD OPERATING PLAN

CHAPTER 2.0

GENERAL INFORMATION

2.1 PURPOSE OF THE PROJECT

This subsection should **briefly**:

- Identify the dam and reservoir
- State the authorized purposes of the project
- Note the informal benefits

All major project features should be identified as well as other projects served.

A more detailed description of the dam should be under SOP Chapter 3.1 - "General Description of Dam".

2.2 DIRECTIONS AND ACCESS TO DAM

This subsection should state in detail pertinent information on access to the dam from easily identified points of origin under normal, adverse, and emergency conditions. Included information should:

- Describe the most expeditious routes of access to the dam
- Describe alternate routes to the dam where appropriate
- Evaluate the routes and their accessibility for year-round or emergency use (paved, gravel, dirt) under normal and adverse conditions
- Note the availability and use of special equipment for access (helicopter, snowmobiles, four-wheel-drive, etc.)

- Mention locations of nearest commercial and private airports
- Reference the project location map

The project location map (prepared for use during dam construction) commonly is included in the SOP. However, it should be current to reflect changes in road networks. The map should be clear and precise. In some cases, project maps may be suitable for use as location maps. For multiple dam projects, it may be desirable to revise one project location map to show current access routes to all dams on the project. For some SOP's, location maps have been prepared by reproducing portions of recent USGS topographic maps with the access routes clearly marked.

2.3 ASSIGNMENT OF RESPONSIBILITY

This subsection should identify clearly all areas of responsibility in the chain of command with respect to dam and reservoir operation and maintenance.

Responsibilities of Utah Dam Safety may be summarized as follows:

> Utah Dam Safety regulates the safety of dams for the purpose of protecting public safety. It is authorized to make rules controlling the construction and operation of dams including the design, maintenance, repair, removal and abandonment. The office furnishes guidelines for the preparation of **Standard Operating Plans,** and approves certain operating procedures identified in the SOP.
>
> Utah Dam Safety has the responsibility to inspect dams where failure would pose a threat to human life or could cause significant property damage. Following an inspection, maintenance necessary to keep the dam and appurtenant structures in satisfactory condition is specified to the owner, who is responsible for that maintenance. Depending on the severity of these deficiencies, orders may be issued for engineering studies, repairs, storage limitation, removal of the dam, breaching of the dam, or any other remedy appropriate to protect life and property.

This subsection should identify the person(s) having responsibility for each of the following **functions**:

- Equipment operation at the dam
- Forecasting reservoir inflows

- Directing flood releases
- Directing irrigation releases
- Recording reservoir and instrumentation data
- Various maintenance work

Modification of a dam and related structures and appurtenances cannot be accomplished without the concurrence of the State Engineer.

The SOP should also include instructions on the best methods to be used to facilitate maintenance of the dam.

For regularly scheduled duties which operating personnel perform, include lists of daily, weekly, and specific yearly interval activities. Schedules serve as a checklist for operating personnel as well as for use of other persons who may operate the dam.

The following Operating Personnel Scheduled Duties table illustrates a typical schedule for the type of duties performed.

OPERATING PERSONNEL SCHEDULED DUTIES

Dam and Reservoir

Daily

1. Record water surface elevation
2. Determine reservoir inflow
3. Record spillway discharges
4. Record canal releases
5. Check and record toe and drain Flows
6. Check security and safety Devices
7. Read weather gauges and record data (where available)
8. Make required changes in gates and valves
9. Check log or safety boom
10 Check spillway outflow channel for debris
11 Check instrumentation schedule
12 Record pertinent information in Operating Log

Monthly

Dam and reservoir

1. Check condition of:
   a. Crest of dam
   b. Upstream and downstream faces
   c. Visible portions of foundation
   d. Abutment contacts
   e. Galleries
   f. Spillway stilling basin
   g. Outlet works stilling basin
   h. Critical landslide areas
   i. Reservoir area
   j. Drainage systems; toe drains, gallery drains,
   k. Measuring devices
   l. Rodent problems
   m. Security and safety devices

Instrumentation

1. Take instrumentation readings:
   a. On a monthly basis
   b. On a <u>weekly</u> basis when reservoir exceeds 90% of its hydraulic height

Electrical System

1. Standby gasoline-engine-driven generator
   a. Run for minimum of 1 hour
   b. Keep battery charged
   c. Check gas supply
2. Replace light bulbs

Outlet Works

1. Grease hydraulic gate hanger
2. Check signs that warn public of hazards
   a. Near trash rack of intake structure
   b. Outlet works stilling basin
   c. At valve house

Spillway

1. Check for debris in inlet channel
2. Check operation of gates
3. Check fence condition and caution signs

Quarterly

Outlet Works

1. Operation instructions-up to date and legible
2. Check gate air vents
3. Clean gate control switchboxes

Spillway

1. Check and clear bridge drains

Semiannually

Outlet Works

1. Check hydraulic oil lines
2. Check oil reservoir level in hydraulic system
3. Lubricate gate rollers
4. Check rubber seals and seal clamp bar
5. Check outlet stems-lubricate

Spillway

1. Check paint on gates
2. Check mechanical hoist bearings and flexible coupling bearings
3. Check gear cases
   a. Hoist gear case, replace grease
   b. Spur gear units and gear motors

Electrical System and Equipment

1. Change oil in standby gasoline engine-driven generator
2. Check exposed electrical wiring
   a. Outlet works valve house
   b. Gate hoists

Annually

Outlet Works

1. Paint
   a. Metalworks
   b. Color-coded valves
   c. Woodwork and trim
2. Exercise gates and valves
3. Check condition of interior and exterior of outlet conduit

Spillway

1. Check and repaint metalwork
2. Examine stilling basin and downstream channel

Dam and Reservoir

1. Review the SOP/EAP
2. Control Vegetation
3. Control Rodents
4. Repair Erosion on Crest and dam faces

Electrical

1. Check electrical conduits, pull-boxes, and switches
   a. Outlet works valve house
   b. Gate hoists
   c. Spillway
   d. Galleries

The “Utah Dam Safety Guide to Routine Maintenance of Dam” (2003) can be downloaded from the Utah Dam Safety website and included as an appendix in the SOP document.

5-year Interval

1. Examine intake structure, upstream face and stilling basin which are normally under water.
2. Perform an internal video inspection of the outlet conduit. Submit an electronic copy to the State Engineer’s office.

Post Earthquake Inspection

Following any reported or felt earthquakes, inspection shall be made of the dam embankment and appurtenances for indications of physical damage such as cracks, displacements, and land movements. Refer to the Emergency Action Plan document for additional instructions during unusual occurrences.

2.4 ATTENDANCE, COMMUNICATIONS, AND WARNING SYSTEMS

The **attendance statement** should note the following:

- Identify the responsible individual (or organizational unit)
- State the extent of attendance at the dam; e.g., whether the dam is:
  - -- attended continuously
  - -- attended part-time (specify attendance period), or
  - -- unattended

If the structure is **unattended**, include:

- The frequency of inspection
- The regulation of gates and valves
- The collection of data and other pertinent facts (e.g., hydrometeorological system, fill-and-spill operation)

This subsection should identify and describe the various physical means of **available communication**:

- Telephone facilities
- Radio facilities (indicate location and distance reached)
- Location of private or public radio facilities for emergency use and identification of local broadcasting stations, and State police facilities for temporary radio communications for flood warnings

If none of the above communications is available at the dam, the location and owner of the nearest phone or radio facility should be noted. These data and the phone numbers should be stated in the Communications Directory of the dam.

In addition to identifying communication facilities, this subsection should refer to the Communications Directory at the beginning of the SOP for the names, phone numbers, and radio call letters and frequencies of persons or organizations associated with both normal and emergency operation of the dam.

PHONE NUMBERS SHOULD NOT APPEAR ANYWHERE IN THE SOP TEXT. THE EXCEPTION IS THE SOP COMMUNICATIONS DIRECTORY SECTION WHICH PROVIDES EASY REFERENCE.

The following **example** of an Attendance, Communications, and Warning Systems subsection was extracted from the SOP for the Bureau of Reclamation's - Unity Dam, Burnt River, Oregon.

> " Unity Dam is attended on a full-time basis. Burnt River Irrigation District, the operating entity, employs a manager who resides at the dam and is on duty year-round. Members of the Board of Directors perform operating duties in the absence of the manager. Attendance is considered adequate at Unity Dam.
>
> The primary communications system is a commercial telephone located in the manager's office/residence. The only backup communication sources are travel by automobile to public telephones in either Unity, Oregon, 3 mi from the dam; or to Hereford, Oregon, 11 mi from the dam (or travel by automobile to the Oregon State Police in Baker where radio systems are operated). The adequacy of the communications system and warning system is considered marginal; the manager should be aware of specific sources and procedures to follow in event of loss of telephone service to the dam.
>
> An alarm system from the dam to the manager's office provides a direct and continuous warning of approaching high reservoir levels. Refer to the Communications Directory section at the front of this SOP for normal and emergency telephone numbers."

2.5 COOPERATION WITH OTHER AGENCIES

This subsection should identify the administrative and operation relations between the operating organization (water-user organization) and other agencies. Relationships between a water-user organization and the State Engineer's Office should be explained in the preceding subsection 2.3, "Assignment of Responsibility."

Other agencies might include:

- Corps of Engineers
- U.S. Fish & Wildlife Services
- National Park Services
- Bureau of Land Management (BLM)
- U.S. Forest Service
- Utah Division of Emergency Management
- Federal Emergency Management Agency (FEMA)
- National Weather Service
- U.S. Geological Survey
- Bureau of Indian Affairs
- Natural Resources Conservation Service (NRCS)
- Utah Geologic Survey
- Utah Division of Water Resources
- Utah Department of Transportation (UDOT)

Note the address and phone number of each cooperator in the Communications Directory.

Any Memorandums of Understanding or Special Use Permits with State or Federal agencies for safety-related aspects of dam operation and maintenance and other agreements for cooperative activities should be summarized.

Formal agreements with other agencies should be referenced in this subsection, and include a brief summary of the terms of agreement relating to Water Rights and/or reservoir operation. If major agreements are written in detail in other SOP sections--such as discussing flood control regulations (in the "Flood Operating Criteria" of the Reservoir Operations chapter)--a reference to the subsection which gives the terms of agreement in detail is sufficient.

Informal agreements with other agencies also should be explained briefly. List specific contracts or Memorandums of Understanding in SOP Chapter 2. Do not include entire documents in the SOP unless pertinent to operations.

2.6 DATA REPORTING

It is intended that the collection and reporting of all categories of dam and reservoir data be covered in this subsection. Include only brief instructions for obtaining the measurements required for the reports. When lengthy instructions for obtaining the data are required, they should be given to the appropriate SOP subsection or in Supporting Documents.

Instructions in this subsection should cover the type, frequency, form, and disposition (to whom) of the data report. Samples of reports or copies of reporting forms should be included in the SOP appendix.

Instructions for reporting routine detailed data should include **hydrologic items** such as:

- Reservoir water surface elevation
- Reservoir capacity
- Reservoir inflow
- Reservoir outflow
- Weather
- U.S.G.S. gage readings
- Structural items for earth and concrete dams

2.7 OPERATING LOG

Under this subsection, each SOP shall include a statement of purpose for the Operating Log that is maintained at each dam site. At part-time attended facilities, records shall be kept for the period of attended operation. At unattended facilities, records shall cover each visit made to the facility.

A logged record shall be maintained by either the operating personnel or the designated alternate on duty. Specific data may vary in form and content to fit the needs and conditions of individual facilities. The information shall include:

Typical Operating Log Entries

1. Normal and emergency modes of operation of outlet works and/or spillways including individual gate position changes
2. Water elevations and discharges
3. Startup and stopping of mechanical equipment
4. Test of standby equipment or gate controls
5. Test and exercise of outlet and spillway control devices
6. Minor and major maintenance activities
7. Reservoir surveillance
8. Initial acknowledgment of emergency or unusual conditions
9. Acts of vandalism
10. Request and concurrence to change from normal operation during emergency or unusual conditions
11. Communications network checks
12. Record of names and addresses of official visitors
13. Certification of SOP review by operating personnel
14. Verification of Dam Safety Inspection
15. Miscellaneous items pertinent to operation, emergency, or unusual conditions at the structures.

When automatic recording and monitoring equipment is not provided-- and to supplement such information--a log shall be maintained in a bound book.

In the event of an unusual occurrence that requires notifying the State Engineer's Office, refer to the facility Emergency Action Plan for reporting instructions and form use.

All entries in the bound Operating Log shall be made legibly in ink, dated, and signed. Neither erasures nor ink eradicators shall be used to make corrections. Instead, an error should be crossed out lightly so that the incorrect notation is still legible after the correct entry is made. The log shall contain a chronological record of all-important events to provide a continuing record of

operating activities for future reference. This will be helpful to provide clues to the cause of equipment trouble or development of unusual conditions occurring at the dam.

2.8 PUBLIC SAFETY AND HEALTH

Since safety is of primary concern, safety instructions and protection should **include**:

- Listing unsafe conditions and hazardous areas
- Noting location of log boom and posted warning signs

If the dam is attended part time, instructions should be given to operating personnel to note unsafe condition or acts and to report them to the authorities for correction.

This subsection also should **include statements** of the following:

- Public use at or near the facility
- Remoteness of the facility from medical or law enforcement assistance
- Potential hazardous areas not discussed under restricted areas (see following subsection)
- Safety equipment available at the facility; i.e., first-aid kits, fire extinguishers, etc.
- Other pertinent information concerning public health or safety

A list of law enforcement, medical aid, and fire protection agencies (city or state police, hospitals, local fire departments) should be shown with reference to the SOP Communications Directory for phone numbers.

2.9 RESTRICTED AREAS

All areas within or surrounding the dam and reservoir from which unauthorized persons are restricted should be described, listed, and outlined on a map and the map included in the SOP appendix. Explain purposes of the restrictions, the barriers, and/or the signs installed to keep out unauthorized persons.

Responsibilities of the operating personnel, operating entity, project office and/or other concerned agencies in posting, patrolling, and enforcing the restrictions should be stated.

Restricted areas are those that are potentially hazardous to--or subject to damage by--the public, such as the following:

- Active landslide areas should be posted off limits to the public
- Warning signs and signs prohibiting rock throwing into hydraulic chutes and stilling basins should be posted adjacent to the structures
- Public entry into chutes, stilling basins, and control houses should be restricted

Public access should be limited from areas surrounding hydraulic structures intakes and reaches of outlet channel adjacent to discharge structures' subject to surging or rapid changes in water surface elevation during releases.

2.10 SOP DISTRIBUTION

The dam owner has responsibility for publishing SOP's and for distributing official SOP's and related Supporting Documents. Distribution should be determined on the basis of need for operation, maintenance, and supervisory purposes only.

To ensure that all SOP copies are kept current, a record of their location must be maintained. The record should be kept in the SOP (itself) by including the Letter of Transmittal, showing the complete distribution list. This will ensure that revised pages are furnished to all copyholders whenever revised instructions are distributed.

Also, it is important to identify and show the distribution of all SOP Supporting Documents. This plan assures that operating personnel know: what, where, and when Supporting Documents are

available and helps keep current all Supporting Documents used for operating purposes.

All SOP copies are to be kept current. For this reason, a limited number are published as required for official distribution plus several to be retained in the project office for replacement and other unforeseen uses. Again, all SOP copies are numbered for control.

2.11 SOP REVISIONS

The SOP revision is the responsibility of the dam owner. At least once each year all SOP's should be reviewed by operating personnel, project offices, and the State Engineer's office to ensure that instructions are adequate and current. Revisions or deviations in operating instructions should be ascertained and either integrated into the SOP or deleted, as appropriate.

SOP Revisions subsection may use the following standard paragraph:

> **Operating procedures shall not deviate from those stated in the SOP and Supporting Documents without appropriate authorization. Changes are made only with the approval of the State Engineer.**

Procedures and corresponding **instructions** that are based on:

- Directives from the State Engineer's office
- Concepts visualized during design and construction
- Hydrology
- Other data or analyses for which the State Engineer's Office has reviewing responsibility

Shall not be revised without referral from the Dam Safety Section for concurrence prior to implementation of the revision. Where the need for deviation or revision develops during emergencies or critical operating conditions, concurrence should be obtained from the appropriate authorities by using the most expeditious means of communication; i.e., phone, radio, and fax.

2.12 SUPPORTING DOCUMENTS

The SOP is the key instruction document. Supporting documents, other than the SOP, comprise the necessary instructions for all phases and levels of responsibility in the operation and maintenance of the dam and reservoir.

This SOP subsection should specifically list all supporting documents that are part of the total instructions for operation and maintenance of the dam and reservoir for all offices having any responsibility in the care and operation of the facility. All supporting documents distribution should be shown in the SOP Distribution. Documents assimilated into the SOP are considered part of the SOP rather than Supporting Documents. Include a brief summary stating the purpose of the supporting document and who is responsible for preparing, updating, and revising, etc.

The title and a brief summary of each supporting document are included here. It should be dated and revision dates shown. Where only a small portion of a publication contains pertinent O&M instructions, such instructions should be included in the SOP or separately bound as a supporting document rather than designating the entire publication as a supporting document.

The number of supporting documents will vary among SOP's.

Suggested SOP Supporting Documents

1 Designer's Operating Criteria

2 Flood Forecasting and Operating Criteria

3 Basin or River Operating Plan

4 Power plant Operating Instructions

5 Administrative Procedures

6 Facilities Security Plan

7 Regional Emergency Handbook

8 Interagency Operating Agreements

9 Major Maintenance Procedures

10 Reservoir Management Plan

11 Manufacturer's Instructions and Drawings

12 Emergency Action Plan

13 Instrumentation reports and/or results

14 Others as appropriate

Reference material should list: manuals, contracts, Memorandums of Understanding, letters, and reports that contain information not listed under Supporting Documents.

.

STANDARD OPERATING PLAN

CHAPTER 3.0

ELECTRICAL, MECHANICAL, STRUCTURAL AND DAM INSTRUMENTATION

3.1 GENERAL DESCRIPTION OF DAM

This SOP chapter should contain detailed operation and maintenance instructions for the dam, hydraulic structures, and all electrical and mechanical equipment. Emergency or back-up procedures should be included.

> **AS A MINIMUM, THE SOP SHOULD INCLUDE ALL OPERATING INSTRUCTIONS THAT PERTAIN DIRECTLY TO SAFE OPERATION OF THE STRUCTURE DURING A FLOOD.**
>
> **PHOTOGRAPHS SHOWING VALVES, LEVERS, SWITCHES, ETC., ARE RECOMMENDED. TERMINOLOGY USED IN FIGURE CAPTIONS IDENTIFYING VALVES, ETC., SHOULD BE CONSISTENT.**

Systems such as the following require description and clear **instructions regarding operation and maintenance**:

- Outlet works
- Spillway
- Electrical system and equipment
- Auxiliary equipment and service system

Maps, plans, and other sources should be reviewed for dimensions and descriptions that will provide a clear picture of the location, makeup, and function of each part of the dam. Especially important are:

- Overall dimensions of the dam and spillway
- Outlet configuration and operation
- Drainage systems and outfall locations
- Location and detail of monitoring points

- Capacity tables for the reservoir
- Discharge tables for the outlet and spillway
- Location and capacity of inflow and outflow ditches
- Records of past inspections, monitoring, repairs, and operating problems
- Photographs of snow drifts which accumulate on and may saturate portions of the dam, taken annually and kept on file for comparison and reference

If a detailed set of drawings for the dam does not exist, a plan and representative cross sections should be drawn up. To avoid confusion, these should be drawn to a convenient scale (e.g., 1 inch = 20 feet)

3.2 SPECIAL INSTRUCTIONS

Conformance to special instructions is important for continuing safety and economical operation of the structures. Therefore, it is imperative that the SOP contain the applicable instructions below. It is suggested Special Instructions be used as a checklist in preparing SOP's to ensure these instructions are included in SOP's where applicable. The instructions and precautions also should be listed under Items of Special Importance:

3.2.1 High-Pressure Minimum Gate Openings. - To prevent damage to the gate leaf and frame, high-pressure regulating gates should not be operated at small gate openings for long periods of time. For gates not having the openings established previously, the SOP should state a conservative minimum gate opening referenced to the gate leaf bottom (in the direction of flow) unless conditions require further analysis of the limit.

3.2.2 Drop-Inlet Outlet Works Operation. - Several drop-inlet outlet works have been damaged when operating at a shallow flow depth over the intake structure sill. Damage was caused by violent blowback of air and water from the shaft and the conduit resulting from pressure of air trapped in the conduit by flowing water. When the reservoir water surface drops below a critical elevation, a vortex forms due to sill-control rather than by the regulating gate (or control valve) and results in air entrainment in the conduit. Operating

instructions should be provided in the SOP for all outlet works with drop-inlets. Operating instructions should be established for the critical water surface elevation.

3.2.3 Ventilation Systems Operation. - Ventilating systems are installed at dams to provide adequate fresh air in confined areas such as tunnels, conduits, galleries, and gate chambers. To ensure safe operating conditions in these areas the SOP should require operating the ventilating fan for a sufficient time period to permit one complete air change before entry by personnel. The time period required to accomplish this change should be stated.

3.2.4 Rock Removal from Chutes and Basins. - Medium and large rocks do not wash from a stilling basin-even during high discharge. Instead, they are swirled by water and pounded against the concrete walls and floor of the stilling basin, causing damage. It is important to remove all rocks in the stilling basin. The SOP should establish procedures for the removal of rocks in a stilling basin. Since most rocks that enter the chute and stilling basin are thrown or rolled there by people, the SOP should require signs near the structures prohibiting throwing rocks into them. The SOP should require, at least annually, that before release of water through the structures, those rocks that can be reached without draining the basin be removed from the chute and basin. In many instances, schedules for examining and cleaning the stilling basin have been established; the schedules should be stated in the SOP. If schedules have not been established, the SOP should require basin examination at 5-year intervals until experience indicates a schedule more consistent with local operating conditions.

3.2.5 Gates and Valves-Exercising and Testing. - Procedures should be developed for exercising and testing the operating control devices. Safety of the structure and good operation and maintenance practices require that each gate (valve) be tested to confirm that it will operate as designed. Circumstances at each structure will govern the extent and frequency of testing. Whether criteria in this SOP guide are used or other criteria are developed, SOP procedures should provide detailed instructions for the operator to perform exercising and testing. A note of caution should appear in the SOP similar to the following:

> **CAUTION: IF DURING ANY TEST THE GATE (VALVE) WILL NOT CLOSE FROM ANY POSITION OR OTHERWISE MALFUNCTIONS, STOP THE TEST AND DETERMINE THE CAUSE OF THE MALFUNCTION AND CORRECT IT.**

Exercising and testing machinery should be done by using normal and auxiliary power sources to ensure the operation of each. All exercising and testing results should be recorded and dated in the Operating Log at the dam.

Open the gate 10 percent - then close. If the gate has not been operated in the past year, the 10 - percent test should be made in progressive steps as follows:

- Barely open (crack) the gate so that it will produce additional leakage - then close
- Open the gate 1 inch - then close
- Open the gate 6 inches - then close
- Open the gate 10 percent - then close. If 10-percent gate opening is impossible because of downstream restrictions, open it as far as possible -then close

If the gate passes this test successfully, a routine test should be scheduled for the following year.

CAUTION: OPERATIONAL TESTING OF AN EMERGENCY GATE UNDER AN UNBALANCED HEAD SHOULD NOT BE PERFORMED UNLESS THE CONDUIT DOWNSTREAM FROM THE GATE IS EQUIPPED WITH EITHER AN AIR INTAKE VENT OR AN AIR INLET AND AIR RELEASE VALVE.

All required lubrication and maintenance of equipment should be done prior to operational testing and exercising.

3.3 INSTRUMENTATION - MONITORING AND MAINTENANCE

Instrumentation of dams refers to a variety of devices for measuring the structural behavior at embankment dams. Generally, dams are instrumented (1) to monitor performance during construction and initial filling to obtain data for improving future designs, and (2) to provide the means of detecting abnormal conditions during operations that could lead to major problems. To meet these needs, SOP's should include:

Scope

Purpose

Types of instrumentation

Reading schedules (see R655-12-4C.2)

Reporting Procedures

Maintenance requirements

Evaluations of data and need

Normal readings

Abnormal/threshold readings

If the dam has many instrument installations, it may be helpful to make this subsection a separate SOP chapter. An instrumentation chapter would include the following:

Dam Instrumentation

- General description of instrumentation
- Responsibilities
- Specifics for each installation
  - -- Detailed description
  - -- Instructions regarding schedules, operating instructions, and evaluations and data transmittal
  - -- Normal readings
  - -- Abnormal / threshold readings
  - -- Location map and drawings

An instrumentation appendix should include a summary table and an instrumentation location map. Also, the SOP should include the latest instrumentation data report form or a statement, graph, or chart for what is a normal reading so that when an abnormal or threshold reading is detected by the dam operator or designated person at the supervisory office, appropriate actions can be taken.

Summary table of the all instruments and an instrumentation location map showing the locations of specific instrumentation and known seepage areas should be included. Maintenance requirements for instrumentation, drains, weirs, channels, etc., should be stated clearly.

Types of instrumentation which may be placed in, on, or adjacent to foundations, abutments, and embankments, or on concrete structures:

- Embankment and foundation piezometers or transducers
- Porous-tube piezometers and observation wells
- Vertical movement devices
- Horizontal movement devices
- Foundation settlement baseplates
- Measurement points on the abutment slopes and on the completed surface of an embankment or structure for measuring settlement and deflections Weirs, flumes, or other devices for measuring seepage
- Accelerographs
- Hydrometeorological system (brief description as it relates to specific dam operation and operating personnel responsibilities)

3.4 DAM MAINTENANCE AND INSPECTIONS

This subsection should record the operation and maintenance procedures pertaining to the dam, its abutments, foundations, and adjacent areas such as:

- Clearing of trees and shrubbery from the embankment dam
- Remove rodents
- Remove debris
- Lubricate gates
- Replace and repair riprap
- Seal concrete joints
- Maintain monitoring equipment
- Cleaning drains
- Exercising valves and backup generators

- Painting of miscellaneous metalwork
- Other typical maintenance procedures

Inspection requirements of the structure and reservoir under special conditions should be established. EAP reference should be made for actions to be taken by the dam operator during unusual occurrences. Features of the dam, abutments, reservoir, and adjoining areas requiring special attention, and conditions and occurrences for which the examiner should be alert may be listed in this subsection.

The embankment, abutments, and visible portions of the foundation adjacent to the main embankment shall be inspected for evidence of the development of unfavorable conditions.

During rapid reservoir filling, the downstream slope of the embankment and foundations downstream from the dam shall be inspected carefully for indications of:

Cracks	Sloughs
Riprap erosion	Seeps
Slides	Subsidence
Springs	Boggy areas

The upstream face of the dam and abutments adjacent to the dam shall be inspected a minimum of once per month or more frequent as conditions warrant for evidence of cracks and subsidence, especially after periods of sustained high-velocity winds or when the reservoir water surface is lowered.

During periods of **sustained high reservoir level**, monthly inspections shall be made of the dam with particular attention given to:

- Dam crest
- Visible portions of the upstream slope protection
- Downstream slopes
- Areas downstream from the dam for evidence of abnormal development caused by seepage through the foundation

During periods of **lower reservoir level**, exposed portions of the embankment, the abutments, and the reservoir floor shall be examined for:

- Sinks or seepage holes
- Cracking
- Unusual beaching conditions
- Sediment deposits

Following any reported earthquakes, inspection shall be made of the dam embankment and appurtenances for indications of physical damage such as cracks, displacements, and land movements.

Refer to the Emergency Action Plan (EAP) for additional instructions during unusual occurrences.

3.5 SAFETY PROCEDURES DURING EQUIPMENT OPERATION

The identity, location, and phone numbers of nearby doctors, hospitals, law enforcement organizations, ambulances, and other agencies or individuals who can give medical assistance are to be listed in the Communications Directory.

Standard paragraphs suggested for this section are:

> Safe clearance procedures shall be followed in operation of the outlet works to safeguard personnel. When maintenance work or inspection is being performed on ____ [list specific items, such as electrical equipment, gates, conduits, tunnels, etc.]. all equipment that could affect personnel safety shall be appropriately tagged to ensure that the controls are not handled while personnel are vulnerable to danger. A "Danger" tag used for such purposes reads "DANGER - HANDS OFF - DO NOT OPERATE." A danger tag is considered the same as a lock, and the tagged unit is not to be operated while the tag is in place. As an example, such a tag should be attached to control valves and gates by the dam operator when personnel are working on them. The dam operator alone should remove the tag after making certain that everyone is in the clear. Before each job is begun, the supervisor will conduct a thorough briefing so that all personnel involved will understand what is to be accomplished and the safety procedures to be used.

Except in the case of an emergency, repairs to _____ [electrical equipment, gates, conduits, or other specific features] will be performed with two or more persons present. Under no condition, however, will the _____ [conduit] be entered unless at least two are available to enter _____ [conduit] and one is present in the _____ [valve house]. Even in an emergency, a second person will be informed of the work to be done and when a clearance report can be expected.

3.6 PROTECTIVE COATING - INSPECTION AND MAINTENANCE

Inspection Schedules and Maintenance Materials

Coatings on Metalwork in Alternate or Continuous Water Submergence - Paints in this category warrant the most rigorous inspection and energetic maintenance since corrosion failure may endanger metalwork in critical locations.

Thin-film coatings:

- VR-3, Vinyl resin paint
- VR-6, Vinyl resin paint
- Coal-tar epoxy paint, MIL-P-23236, Type 1, Class 2 Red lead, TT-P-86, Type IV, with or without topcoats of phenolic aluminum TT-V-119
- Galvanizing

Coatings in this category should be inspected the first and third year after being placed in service, and thereafter at 5-year intervals. Maintenance paintings should be with the original type of paint. After 10 years of service, consideration should be given to application of one complete topcoat after preparing surface for repainting. Repair of galvanizing may be by regalvanizing or, depending on circumstances, by application of protective coatings.

Thick-film coatings:

Coal-tar Enamel - Should be inspected after the second and fifth year of service, and thereafter at 5-year intervals. Temporary repair of small areas should be made using coal-tar epoxy paint, and consideration should be given to making permanent repair to temporarily patched areas using coal-tar enamel after about 10 years of service.

Cement Mortar - Should be inspected after the first and fifth year of service, and thereafter at 5-year intervals. Repair may require special methods, possibly including use of epoxy bonding materials.

Coatings on Wood, Masonry, or Metalwork in Other Exposures

Although deterioration of these coatings will usually progress more slowly and the consequences of failure will be less serious, significant economics will be effected by proper maintenance. After a fifth-year inspection, subsequent inspections of paints in exterior or interior exposures may be scheduled at 2-5 year intervals, depending on the apparent need.

Coatings on Surfaces that are Normally Inaccessible or Only Occasionally Exposed

It is not intended that equipment be dismantled simply for inspection purposes, or that unreasonable expenses be incurred through otherwise unnecessary shutdowns to examine coatings. However, when opportunity arises for inspection of surfaces that are seldom exposed, a detailed report of the coating conditions observed should be prepared for later reference and maintenance work scheduled, if required.

Miscellaneous Materials

Canal groove sealers, concrete epoxy repairs, damp proofers, roofing, and similar materials are susceptible to gradual deterioration comparable to that sustained by coatings. They require regular maintenance and should be included in the inspection schedule; a 3-year interval will usually be suitable.

STANDARD OPERATING PLAN

CHAPTER 4.0

RESERVOIR OPERATIONS

4.1 RESERVOIR CAPACITY ALLOCATIONS

Current reservoir capacity allocations and water rights should be presented in the SOP.

In addition, it is essential to include area-capacity curves and tables (based on elevations to the nearest tenth of a foot) in the appendix or referenced as a Supporting Document.

The SOP should mention that sediment accumulation, as detected during reservoir resurvey or drought conditions may change the capacity allocations.

4.2 DESIGN FLOOD STUDY AND ROUTING

State statutes require that high and moderate hazard dams must pass the Probable Maximum Flood (PMF) or a percentage of the PMF that is determined to be significant when compared to the breach flow of the dam - called the Inflow Design Flood. The minimum allowable routed flood for any hazard is the 100-year event. A description of the current reservoir PMF and/or IDF are included in the SOP to give operating personnel some idea of the type and magnitude of the flood for which the dam, spillway, and outlet works are considered adequate. The PMF and/or IDF should show the date the described flood was approved for design or review purposes. The flood description should include - as a minimum - volume, duration, and peak flow.

A description of the type of flood (rain, snowmelt, or combination), the months in the year during which it can occur, and the assumed antecedent hydrologic conditions would be helpful in support of some operating procedures and to operating personnel when evaluating a flood event. This subsection should contain a description of the **assumptions used in routing** the flood through the reservoir, including:

- Reservoir water surface elevation at beginning of flood event
- Spillway gate operation
- Outlet works release schedules
- Feeder canal operation
- Stoplog removal schedule

A statement of the resulting maximum reservoir water surface elevation and peak spillway and outlet works discharges (preferably including a hydrograph) should be included. Hydrographs showing the reservoir routings of the PMF and IDF, flood control design flood - if flood control is an authorized project purpose and outstanding floods of record, if available, should be included in the appendix and appropriately referenced here. Downstream routings and inundation maps of spillway and outlet releases from those floods and flow from dam failure, which are prepared for the EAP, should be referenced here also.

An example of **typical information required** is:

> The hydrograph of the PMF and IDF, approved in March 1967, and having a peak inflow of 82,000 ft^3/s and 7-day volume of 427,000 acre-feet, is shown in the appendix. This flood was based on the transposition and adjustment of the Morgan, Utah storm of August 16, 1958. This storm was assumed to produce an average rainfall over the entire 1600-square-mile drainage basin of 6.75 inches in 1 hour. The inflow design flood was determined by adding the runoff resulting from the storm to an assumed base flow of 1,000 ft^3/s in the Weber River. When routed through Watkins Reservoir with the reservoir water surface at spillway crest elevation 4575.0 at the beginning of the flood event and the outlet works discharging 2,200 ft^3/s, the inflow design flood produces a maximum water surface at elevation 4592.8 and a maximum spillway discharge of 62,000 ft^3/s.

4.3 FILLING SCHEDULE AND RELEASE PROCEDURES

The filling plan, by which reservoir inflows are to be stored and by which stored water is to be released each year to accomplish the authorized and incidental objectives of the project, should be described in this SOP subsection. It should explain when water is stored in the reservoir and should state all restrictions that exist on rates, quantities, and times for which water may be

stored. Factors governing reservoir releases for project purposes also should be discussed. This SOP subsection should indicate specific operating instructions each time gates are to be opened, closed, or reset.

This subsection should list all established requirements for releases, such as maintenance or streamflows for various purposes and flood control options. Detailed reservoir operating procedures given elsewhere in the SOP do not need to be repeated here. However, all procedures for reservoir operation should be briefly noted in this SOP subsection; reference the SOP section where the details can be found.

4.4 INFLOW FORECASTING

Inflow forecasting should include instructions and procedures for preparing, both preceding and during runoff months, periodic estimates of inflow volumes for the runoff season. These estimates provide a basis to plan reservoir and project operations before and during the flood season, and to permit optimization and coordination of water supply and other reservoir functions. In addition, it will help in planning operating procedures consistent with operating criteria to protect the dam and its appurtenances against failure caused by high reservoir water levels and excessive discharge rates. Such procedures are mostly for reservoirs having snowmelt inflow. In some exceptional cases, short-term inflow forecasting procedures may be appropriate for reservoirs having large watersheds and only rainfall runoff.

The instructions and procedures should be described in sufficient detail and completeness in a referenced Supporting Document to enable newly assigned personnel to be effective in estimating inflow and to fully implement the procedures.

Administrative and technical procedures should be included. Administrative procedures should identify organizational entities responsible for forecasting estimates and related collection of data and conversion of forecasts into operating plans. **Technical procedures** to consider include:

- Information necessary to monitor hydrometeorological stations
- Specific correlations, equations, graphical tools, and analytical procedures used in forecasting inflow
- Instructions when forecasts are to be made under various conditions

If agencies (e.g., the Soil Conservation Service, National Weather Service, Utah Division of Water Resources or others) are engaged to prepare inflow forecasts for a particular reservoir, the SOP should include a description of the procedures and criteria used by those agencies and instructions for operating personnel in the procurement and use of such forecasts.

Development of inflow forecasting procedures is a continuing process because correlations are subject to revision as more data becomes available. Hence, SOP instructions should include a requirement to examine the procedures annually upon each additional year of operating experience and to make revisions and improvements where needed.

4.5 FLOOD OPERATING CRITERIA

This SOP subsection establishes dam and reservoir flood operating criteria and procedures to be followed preceding and during flood inflows which are not appropriate to include in the preceding subsections Filling Schedule and Release Procedures and Inflow Forecasting.

This subsection describes established criteria for storage and release schedules preceding and during flood inflow periods (including established constraints for downstream flood control), and reservoir operating criteria needed for dam safety. Flood operating criteria and inflow forecasts provide the basis for operating plans for routing of flood inflows.

4.6 SPECIAL REPORT DURING FLOOD OR HIGH WATER

Because of the importance of reporting promptly and completely during floods and highwater periods, comprehensive instructions on reports required from personnel at the dam during these periods should be assembled in this subsection for ready reference. **Instructions** should establish:

- When initial reports are to be made
- Who shall receive reports
- Data requirements
- Reporting intervals

Presumably, further reporting procedures will be established during the first report; if not, reporting intervals and data requirements for all reports should be established in the SOP.

4.6.1 Surcharge capacity. - Criteria used in routing the IDF and/or PMF through a reservoir require surcharge capacity for that purpose. Surcharge capacity is reserved for emergency situations or extreme conditions on the reservoir or the river basin. An example is the storage of inflows, which if released, would exceed the safe-channel capacity downstream and cause significant damage if passed directly through the reservoir. An SOP statement should include notifying the State Engineer's Office, that reservoir rise into surcharge is imminent.

During an emergency caused by high inflows, if downstream discharge is at the maximum channel capacity and if the watershed and weather conditions indicate an acceptable risk situation, the supervisory office may decide to use surcharge space before notifying the State Engineer. Surcharge storage during emergency conditions will be considered temporary, and the downstream channel will be allowed to flow at full capacity as long as there is available reservoir surcharge. Often unusual conditions and circumstances may arise for which additional storage would be beneficial and justified on a one-time basis. Analyses of hydrologic, structural, operational conditions, flood routing, and risk studies are required before authorization would be granted. Authorization for temporary storage in surcharge requires the State Engineers approval.

If justifiable need for surcharge storage develops on a recurring basis - such as additional storage for power generation or irrigation use - analyses are to be completed prior to authorization. For this type of situation, surcharge storage must be authorized in advance by the State Engineer, upon application.

4.6.2 Attendance. - The 24-hour attendance requirement at all dams under certain conditions is outlined in appendix.

4.7 FILLING AND DRAWDOWN LIMITS

This SOP subsection should have all recorded special limits on rates and ranges of reservoir filling and drawdown that have been established because of landslides or other geologic conditions in the reservoir and for embankment dams because of stability requirements.

Include description and location of sinkholes or other unusual geological formations. Locations of landslides or potential landslides that may be activated by drawdown should be described and a map included in the SOP appendix.

Reasons for restrictions should be provided. Special reporting requirements or obtaining advance approval - when for any reason established limits must be exceeded - should be included also. If special limits have not been established, this subsection should have a statement that limits are not applicable.

4.8 EARTHQUAKE

Identify the Latitude and Longitudinal coordinates of the dam.

Seismic Evaluation: Enter a summary of seismic evaluation, if such a study has been done.

After an earthquake - Inspect dam if it is within the zone of influence described below:

Richter Magnitude	Search Radius (MI)
4.0 to 4.5	10
4.6 to 5.0	12
5.1 to 5.5	21
5.6 to 6.0	28
6.1 to 6.5	38
6.6 to 7.0	55
7.1 and greater	75

(1) Thoroughly inspect for damage

   (a) Both dam faces for cracks, settlement, or seepage
   (b) Abutments for possible displacement
   (c) Drains and seeps
   (d) Spillway structure
   (e) Outlet works control house, shaft, and gate chamber
   (f) Power supply and standby power unit
   (g) Visible reservoir and downstream areas for landslides
   (h) Other appurtenant structures
   (i) Read instruments and note any abnormal or changed readings.

(2) Report inspection findings to the Utah State Department of Natural Resources, State Engineers Office, Dam Safety Section during the earthquake incident.

(3) If apparent damage has not occurred to the dam, embankments, or appurtenant structures, a "No Damage" report should be made to the Utah State Department of Natural Resources, State Engineers Office, Dam Safety Section.

(4) Continue to inspect and monitor the facilities for at least 48 hours or as instructed by ***your engineer*** and the Utah State Department of Natural Resources, State Engineers Office, Dam Safety Section - in the event unobservable or delayed damage should occur.

(5) Some damage to structures may not be apparent during the inspection immediately following an earthquake. It is possible that the settlement of structures, the reactivation of old slides, or the development of new slides may not occur with ground shaking and would manifest itself after the initial inspection. A secondary inspection 2 weeks to a month after the initial inspection should be made.

(6) Survey settlement and alignment measurement points if requested ***your engineer*** and the Utah State Department of Natural Resources, State Engineers Office, Dam Safety Section.

4.9 LANDSLIDE SURVEILLANCE AND LANDSLIDE

Landslide Surveillance

Landslide surveillance procedures should be established. The procedures require the identification, annual examination, and preparation of data and/or data reporting of landslide areas. As a result of these and other examinations, operating procedures and appropriate schedules of landslide observations and reports have been or will be established for specific dams and reservoirs.

Except for reporting procedures and reservoir operating instructions, all information and instructions related to landslides and landslide surveillance should be given in this SOP subsection. Inspection requirements relative to landslides should be presented in the SOP. Reservoir operating requirements resulting from landslide conditions should be included in the preceding SOP section.

Special instructions for operation and maintenance personnel, which may be developed as a result of the annual examination of landslide areas and which should be included in the SOP, may pertain to one or more of - but not necessarily be limited to - the following **actions**.

- Maintain signs posted for warning of landslide areas
- Identify names and locations of persons and entities in established locations which would be affected by either slow or sudden movement of a critical landslide, and establishment and implementation of related emergency communication procedures
- Maintenance and observation of landslide monitoring instruments
- Measurement of landslide areas by land surveying
- Examination of and reporting on critical landslide areas between annual examinations
- Adherence to special limitations on reservoir drawdown rate
- Immediate reporting of unusual landslide activity

Photographs of signs, drawings of slide areas, and photographs or profile drawings of slide areas should be included in an SOP appendix. When changes occur, this material will need to show current conditions.

Landslide Surveillance should describe landslide observations and measurements to be made following an earthquake and should refer to the Emergency Action Plan for reporting procedures.

Landslide

Any *landslide* that could move into the outlet works, spillway area, or into the reservoir - rapidly displacing large volumes of water - would be dangerous to the dam. Landslides or potential landslides into the downstream channel that may impound water should be reported.

Any landslide that may affect either abutment should be reported to the Utah State Department of Natural Resources, State Engineers Office, Dam Safety Section immediately.

All landslides or potential landslides that may affect the dam, abutments, outlet works, or reservoir basin should be reported to the Utah State Department of Natural Resources, State Engineers Office, Dam Safety Section. Identify landslide areas by name and location.

a. *Determine* -

(1) Size
(2) Possible cause
(3) Degree of effect on operation
(4) Probability of additional movement of disturbed area or of other slide
(5) Development of new slides
(6) Any other facts believed pertinent

b. Contact ***your engineer*** and the Utah State Department of Natural Resources, State Engineers Office, Dam Safety Section for assistance.

For a landslide that occurs in the downstream channel:

a. *Determine* -

(1) Size (including depth and percent across river channel)
(2) Capability of immediately closing outlet works
(3) Other inflows
(4) Location in relation to the toe of the dam and other structures
(5) Availability or need for heavy equipment

b. Contact ***your engineer*** and the Utah State Department of Natural Resources, State Engineers Office, Dam Safety Section for assistance.

4.10 RECREATION MANAGEMENT PLAN

State whether or not a recreation management plan has been established for the reservoir area. If a plan has been published, the subsection should **identify**:

- The agreement establishing the plan
- Indicate the agency responsible for operating the plan
- State how the plan affects reservoir operation

This subsection should identify regulations regarding off-road vehicle use for protecting public lands.

> Maps designating roads and trails for off-road vehicle use, as well as maps indicating prohibited areas should be included in the SOP appendix.

This subsection should reference all contracts and agreements with other agencies for the benefit of fish and wildlife. Explain what requirements there are, if any, and how the agreements affect dam and reservoir operations. Such requirements might include minimum water surface elevations, reservoir levels during specified periods of the year, and minimum reservoir release rates to meet downstream flow.

4.11 HYDROPOWER AND OTHER RELEASE CRITERIA

For reservoirs serving as forebays to hydroelectric plants, this subsection should state the basic criteria used in determining the time and quantity of hydropower releases and should indicate the relation of releases to other reservoir operating functions and criteria. Where the only reservoir function is hydroelectric, or where the reservoir is one of interrelated reservoirs - when operation is coordinated to maximize power generation consistent with other authorized project operation purposes - the criteria may be included here by referencing appropriate Supporting Documents developed for power operations.

This subsection should state clearly the reporting requirements, release range, and power demands before effecting sudden or large releases of water. Also, describe warning signs, devices, etc., to alert people downstream of increased releases.

Operating criteria for other reservoir functions not appropriately included in other SOP subsections may be placed here. Where appropriate, this subsection may include:

- Reviews of reservoir operating criteria for downstream pollution abatement
- Structure protection during periods of the year
- Control of silt disposition in the reservoir

A detailed discussion of operating criteria (in this subsection) does not preclude reiterative criteria in other SOP chapters.

STANDARD OPERATING PLAN

CHAPTER 5.0

APPENDIX A

5.1 STANDARD OPERATING PLAN CHECKLIST

Dam _____

Reservoir _____

_____
Reviewed by Prepared by

_____ _____
Date Date

1.0 SOP PRELIMINARY PAGES AND COMMUNICATIONS DIRECTORY

1.1 SOP Preliminary Pages

	Adequate	Inadequate
1. Cover		
a. Correct title of dam	_____	_____
b. Photo of dam and reservoir	_____	_____
2. Title Page		
a. Correct name of dam and reservoir. . . .	_____	_____
b. Assigned dam number	_____	_____
c. Project and County	_____	_____
d. Operating entity		_____
e. SOP copy publish date.	_____	_____
f. SOP prepared by (office)	_____	_____
3. Letter of Transmittal		
a. Legibly dated and signed	_____	_____
b. Complete distribution list	_____	_____
4. SOP Revision Sheet		

a. Number . . . . . _____ _____
b. Date . . . . . _____ _____
c. Instructions . . . . . _____ _____

5. Certification of SOP Review by Operating Personnel

a. Standard paragraph use . . . . . _____ _____

6. Verification of SOP by Dam Safety Team. . _____ _____

7. SOP Preface

a. Standard paragraph use . . . . . _____ _____

8. Items of Special Importance . . . . . _____ _____

a. All precautions contained in SOP . . . . _____ _____

9. SOP Contents

a. All section headings and pages numbered . _____ _____
b. All tables and figures listed. . . . . _____ _____
c. Communications Directory included. . . . _____ _____
d. Appendix - complete listing. . . . . _____ _____
e. As-constructed drawings included . . . . _____ _____

1.2 Emergency and Unusual Occurrences

1. General

a. Slumping or cracking of the dam or abutments. . . . . _____ _____
b. Failure of appurtenances or operating equipment . . . . . _____ _____
c. New springs, seeps, or boggy areas . . . _____ _____
d. Rapid increase or cloudy appearance in seepage. . . . . _____ _____
e. Abnormal instrumentation readings. . . _____ _____
f. Earthquake. . . . . _____ _____
g. Landslide. . . . . _____ _____
h. Severe storms. . . . . _____ _____
i. Fires. . . . . _____ _____
j. Demonstrations, sabotage, or nuclear attack. . . . . _____ _____
k. Oil and hazardous substance spills . . . _____ _____
l. Large or sudden releases into the downstream channel. . . . . _____ _____
m. Fish and Wildlife losses . . . . . _____ _____

n. Drowning . . . . . _____ _____
o. Major accidents. . . . . _____ _____
p. Criminal action involving project property. . . . . _____ _____

2. Communications Systems

a. Available communications described . . . _____ _____

3. Telephone Report of Emergency or Unusual Conditions

a. Copy of record form included . . . . . _____ _____
b. Record maintained in dam Operating Log . _____ _____

1.3 SOP Communications Directory

1. Specific Communication Sources (all levels of responsibility) . . . . . _____ _____

2. Persons Contacted

a. Name . . . . . _____ _____
b. Title. . . . . _____ _____
c. Location . . . . . _____ _____
d. Office and phone number . . . . . _____ _____
e. Mobile phone number (backup numbers) . . _____ _____

3. Regional Communications Directory for Dams

a. The particular dam . . . . . _____
b. Emergency services and cooperators . . . _____
c. Disaster and alternate communications. . _____ _____
d. Phone numbers of communication systems for construction equipment, materials, labors, engineering expertise, and underwater examiners. . . . . _____ _____

2.0 GENERAL INFORMATION

2.1 Purpose of the Project

1. Identify the dam and reservoir. . . . . _____ _____

2. Authorized purposes . . . . . _____ _____

3. Note informal benefits. . . . . _____ _____

4. All major project features. . . . . _____ _____

5. Historical data or designation. . . . . _____ _____

6. Other unique information. . . . . _____ _____

2.2 Directions and Access to Dam

1. Most expeditious route from project or operating headquarters under normal and emergency conditions . . . . . _____ _____

2. Alternative route description if significant . . . . . _____ _____

3. Evaluation of nature of routes and availability for year-round use. . . . . _____ _____

4. Availability and use of special equipment (helicopter, snowmobile, 4-wheel-drive, etc.) . . . . . _____ _____

5. Locations of commercial and private airports . . . . . _____ _____

6. Project location map

a. Clear and precise. . . . . _____ _____

2.3 Assignment of Responsibility

1. Basic responsibility described

2. Identify organizational unit or position responsible

a. Equipment operation in the structures at dam . . . . . _____
b. Forecasting reservoir inflows. . . . . _____
c. Directing flood releases . . . . . _____
d. Directing irrigation releases. . . . . _____
e. Recording reservoir data . . . . . _____
f. Various maintenance work . . . . . _____ _____

3. Dam operator's responsibilities . . . . . _____ _____

a. Modification of facility . . . . . _____ _____
Standard paragraph use. . . . . _____ _____
b. Checklist of operating personnel

scheduled duties. . . . . _____
(1) Separate colored pages . . . . . _____
(2) Daily, monthly, quarterly, yearly interval (period) activities. . . . . _____ _____
(3) See SOP Guide for example. . . . . _____ _____

2.4 Attendance, Communications, and Warning Systems

1. Responsible individual (or unit). . . . . _____ _____
2. Location or duty station. . . . . _____
3. Period of attendance. . . . . _____
   a. If unattended
      (1) Frequency of inspection. . . . . _____
      (2) Regulation of gates and valves . . . . _____
      (3) Collection of data . . . . . _____
      (4) Other pertinent facts. . . . . _____
4. Justification . . . . . _____
5. Description of communication facilities . _____ _____
   a. Phone, radio, power line communications . _____
   b. Other, private or public radio facilities _____
   c. Justification. . . . . _____ _____
6. Refer to Communications Directory for current phone number. . . . . _____ _____
7. Warning systems . . . . . _____ _____

2.5 Cooperation With Other Agencies

1. Identify administrative and operational relations between operating organization and other agencies . . . . . _____ _____
2. Include reference to agreements with Federal or State agencies, and local agencies under "Reference Material". . . _____ _____
   a. Summary of terms of agreement included . _____ _____
   b. If pertinent to operations include in appendix . . . . . _____ _____
4. List address and phone number for each cooperator in the Communications Directory. . . . . _____ _____
5. Informal agreements briefly explained . . _____ _____

2.6 Data Reporting

1. Type of report required, its frequency, form of the report and disposition to whom _____ _____

2. Sample forms in appendix. . . . . _____ _____

3. Hydrometeorological stations

a. Location(s). . . . . _____ _____
b. USGS Station number. . . . . _____ _____
c. Type of data reported. . . . . _____ _____
d. Automated manual status. . . . . _____ _____
e. Reliability. . . . . _____ _____
f. Frequency of backup data collection. . . _____ _____

4. Routine data reporting instructions

a. Reservoir water surface (elevation). . . _____ _____
b. Reservoir capacity (acre-feet) . . . . . _____ _____
c. Reservoir inflow (ft^3/s average) . . . . _____ _____
d. Reservoir outflow (ft^3/s average). . . . _____ _____
e. Weather. . . . . _____ _____
f. Structural reporting . . . . . _____ _____
(1) Earth and concrete dams. . . . . _____ _____

5. Reference SOP Chapter, "Instrumentation Monitoring and Maintenance" or "Dam Instrumentation" for detailed information. . . . . _____ _____

2.7 Operating Log

1. Statement of purpose of Operating Log. . _____ _____

2. Information required listed. . . . . _____ _____

3. Include form in appendix . . . . . _____ _____

2.8 Public Safety and Health

1. List unsafe conditions and hazardous areas . . . . . _____ _____

2. Note location of log boom (if any) and posted warning signs. . . . . _____ _____

3. Statement of public use near or at the facility . . . . . _____ _____

4. Remoteness from medical or law

enforcement. . . . . _____ _____

5. Potential hazardous areas . . . . . _____ _____

6. Safety equipment available. . . . . _____ _____

7. Other pertinent information concerning public health or safety. . . . . _____ _____

8. List of assisting agencies

a. Law enforcement
(1) Sheriff. . . . . _____ _____
(2) State Police . . . . . _____ _____
b. Medical
(1) Hospital . . . . . _____
(2) Ambulance. . . . . _____ _____
c. Fire Protection. . . . . _____ _____
(1) Local. . . . . _____ _____
(2) Forest Service or BLM (if any) . . . . _____ _____
d. Reference to Communications Directory . . . . . _____ _____

2.9 Restricted Areas

1. List of restricted areas outlined on map. _____ _____

a. Map included in appendix . . . . . _____ _____
b. See SOP Guide

2. Purposes for restrictions . . . . . _____ _____

3. Barriers, signs, and locations explained. _____ _____

4. Responsibilities of the dam operator. . . _____ _____

5. Active landslide areas posted . . . . . _____ _____

6. Warning and prohibiting rock throwing - signs. . . . . _____ _____

7. Restricted access into chutes, basins, and control houses . . . . . _____ _____

8. Restricted access to areas subject to rapid changes in water level . . . . . _____ _____

2.10 SOP Distribution

1. "Letter of Transmittal" . . . . . _____ _____

a. Complete distribution list . . . . . _____ _____

2. Identify and show distribution. . . . . _____ _____

a. Supporting documents . . . . . _____ _____

3. Standard paragraph use. . . . . _____ _____

2.11 SOP Revisions

1. Instructions for annual review of SOP . . _____ _____

2. Standard paragraph use. . . . . _____ _____

3. Revision number and date on revised pages. . . . . _____ _____

2.12 Supporting Documents

1. Instructions for annual review of SOP . . _____ _____

2. Distribution shown. . . . . _____ _____

3. Summary of purpose for each document. . . _____ _____

4. Prepared by . . . . . _____ _____

5. Revision responsibility . . . . . _____ _____

6. See list in SOP Guide . . . . . _____ _____

3.0 ELECTRICAL, MECHANICAL, AND STRUCTURAL

3.1 General Description of Dam

1. Operating and maintenance instructions

a. Dam. . . . . _____ _____
b. Hydraulic structures . . . . . _____ _____
c. Electrical and mechanical equipment. . . _____ _____

2. List of features . . . . . _____ _____

3. Latitude and longitudinal coordinates . . _____ _____

3.2 Special Instructions

1. High-pressure minimum gate openings . . . _____ _____

2. Drop-inlet outlet works operation . . . . _____ _____

3. Ventilation systems operation . . . . . _____ _____

4. Rock removal from chutes and basins . . . _____ _____

5. Gates and valves - exercising and testing _____ _____

3.3 Instrumentation - Monitoring and Maintenance

1. Scope . . . . . _____ _____

2. Purpose . . . . . _____ _____

3. Types of instrumentation. . . . . _____ _____

4. Reading schedules . . . . . _____ _____

5. Reporting procedures. . . . . _____ _____

6. Maintenance requirements. . . . . _____ _____

7. Evaluations of data and need. . . . . _____ _____

8. Latest data report form with
   a. Normal reading ranges . . . . . _____ _____
   b. Abnormal/threshold values . . . . . _____ _____

9. Responsibility for checking readings. . . _____ _____

10. Summary table, and location maps of instrumentation and known seepage areas. _____ _____

3.4 Dam Maintenance and inspections

1. Maintenance

   a. Clearing trees and shrubbery . . . . . _____ _____
   b. Clearing drains. . . . . _____ _____
   c. Exercising valves. . . . . _____ _____
   d. Painting, parapets, walls, ladders, stairways, guardrails, and delineating safety. . . . . _____
   e. Typical maintenance procedures . . . . . _____
   f. Regular maintenance schedules. . . . . _____
   g. Inspection requirements. . . . . _____
   h. Reference to EAP for unusual occurrences. _____
   i. Features requiring special attention . . . _____
   j. Conditions and occurrences for the examiner to be alert . . . . . _____ _____
   k. Standard paragraph use . . . . . _____ _____

2. Embankment and foundation inspection

a. Regular inspection intervals established _____ _____
Embankment, abutment, visible portion of the foundation . . . . . _____ _____
b. Special inspections following
(1) Rapid filling of reservoir . . . . . _____ _____
(2) High velocity winds. . . . . _____ _____
(3) Reservoir water surface lowered. . . . _____ _____
(4) Sustained high reservoir level . . . . _____ _____
(5) Low reservoir level. . . . . _____ _____
(6) Following reportable earthquakes . . . _____ _____

c. Reference to EAP for instructions during unusual occurrences . . . . . _____ _____

3.5 Safety Procedures During Equipment Operation

1. Reference to safety publications. . . . . _____ _____

2. Standard paragraph use. . . . . _____ _____

a. Procedures for "tagging" equipment . . . _____ _____

3. Reference to Communications Directory . . _____ _____

3.6 Protective Coating-Inspection and Maintenance

1. Standard chapter use. . . . . _____ _____

4.0 RESERVOIR OPERATIONS

4.1 Reservoir Capacity Allocations

1. Area - capacity tables and curves

a. Referenced . . . . . _____ _____
b. Included in appendix . . . . . _____ _____

2. Sediment accumulation recognized. . . . _____ _____

4.2 Design Flood Study and Routing

1. Current reservoir inflow design flood . . _____ _____

 a. Approval date of study and hydrograph. . _____ _____
 b. Volume (magnitude) . . . . . _____ _____
 c. Duration . . . . . _____ _____
 d. Peak inflow. . . . . _____ _____
 e. Type of flood. . . . . _____ _____
 f. Occurring months of year . . . . . _____ _____
 g. Antecedent hydrologic conditions . . . . _____ _____
 h. Description of assumptions used. . . . . _____ _____
  (1) Beginning water surface elevation. . . _____ _____
  (2) Spillway gate operation. . . . . _____ _____
  (3) Outlet works release schedule. . . . . _____ _____
  (4) Feeder canal operation . . . . . _____
  (5) Stoplog removal schedule . . . . . _____ _____

 i. Peak discharge (spillway and outlet works) . . . . . _____ _____

2. Hydrographs . . . . . _____ _____

3. Inundation maps . . . . . _____ _____

4. Outstanding floods of record listed or referenced . . . . . _____ _____

4.3 Filling Schedule and Release Procedures

1. Filling schedule. . . . . _____ _____

2. Release schedule. . . . . _____ _____

3. Restrictions. . . . . _____ _____

4. Specific dam operator gate instructions . _____ _____

5. Streamflow and flood control options. . . _____ _____

6. Detailed reservoir operating procedures . _____ _____

4.4 Inflow Forecasting

1. Periodic estimates of inflow volumes. . . _____ _____

 a. Preceding runoff months. . . . . _____ _____
 b. During runoff months . . . . . _____ _____

2. Referenced to Supporting Documents

 a. Hydrometeorological station monitoring . _____ _____
 b. Specific correlations and equations. . . _____ _____

3. SCS and NWS procedures and criteria, if applicable . . . . . _____ _____

4. Examine procedures annually . . . . . _____ _____

4.5 Flood Operating Criteria

1. Listing of storage and release schedules

a. Preceding flood inflow . . . . . _____ _____
b. During flood inflow. . . . . _____ _____

2. Instructions during communications outages included . . . . . _____ _____

a. Narrative and graphical form . . . . . _____ _____

3. Corps of Engineers documents and agreements referenced. . . . . _____ _____

4.6 Special Report During Flood or High Water

1. Reporting instructions

a. Initial report schedule. . . . . _____ _____
b. Who receives reports . . . . . _____ _____
c. Data requirements. . . . . _____ _____
d. Reporting intervals. . . . . _____ _____

2. Surcharge notification detailed . . . . . _____ _____
3. Attendance requirements . . . . . _____ _____

4.7 Filling and Drawdown Limits

1. Special limits on rates and ranges

a. Reasons. . . . . _____ _____
b. Reporting requirements . . . . . _____ _____

2. Statement if limits not applicable. . . . _____ _____

4.8 Earthquake

1. Seismic evaluation . . . . . _____ _____

2. Inspection requirements . . . . . _____ _____

3. Special instructions . . . . . _____ _____

4. See SOP Guide . . . . . _____ _____

4.9 Landslide Surveillance and Landslide

1. Identification of slide areas . . . . . _____ _____

2. Inspection requirements . . . . . _____ _____

3. Special instructions. . . . . _____ _____

4. Standard paragraph use. . . . . _____ _____

4.10 Recreation Management Plan

1. Off-road Vehicle Regulations

a. Regulations referenced . . . . . _____ _____

b. Agency responsible for operation . . . . _____ _____

c. Reservoir operations . . . . . _____ _____

(1) If plan affects reservoir. . . . . _____ _____
(2) How plan affects reservoir . . . . . _____ _____
(3) If plan affects personnel responsibilities. . . . . _____ _____
(4) How plan affects personnel responsibilities. . . . . _____ _____

d. Designated areas (maps included)

(1) Areas allowed to public. . . . . _____ _____
(2) Areas prohibited to public . . . . . _____ _____

2. Fish and Wildlife Consideration

a. Reference all contracts and agreements. _____ _____

b. Note effect on dam and reservoir operations . . . . . _____ _____

4.11 Hydropower and Other Release Criteria

1. Time and quantity release criteria stated _____ _____
2. Relation to other operating functions . . _____ _____
3. Reporting requirements for sudden or large releases . . . . . _____ _____
4. Warning signs and devices available . . . _____ _____
5. Downstream pollution abatement. . . . . _____ _____
6. Structure protection. . . . . _____ _____
7. Control of silt deposition. . . . . _____ _____

APPENDIX B

ROUTINE MAINTENANCE GUIDE

A. VEGETATION CONTROL

All types of woody, deep-rooted vegetation and brush growing on dam embankments or in the spillway are considered a problem and should be controlled. Some of the problems associated with excessive vegetation growth on the dam are:

- Heavy vegetation obstructs the view of the dam inspector and obscures any cracking, seepage and other surficial indications of a problem with the dam.

- After trees and brush die, the root systems can decay, leaving behind a tunnel through which water can pass (piping).

- Large trees blown over during windstorms can have their root systems uprooted, leaving behind a large hole in the embankment that could lead to breaching.

- Vegetation on the embankment provides habitat for burrowing animals, whose presence further endangers the dam.

Taking early action to remove vegetation before it becomes established is a critical part of dam maintenance. Common types of vegetation detrimental to dams are willows, saltcedar (tamarisk), Russian olives, cottonwoods, sagebrush, aspens, poplars, pine, spruce, fir, and juniper.

Evergreen species are the easiest to eradicate since most of them die when cut and do not regenerate from roots. Deciduous trees are generally more difficult to control because many are capable of reproducing from roots and do not die from cutting. Some form of poisoning is an integral part of a program to control this type of vegetation.

As a general statement for all trees whether evergreen or deciduous, killing trees over about 6 feet tall on the dam must also be accompanied by excavating the roots and recompacting clean fill material into the excavation. This should be done in a radius extending from the trunk equal to the height of the tree or until the laterally extending roots are less than about a half inch in diameter.

POLICY - Only grasses which do not obscure observation of the embankment should be allowed to grow on the dam itself (contact your county agricultural agent for information on appropriate grasses for your area). All brush and trees should be prevented from growing: 1) on the dam itself and within 50 feet of the dam for deciduous trees and 25 feet for evergreens, 2) in the spillway and within 50 feet of the spillway for deciduous trees and 25 feet for evergreens, 3) near the spillway or outlet channels such that flow through those structures is reduced or water backs up on the embankment. See illustration 1.

B. HERBICIDE APPLICATION

Several formulations of herbicides suitable for tree and brush control are available. They can be foliar applied or soil applied and consist of liquid spray solutions, granules, and pellets. Here is a brief description of common application methods (See illustration 2):

Foliar applications consist of spraying the chemical directly on to the target plant, especially the leaves. It is necessary to thoroughly cover all above ground vegetation on the plant to the point of runoff. Foliar applications need to be made in the late spring or early summer when plants are actively growing and new growth is young and succulent. In many plants, the heat of summer causes the tree to develop a waxy layer on the leaves which inhibits absorption of foliar applied herbicides into the plant. Also, the tree may become coated with dust as the summer progresses. Both of these factors reduce the effectiveness of foliar applied herbicides. Many foliar herbicides are neutralized in the soil.

Soil treatment consists of applying the herbicide directly to the soil around the target plant. These treatments are intended to be moved into the soil by precipitation and can remain active for several years. If significant quantities of low-lying vegetation exist around the target plant, it may be necessary to remove that vegetation and perhaps scarify the soil to obtain acceptable results. Time of year of these applications is not as critical as with foliar sprays since the herbicide is taken into the plant through the roots. However, do not apply soil treatments to frozen ground. These chemicals are often restricted from use where they may come into contact with irrigation waters, and all precautions and instructions on the labels of herbicides should be followed. They should not be used around the upstream side of the dam nor areas where surface water could move the chemical into conveyance structures.

Frill method consists of making cuts at a convenient height in a circle completely around a tree with downward axe strokes. These cuts should extend well into the sapwood and the sapwood be continuously exposed around the tree. The frilled area is then saturated with herbicide.

Notch or cup method consists of forming one or more notches or cups on the tree with two downward axe cuts, one above the other, and prying out the chips. Notches should be at the base of the tree as near the ground as possible and on the main roots if any show. Two notches are recommended for trees up to 6 inches in diameter, and notches spaced every 10 to 16 inches around larger trees are recommended. Again, the herbicide is applied into the notched areas.

Cut stump method consists of cutting the tree and spraying or painting herbicide onto the remaining stump. Best results are obtained by treating the stump immediately following cutting. Care should be taken to ensure thorough coverage of the area just inside of the bark of the tree.

C. HERBICIDE SELECTION

Translocated herbicides (herbicides which are moved from the place of application to other parts of the plant e.g., moved from the leaves to the roots.) are the main type which are useful for control of vegetation detrimental to dams. These herbicides should be applied when the vegetation is growing and is not dormant. One commonly used herbicide which is not translocated is glyphosate (tradename Roundup). It is not recommended for the uses described herein; particularly, it is not effective in trunk or stump treatments. Translocated foliar sprays which are applied to the leaves (foliage) of plants destroy the plant by being translocated or moved by the plant into its roots. Only plants which are contacted by the chemical are affected. Foliar sprays are normally neutralized in the soil. Soil treatments are applied to the ground rather than directly to the vegetation. They remain active in the soil where they kill plant roots. A single treatment of soil sterilant can remain effective for several years. Choice of a specific herbicide will normally be dictated by where it is to be applied and the proximity of this area to irrigation water rather than the type of vegetation targeted. Extra care needs to be taken in selecting a herbicide for application to vegetation on the upstream side of the dam since some herbicides may contaminate the irrigation supply and result

in damage to crops. A complete and thorough discussion of herbicides and the laws controlling their use is beyond the scope of this publication and the reader is referred to the following publications:

UTAH WEED CONTROL HANDBOOK 1989 compiled by Steven A. Dewey
Utah State University
Available through any county extension office

Herbicide Manual
by Gary W. Hansen, Floyd E. Oliver, N. E. Otto U. S. Department of the Interior
Bureau of Reclamation

Applying Pesticides Correctly
A Guide for Private and Commercial Applicators U. S. Department of Agriculture
U. S. Department of Environmental Protection distributed by the Utah
Department of Agriculture

Willows do not have a large taproot although sinker roots on large trees can be 6 to 8 feet deep. These trees are commonly found around water and reproduce from roots, seeds or from cuttings. Application of a foliar herbicide, such as 2-4-D, will kill young willows if properly applied. Repeat applications are normally required because 2-4-D does not affect the seeds. A soil sterilant, such as tebuthiuron (available from Elanco as SPIKE), is probably the easiest way to control willows, especially large ones. However, it may only be used on areas of the dam where the chemical will not be washed into irrigation waters. Always carefully read and follow the instructions on the labels of these chemicals.

Small, brushy willows have shallow, spreading roots that should not require excavation to repair their damage. Large willows will require extensive excavation to successfully remove spreading roots. For this reason, it is imperative that willows be controlled while they are small.

Saltcedar (tamarisk) trees are becoming more of a problem on Utah dams. One of the best and easiest to control saltcedar is the cut stump application. The tree is first cut and the stump is then sprayed or painted with the herbicide picloram plus 2-4-D (available from Dow Chemical as Tordon RTU). It is essential that the entire cut stump surface be coated with the herbicide, especially the area next to the bark. Application of the herbicide should be done immediately following cutting of the tree. A good kill should be obtained using this procedure. Young, new growth of saltcedar can be handled by applying a foliar spray such as imazapyr (available from American Cyanamid as Arsenal). Foliar applications of 2-4-D are not effective on saltcedar.

Russian olive trees have a shallow root system spreading laterally some 3 to 4 feet or more beyond their limb width. Applications of 2-4-D as a foliar spray is not effective. However, the cut stump treatment recommended for saltcedar above or a notch method using a translocated herbicide should be effective. Soil sterilant treatments should also work well to control Russian olives. If controlled when they are young, roots of Russian olives do not need to be excavated. If they are allowed to reach a height of 6 feet or more, roots need to be excavated and soil recompacted in the excavation.

Cottonwoods do not have a taproot but do have sinker roots which grow downward from a lateral root and may be 3 or 4 feet in depth. Lateral roots can extend 150 feet or more from the tree. These trees are very sensitive to water drawdown and can be a significant deadfall problem at reservoirs which have them growing around the edge of the water. Because of their extreme lateral root growth, clearance zones around dams should be increased for cottonwoods. Cutting small cottonwoods will probably cause sprouting of

new growth from roots, and herbicide treatments need to be incorporated into small cottonwood removal. Cutting of large cottonwoods should also be accompanied with painting the stump as recommended under saltcedar.

Aspen trees also do not have a taproot. and reproduce by root suckers or seeds. Any of the methods described above should effectively kill aspens. Simply cutting the offending trees will result in additional new growth from root suckers, making herbicidal treatment a necessity. Roots from all but the smallest aspens should be removed from the embankment.

Pine and Spruce trees have extremely shallow root systems. The width of the lateral radial spread of the roots can be equal to the height of the tree and more. Pines do have taproots, which may reach 10 feet deep for large trees. Usually, with the exception of firs, simply cutting these evergreens is all that is required for control. Firs may re-sprout after cutting and their stumps should be poisoned.

For assistance in selecting and implementing a vegetation control program, we recommend that the local Utah State University County Extension Agent be contacted. Each county (except Daggett) has a local extension agent and a county weed supervisor who can assist or advise you in herbicide application programs.

D. BURROWING ANIMAL CONTROL

The information on rodents used in this guidebook has been taken from Field Rodent Damage Control Booklet by Ray H. Piggott and Donald W. Hawthorne, developed by the U. S. Fish and Wildlife Service cooperating with the Utah State Department of Agriculture. Some of the typical burrowing animals which damage dams in Utah are squirrels, prairie dogs, rock chucks, badgers, beaver and muskrat. Proper maintenance of embankment dams require that these animals be prevented from burrowing on the dam and that they be eradicated if they are present on a dam. Repair of rodent damages will be discussed in this section.

Control of ground squirrels can be accomplished by using strychnine-treated oats at 0.50% concentration. This bait should be scattered thinly in teaspoonful quantities near the burrow openings or in areas where feeding is evident. Do not place the bait inside the burrows. Thorough, systematic coverage will produce the best results. A pre-bait appetizer of clean oats may help gain bait acceptance. Treatment should be done just after the animals become active after coming out of hibernation.

Small burrowers can attract badgers that dig for them and create very large holes in dams. Under R608-11-3 General Rules, Section (J) Depredation, Utah Proclamation of the Wildlife Board For Taking, Possessing, Selling, Purchasing and Disposing of Furbearers, 1989-90, it is stated, "Badgers ... may be taken without a license when creating a nuisance or causing damage and these animals or parts of them are not being commercialized." Badgers can be shot under this depredation exemption. Employment of a professional trapper may be the best way to rid a site of badgers. It is recommended that dam owners having problems with badgers contact the Utah State Division of Wildlife Resources office or conservation officer nearest them. The addresses and phone numbers of these offices are found in the Appendix.

Beaver may also pose problems on dams and water conveyance structures. As discussed above for badgers, the Proclamation for Furbearers regulates taking beaver. Also in Section (J) Depredation, it states, "Beaver doing damage may be taken or removed by an individual during closed seasons. A "Beaver Nuisance Permit" to remove damaging beaver must first be obtained from Division offices or conservation officers." If beaver are a problem, the Division of Wildlife Resources should be contacted for a permit and assistance.

Rock chucks (marmots) can also damage dams. No toxic chemicals are registered for use on rock chucks. Shooting can provide some control. If the den can be located, gas cartridges can be used. This is done by lighting the cartridge, placing it inside the den opening, and sealing the opening. The acrid gas released by the cartridge then displaces the air inside the burrow. A profess- ional trapper may also be the best solution to deal with rock chucks.

Muskrat can also be a particularly troublesome problem for dam owners since the only viable means for removing them is to trap them. Muskrats can be seen swimming in the reservoir but are seldom seen on land. Employing a professional trapper is also recommended to rid a reservoir of muskrat.

The Utah Division of Wildlife Resources, Proclamation of the Wildlife Board for Nongame Mammals sets forth rules governing certain nongame mammals. Among these is the Utah Prairie Dog, which is a protected species in Beaver, Garfield, Iron, Kane, Piute, Sevier, and Wayne Counties. On sites in these counties where the prairie dog is present, assistance from the Division of Wildlife Resources should be requested to remove the offending animals. A certificate of registration from DWR must first be obtained before taking action against the prairie dog.

Repair of rodent burrows on dams should be made by digging out the holes and recompacting clean fill into the excavation. This work can usually be done by hand.

The Utah State Department of Agriculture licenses and regulates pesticide applications. Individuals desiring to use pesticides on their own private property can do so by obtaining a private applicator's license from the Department of Agriculture. Irrigation companies should have an individual in the company obtain a noncommercial applicator's license for using rodenticides on irrigation company facilities. Both of these licenses can be obtained from the Department of Agriculture at various local offices around the state, which are listed in the Appendix.

E. OTHER EMBANKMENT MAINTENANCE

Deterioration of the surfaces of an earth dam may occur for several reasons. For example, wave action may cut into the upstream slope, vehicles may cause ruts in the crest or slopes, or runoff waters may leave erosion gullies on the downstream slope. Damage of this nature must be repaired on a continuing basis. The maintenance procedures described below are effective in repairing minor earthwork problems. The material selected for repairing embankments depends upon the purpose of the earthwork. Generally, earth should be free from vegetation, organic materials, trash, or large rock. Most of the earth should be fine-grained soils or earth clods which easily break down when worked with compaction equipment. The intent is to use a material, which when compacted, forms a firm, solid mass, free from excessive voids. If flow-resistant portions of an embankment are being repaired, materials that are high in clay or silt content should be used. If the area is to be free draining or highly permeable (i.e., riprap bedding, etc.) the material should have a higher percentage of sand and gravel. As a general rule, it is usually satisfactory to replace or repair damaged areas with soils similar to those originally in place.

F. CREST OF DAM

A dam's crest usually provides the primary access for inspection and maintenance. Because surface water will pond on a crest unless that surface is well maintained, this part of a dam usually requires periodic regrading. However, problems found on the crest should not be simply graded over or covered up. When a questionable condition is found, the state's dam safety engineers should be notified immediately.

Surface runoff should be directed toward the upstream face of the dam by having the crest graded toward the reservoir. Less erosion will result since the upstream face of the dam is usually armored with riprap, the slope is normally flatter and the distance from the crest to the reservoir level is less that from the crest to the downstream toe.

Traffic damage control - As mentioned earlier, vehicles driving across an embankment dam can create ruts in the dam crest if the crest is not surfaced with a suitable roadbase material. The ruts can then collect water and cause saturation and softening of the dam. Other ruts may be formed by vehicles driving up and down a dam face. These ruts can collect runoff and result in severe erosion. Vehicles should be banned from dam slopes and kept out by fences or barricades. Any ruts should be repaired as soon as possible.

Excessive settlement of the embankment or foundation can result in a low area in the dam crest and loss of the freeboard (vertical distance between the top of the spillway and the top of the dam) necessary to pass flood flows safely through the spillway. The dam crest should be surveyed, the probable cause for the formation of the low spot determined by an engineer, remedial action taken to correct the problem and then a uniform crest should be re-established by placing fill in low areas using proper construction techniques.

G. SLOPES OF THE DAM

Livestock access to the dam embankment should be controlled through installation of proper fencing. The main problem associated with livestock on the embankment is erosion caused by: excessive travel by livestock, especially during periods of wet weather, overgrazing of protective grasses and disruption of riprap. Increased erosion maintenance would be necessary if grazing is allowed.

Runoff should be directed away from the abutment contacts through the use of deflecting berms. Sources of excess runoff should be identified, e.g. access roads, parking areas, and runoff intercepted and redirected before it reaches the embankment. The abutment contacts should be kept clear of any obstructing vegetation so that the area can be properly inspected for seepage, etc.

Effective slope protection must prevent soil from being removed from the embankment. Slope protection will require routine maintenance to assure satisfactory long-term operation. Weathering can deteriorate poor quality riprap, breaking it into sizes that are too small to resist wave action. Rounded, similar size rocks have a tendency to roll downhill. Similar sized rocks allow waves to pass between them washing out the finer gravels and sand, causing the riprap to settle. Riprap needs to be replaced anytime the finer material of the bedding is exposed. When riprap breaks down and erosion and beaching occur more often than once every three to five years, it may be necessary to place new bedding and riprap material that has been designed with the gradation and size that will assure its stability when subjected to wave action and weathering.

H. DRAINS, PIEZOMETERS AND WEIRS

Drains should be maintained open; this may require occasional reaming and cleaning. Rodent screens should be placed over the downstream end of the drain to protect them from nesting rodents. The drain outfall channel should be sloped to prevent ponding. PVC piping should be buried to protect it from deterioration due to sunlight.

Piezometers should be equipped with a surface casing and locking lid to protect them from vandalism. The piezometer pipe should have a cap to keep soil or water from entering it. Piezometers casings located in or near traffic areas should be protected from vehicular damage.

Weirs and Weir Ponds should be maintained free from weeds and trash. Sediments accumulating behind weirs installed to measure seepage should be monitored with their quantities measured and noted at the time they are cleaned out. The crest of the weir should be checked periodically to assure that it is level and should also be checked with reference to the zero of the gage. The downstream channel should be adequately sloped to prevent water ponding at the base of the weir. The downstream toe of the weir should be protected against erosion by placement of rock of adequate size.

I. OUTLET MAINTENANCE

A dam's inlet and outlet works are essential to the operation of a dam. Pool level drawdown should not exceed about 1 foot per day for slopes of clay or silt materials except in emergency situations. Very flat slopes or slopes with free-draining upstream soils can, however, withstand more rapid drawdown rates. The low-level outlet must always be operable so that the pool level can be drawn down in case of an emergency or for repairs. Outlet controls must be accessible during periods when the reservoir is spilling. All valves and gates should be operated at least once a year. Valves or gates that have not been operated for a long time can present a special problem for owners. If the valve cannot be closed after it is opened, the impoundment could be completely drained. An uncontrolled and rapid drawdown could also cause more serious problems such as slides along the saturated upstream slope of the embankment or downstream flooding. Therefore, when a valve or gate is operated, it should be inspected and all appropriate parts lubricated and repaired. It is also prudent to advise downstream residents of large and/or prolonged discharges.

Sediments can build up and block the drain inlet, or debris can enter the valve chamber, hindering its function. The likelihood of these problems is greatly decreased if the valve or gate is operated and maintained conscientiously.

Corrosion is a common problem of metal conduits. Exposure to moisture, acid conditions, or salt will accelerate corrosion. In particular, acid runoff from strip mine areas will cause rapid corrosion of steel pipes. In such areas, pipes made of noncorrosive materials such as concrete or plastic should be used. Metal pipes that have been coated to resist accelerated corrosion are also available. The coating can be of epoxy, aluminum, zinc, asbestos or mortar. Coatings applied to pipes already in service are generally not very effective because of the difficulty of establishing a bond with the pipe. Similarly, bituminous coatings cannot be expected to last more than one or two years on flowways. Of course, corrosion of metal parts of operating mechanisms can be effectively treated and prevented by keeping those parts greased and/or painted. Corrosion of metal conduits can also be controlled or arrested by installing cathodic protection. A metallic anode made out of a material such as magnesium is buried in the soil and is connected to the metal pipe by wire. An electric potential is established which causes the magnesium to corrode and not the pipe.

Cavitation is another potential outlet problem. When water flows through an outlet system and passes restrictions (e.g. valves), a pressure drop may occur. If localized water pressures drop below the vapor pressure of water, a partial vacuum is created and the water actually boils, causing shockwaves that can damage the outlet pipes and control valves. Cavitation may be minimized if a ventilating pipe is connected just downstream of the restriction. Cavitation can be a serious problem for large dams where discharge velocities through the outlets are high.

J. EXERCISING VALVES

All valves should be fully opened and closed at least once per year. This not only limits corrosion buildup on control stems and gate guides, but also provides an opportunity to check for smooth operation of the system. Jerky or erratic operation could signal problems and indicate a need for more detailed inspection.

K. GATE OPERATION

The full range of gate settings should be checked. The person performing the inspection should slowly open the valve, checking for noise and vibration - certain valve settings may result in greater turbulence. He should also listen for noises that sound like gravel being rapidly transported through the system. This sound indicates that cavitation is occurring, and the gate settings at which the noises occur should be avoided. The operation of all mechanical and electrical systems, backup electric motors, power generators, and power and lighting wiring associated with the outlet should also be checked.

Electricity is often used on dams to operate the outlet gates, provide lighting and operate other electrical equipment. Thus, it is important that the electrical system be well maintained. Maintenance should include a thorough check of the fuses and a test of the system to be sure everything is properly functioning. Moisture and dust should be kept away from the electrical system, and wiring should be checked for corrosion and mineral deposits. Any necessary repairs should be completed immediately, and records of the repair work should be kept. In addition, generators kept for back-up emergency power must be maintained. Maintenance should include oil changes, battery checks, antifreeze checks, and making sure that fuel is readily available.

A hydraulic control system is often used to open and close the sliding gates of the outlet or intake works. The hydraulic system usually has long hoses and pipelines to transmit hydraulic fluid to the gate operating cylinders, and there are gauges to indicate hydraulic pressure in the system. Routine checks should be performed on the hydraulic cylinders, hoses and pipelines as required.

L. OUTLET INSPECTIONS

Inspecting the outlet system should be done by entering all accessible portions of the structure including the conduit if it is large enough. While inside the conduit, it should be tapped with a hammer to help locate possible voids behind the pipe. All joints, connections and vents should be checked for leakage, offsets or damage. Any material obstructing the conduit should be removed. Conduits, which are too small to enter, should be periodically inspected by remote video camera. If possible, the entire length of the conduit should be inspected for any obvious holes, cavitation damage, vertical and horizontal alignment.

M. SPILLWAY MAINTENANCE

The main function of a spillway is to provide a safe exit for excess water in a reservoir. If a spillway is of inadequate size, a dam could be overtopped and fail. Defects in a spillway can cause failure by rapid erosion of the underlying soils. A spillway should always be kept clear of obstructions, have the ability to resist erosion, and be protected from deterioration.

Obstructions of a spillway may result from excessive growth of grass, weeds, brush, trees, debris, landslide deposits, or rocks placed in the spillway by recreationists. Any of these obstructions can reduce the capacity of a spillway and lead to overtopping of the dam. The installation of log booms can help to prevent floating debris from entering the spillway. Only low-lying grasses should be permitted to grow in the spillway and any obstructions in the spillway should be promptly removed so that the spillway can pass its design capacity. In addition, medium sized rocks that can be carried by swift flowing water in a spillway can damage spillway concrete.

Cracks in the concrete lining of a spillway are commonly encountered. Hairline cracks are usually of no real consequence, but large cracks are of concern. These cracks may be caused by loss of foundation support, shrinkage, movement of the structure, or excessive earth or water pressure. Large cracks may allow earth materials behind the structure to be washed out, causing erosion and perhaps more cracks. It is even possible for the structure to become dislodged and washed away. A severely cracked spillway should be examined by and repaired under the supervision of an engineer. The Division may require monitoring of cracks or other deficiencies such as tilting walls and will assist owners in setting up a monitoring program if the owner so desires.

It is essential that the spillway be erosion resistant. Erosion protection is very important for spillways in sandy soils, deteriorated granite, clay or silt deposits. Low-lying grasses, riprap and concrete structures usually are used to armor spillways.

Spillway surfaces exposed to freeze-thaw cycles often suffer from surface spalling. Chemical action, contamination, and unsound aggregates can also cause spalling. If spalling is extensive, the spalled area should be sketched or photographed, showing the length, width, and depth of the area. The problem should be examined closely to see if the remaining concrete is sound and if reinforcing bars are exposed. The concrete should be tapped with a rock hammer to determine whether voids exist below the surface of the concrete. The condition should be periodically examined to determine if it is worsening.

Vertical walls of a spillway are usually equipped with "weep holes". These holes are intended to drain water from the soil behind the walls and help to prevent damage to the walls from freezing and water pressure. If all weep holes in a wall are dry, then it is probable that the soil behind the wall is dry. If some weep holes flow but others do not, it possible that those which do not flow may be plugged. Any mud, mineral deposits or other obstructions accumulated in weep holes should be removed. Properly functioning weep holes can prolong the life of all concrete walls. Rodent screens should be installed if necessary.

Making sure the spillway is exposed to sunlight on high mountain dams will prevent the accumulation of drifted snow and ice in the spillway entrance that could obstruct the early spring runoff and result in overtopping of the dam. In new dams, exposing the spillway to sunlight should be considered in the design phase. In existing dams, any vegetation that shades the spillway should be removed. A visit to the dam prior to heavy runoff should be scheduled to determine if the spillway is blocked by snow or ice, if that is the case, the blockage should be removed either by excavating a starter channel or spreading coal dust on the surface of the snow to aid in its melting.

The placing of flashboards or stoplogs on the crest of the spillway to raise the water retention level is considered a poor practice by this office. In the event of a flood, stoplogs can be very difficult to remove due to the additional water force acting upon them and wooden flashboards may not fail as designed. Either of these problems could lead to overtopping of the dam.

The spillway discharge channel should be aligned so that it directs water away from the toe of the dam. The channel should be maintained free of obstructing vegetation and debris. Erosional damage should be repaired as soon as possible.

N. RESERVOIR BASIN

Floating debris can obstruct and damage spillways and outlets and should be removed from the reservoir basin and dam embankment as a part of routine maintenance.

Landslides entering the reservoir basin greatly contribute to the sediment load and may drastically shorten the useful life of a reservoir. Landslides entering a reservoir displace the impounded water; if this displacement is large enough it can lead to overtopping of the dam. Landslides into a reservoir are often due to the reservoir slopes becoming saturated with water and then the reservoir being rapidly drawn down. Avoiding rapid drawdowns, blanketing unstable soils with clay, and directing runoff away from unstable soil areas are effective methods to prevent landslides.

Sediment buildup in the reservoir is usually due to destabilization of upstream drainages. A comprehensive basin management plan that emphasizes erosion control, retention of vegetation and environmentally sound stream channel stabilizations practices would be the most effective solution to the sediment problems. Dredging of the reservoir would forestall the loss of capacity but removing the sediment source would be much more effective.

Sinkholes in the reservoir basin, especially adjacent to the embankment, should be cause for concern. They may be indicative of internal erosion (piping) of the embankment material. Away from the upstream toe of the embankment, sinkholes may form due to seepage through the foundation material. If the foundation material is erodible the seepage could lead to failure of the dam. All sinkholes should be brought to the attention of the Dam Safety Office and monitored for any significant changes.

O. SIGNS OF EMBANKMENT DISTRESS

Structural problems with the embankment may be exhibited in the embankment itself, the foundation of the dam, or the abutments. Many of these types of problems become evident early in the life of the dam, often during the first reservoir filling. Symptoms of structural problems are seepage, cracking, movement, settlement, sinkholes and erosion.

Seepage may be evidenced by water emerging in a concentrated location or wet areas. Seepage may occur through joints in the bedrock or zones of high permeability in the foundation or abutments. Seepage may also be attributed to improper construction. In modern dams, seepage flows through the embankment are usually intercepted by permeable drain materials and carried away by pipes from the drain. Excessive drain flows or embankment seepage occurring outside of the drain outlets indicates serious problems. Any evidence of seepage will be discussed with the owner during inspections by the Division. It may be necessary to measure seepage flows and maintain a written historical record of the flows. Physically measuring flows allows a correlation of seepage flow to reservoir elevation and eliminates guesswork from estimating those quantities. Increases will be apparent. Another benefit from using weirs to measure flows is that soils that are possibly being moved by the water may settle out in the pool behind the weir. This allows estimates of sediments being removed and observation of potentially dangerous piping. Piping consists of the progressive erosion and removal of soil by concentrated seepage flows through a dam, its foundation, or its abutments. Seepage that is causing piping may create a sand boil where the water emerges. If new seepage areas develop, an increase in

existing seepage occurs, or sand boils develop, the Dam Safety Section of the Division of Water Rights should immediately be contacted.

Cracking can occur in a variety of places on the dam. Transverse cracks, those that occur perpendicular to the crest, usually indicate that stresses in the dam are being created by unequal settlement of the fill or foundation material. Longitudinal cracks, which are parallel to the crest, can occur anywhere from the upstream toe to the downstream toe. Foundation problems or an embankment weakness can be manifested by cracks. Emptying the reservoir quickly can cause cracks on the upstream side of the dam. Randomly oriented, shallow cracks are usually attributable to drying of the surface soils on the dam. Cracks of any sort should be reported to the Dam Safety Section of the Division of Water Rights.

Movement of the embankment can occur as a slough or slide. These problems are usually initiated by a period of unusually high moisture in the ground and are aggravated by seepage flows. Cracks at the top and bulging at the bottom, or toe, of the moving material frequently accompanies a slope failure. Establishing survey monuments allows the extent of movement to be accurately measured. If any movement of embankment or abutment material occurs, the Dam Safety Section of the Division of Water Rights should be contacted.

Sinkholes are created by piping of material by seepage flows. They can occur directly on the dam but usually occur along the upstream toe of the dam. During low reservoir levels, the reservoir basin, the abutments, and the upstream face of the dam should be examined closely for sinkhole depressions. Sinkholes may indicate serious deficiencies with the dam and should be remedied quickly. Corrective action will need to be designed by a professional engineer.

Erosion of the embankment can result from inadequate protection of the dam from wave action or from rain collecting and running down the face of the dam. Waves create steps, sometimes called beaches and benches, along the upstream face of dams not properly protected by riprap. Surface runoff should be directed toward the upstream face of the dam by having the crest graded toward the reservoir. Less erosion will result since the upstream face of the dam is usually armored with riprap and the distance from the crest to the reservoir level is less than from the crest to the downstream toe. Erosion of the upstream face of the dam should be corrected by placing an adequate layer of properly graded riprap.

APPENDIX C

GLOSSARY

ABUTMENT - That part of a valley side against which a dam is constructed. Right and left abutments are those on the right and left sides respectively of an observer facing downstream.

AIRVENT PIPE - A pipe designed to provide air to the outlet conduit to reduce turbulence during release of water. Extra air is usually necessary downstream of constrictions.

BEACHING or BENCHING - The removal, by wave action, of a portion of the upstream (reservoir) side of the embankment and the resultant deposition of this material farther down the slope. Such deposition creates a relatively flat beach area.

BOIL - A disturbance in the surface layer of soil caused by water escaping under pressure. The boil may be accompanied by deposition of soil particles (usually sand) in a circle around the point at which the water exits.

BREACH - An opening or a breakthrough of a dam sometimes caused by rapid erosion of a section of earth embankment by water.

CAVITATION - Wear on hydraulic structures where a high hydraulic gradient is present. Cavitation is caused by the abrupt change in direction and velocity of the water so the pressure at some points is reduced to the vapor pressure and vapor pockets are created. These pockets collapse with great impact when they enter areas of higher pressure, producing very high impact pressures over small areas that eventually cause pits and holes in the surface. Noises and vibrations may be evident during high flows.

CONDUIT - A closed channel to convey the discharge through or under a dam.

CORE - A zone of material of low permeability, usually clayey soils, in an embankment dam.

CREST LENGTH - The length of the dam, from one abutment to the other, along the top of the dam. This includes the spillway width if it is adjacent to the embankment.

CUTOFF - An impervious construction or material that reduces seepage or prevents it from passing through foundation material.

CUTOFF TRENCH - An excavation into the foundation later to be filled with impervious material to form a cutoff below the dam.

CUTOFF WALL - A wall of impervious material (usually concrete) built into the foundation to reduce seepage under the dam.

DRAINS - Permeable vertical or horizontal sections in the dam that collect water to prevent saturation of the downstream portion of the embankment. This water is frequently piped from the drainage layer to daylight outside the embankment.

DRAINAGE AREA - Land above the dam site from which surface waters naturally drain to the dam.

FILTER - A band or zone of granular material that is incorporated into a dam and is graded to allow seepage to flow into the filter without allowing the migration of soils from zones adjacent to the filter.

FLASHBOARDS - A length of timber, concrete, or steel placed on the crest of a spillway to raise the water level, but that may be quickly removed in the event of a flood either by a tripping device or by deliberately designed failure of the flashboard or its supports.

FLOODPLAIN - An area adjoining a body of water or natural stream that has been or may be covered by floodwater.

FLOWLINE - The path that a particle of water follows in its course of seepage under laminar flow conditions.

FLUME - A flow-measuring device

FOUNDATION OF DAM - The natural material on which the dam structure is placed.

FREEBOARD - The vertical distance between a stated water level and the top of a dam. Usually, this term is used to denote the difference in elevations between the flowline of the spillway, which is considered to be the maximum normal water surface, and the top of the dam.

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

HEIGHT OF DAM - Hydraulic height refers to the height that water can rise to behind a dam. It is the difference between the elevations of the lowest point in the original streambed at the downstream toe of the dam and the maximum controllable water surface. Structural Height is the same as hydraulic height except that it is measured to the top of the dam.

INSTRUMENTATION - Permanent devices that are installed in/near a dam to allow monitoring of the dam and impoundment. These devices may include a staff gage for measuring the reservoir level, piezometers and/or observation wells to determine the phreatic surface through the dam, weirs or flumes, and survey monuments. Each of these terms is defined in this glossary.

INTAKE - A structure that is designed to guide water into another, such as the intake structure for the outlet conduit.

LIQUIFACTION - The sudden large decrease of the shearing resistance of a cohesionless soil. It is caused by a collapse of the structure by shock or other type of strain and is associated with a sudden but temporary increase of the pore-filled pressure. It involves a temporary transformation of the soil into a fluid mass.

LOG BOOM - A device intended to prevent large floating debris from being carried into the spillway and possibly clogging it. Typically, it is constructed out of logs that are hinged together and anchored on either side of the spillway so that the floating debris catches on the log boom and is kept in the reservoir basin.

OUTLET - A conduit through which controlled releases can be made from the reservoir.

PHREATIC SURFACE - The upper surface of saturation within an embankment.

PIEZOMETER - A device for measuring internal water pressures or levels in the dam, its foundation, or the abutments. Most piezometers are wells with small diameter pipes installed through which the water level is measured. Observation wells are similar to piezometers but are often larger in diameter than piezometers.

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

PLUNGE POOL - A natural or sometimes artificially created pool that dissipates the energy of free-falling water. The pool is located at a safe distance downstream of the structure from which water is being released. Also called STILLING BASIN.

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

SLUMP AREA - A portion of earth embankment that moves downslope, sometimes suddenly, often with cracks and bulges developing.

SPALLING - the separation and deterioration of a thin surface layer of concrete or rock.

SPILLWAY SYSTEM - A structure over or through which excess reservoir water is discharged. If the flow is controlled by gates, it is considered a controlled spillway; if the elevation of the spillway crest cannot be adjusted and is the only control, it is considered an uncontrolled spillway.

EMERGENCY SPILLWAY - A secondary spillway designed to operate only during extreme floods.

PRINCIPAL SPILLWAY - The main spillway for normal operations and flows.

STILLING BASIN - A basin constructed to dissipate the energy of fast-flowing water from a spillway or outlet to protect the riverbed from erosion.

STOPLOGS - Removable logs or timbers, steel or concrete beams placed on top of each other with their ends held in guides on each side of a channel to raise the reservoir level.

SURVEY MONUMENTS - Surveyed monuments are sometimes installed on dams to allow monitoring of movement of the dam.

TOE OF EMBANKMENT - The intersection of the face of a dam with the ground surface.

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

WATERSTOP - A strip of metal, rubber or other material used to prevent leakage through joints between adjacent sections of concrete.

WEEPHOLES - Holes in concrete walls or slabs intended to drain water from the soil behind the wall.

WEIR - A low dam or wall built across a stream to raise the upstream water level or a structure built across a stream or channel for the purpose of measuring flow. Sometimes described as measuring weir or gauging weir. Types of weirs include broad crested weir, sharp-crested weir, ogee weir, and V-notched weir.

PERTINENT CONTACTS

Offices and Addresses of the Utah Division of Water Rights

DAM SAFETY SECTION **PHONE (801) 538-7414**

Salt Lake Office
1594 West North Temple
P.O. Box 146300
Salt Lake City, Utah 84114
Phone (801) 538-7240

Northern (Logan) Regional Office
1780 North Research Parkway, Ste 104
North Logan, Utah 84341
Phone (435) 752-8755

Eastern (Vernal) Regional Office
318 North Vernal Avenue
Vernal, Utah 84078
Phone (435) 247-1514

Southestern (Price) Regional Office
319 North Carbonville Road, Suite B
P.O. Box 718
Price, Utah 84501
Phone (435) 613-3750

Southern (Richfield) Regional Office
2031 South Industrial Park Road
Richfield, Utah 84701
Phone (435) 896-2557

Southwestern (Ceder City) Regional Office
646 North Main
P.O. Box 506
Cedar City, Utah 84721
Phone (435) 586-4231

Utah Division of Water Resources
1594 West North Temple
P.O. Box 146201
Salt Lake City, Utah 84114
Phone (801) 538-7230

Offices and Addresses of the Utah Division of Wildlife Resources

Salt Lake Office
1594 West North Temple
P.O. Box 146301
Salt Lake City, Utah 84114
Phone (801) 538-7400

Northern Regional Office
515 East 5300 South
Ogden, Utah 84405
Phone (801) 476-2740

Central Regional Office
1115 North Main Street
Springville, Utah 84663
Phone (801) 491-5678

Southern Regional Office
1470 North Airport Road
Cedar City, Utah 84720
Phone (435) 865-6100

Southeastern Regional Office
319 North Carbonville Rd.
Price, Utah 84501
Phone (435) 613-3700

Northeastern Regional Office
318 North Vernal Avenue
Vernal, Utah 84078
Phone (435) 781-9453