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APPENDIX I

World Bank: Operational Policy 4.37 on the Safety of Dams

THE WORLD BANK OPERATIONAL MANUAL

Operational Policies

OP 4.37
October 2001

These policies were prepared for use by World Bank staff and are not necessarily a complete treatment of the subject.

Safety of Dams

Note: OP and BP 4.37 replace the versions dated September 1996. Other Bank policies that may apply to projects that involve dams include the following: OP/BP 4.01, *Environmental Assessment*; OP/BP 4.04, *Natural Habitats*; OP 4.11, *Cultural Property*; OD 4.20, *Indigenous Peoples*; OD 4.30, *Involuntary Resettlement*; and OP/BP 7.50, *Projects on International Waterways*. Questions on dam safety should be addressed to the Director, Rural Development Department (RDV).

1. For the life of any dam, the owner¹ is responsible for ensuring that appropriate measures are taken and sufficient resources provided for the safety of the dam, irrespective of its funding sources or construction status. Because there are serious consequences if a dam does not function properly or fails, the Bank² is concerned about the safety of new dams it finances and existing dams on which a Bank-financed project is directly dependent.

New Dams

2. When the Bank finances a project that includes the construction of a new dam,³ it requires that the dam be designed and its construction

1. The owner may be a national or local government, a parastatal, a private company, or a consortium of entities. If an entity other than the one with legal title to the dam site, dam, and/or reservoir holds a license to operate the dam, and has responsibility for its safety, the term "owner" includes such other entity.

2. "Bank" includes the International Development Association (IDA), and "loans" include credits.

3. For example, a water storage dam for a hydropower, water supply, irrigation, flood control, or multipurpose project; a tailings or a slimes dam for a mine project; or an ash impoundment dam for a thermal power plant.

supervised by experienced and competent professionals. It also requires that the borrower⁴ adopt and implement certain dam safety measures for the design, bid tendering, construction, operation, and maintenance of the dam and associated works.

3. The Bank distinguishes between small and large dams.
 - a) Small dams are normally less than 15 meters in height. This category includes, for example, farm ponds, local silt retention dams, and low embankment tanks.
 - b) Large dams are 15 meters or more in height. Dams that are between 10 and 15 meters in height are treated as large dams if they present special design complexities—for example, an unusually large flood-handling requirement, location in a zone of high seismicity, foundations that are complex and difficult to prepare, or retention of toxic materials.⁵ Dams under 10 meters in height are treated as large dams if they are expected to become large dams during the operation of the facility.
4. For small dams, generic dam safety measures designed by qualified engineers are usually adequate. For large dams, the Bank requires
 - a) reviews by an independent panel of experts (the Panel) of the investigation, design, and construction of the dam and the start of operations;
 - b) preparation and implementation of detailed plans: a plan for construction supervision and quality assurance, an instrumentation plan, an operation and maintenance plan, and an emergency preparedness plan;⁶

4. When the owner is not the borrower, the borrower ensures that the obligations of the borrower under this OP are properly assumed by the owner under arrangements acceptable to the Bank.

5. The definition of “large dams” is based on the criteria used to compile the list of large dams in the World Register of Dams, published by the International Commission on Large Dams.

6. BP 4.37, Annex A, sets out the content of these plans and the timetable for preparing and finalizing them. In the dam safety practice of several countries, the operation and maintenance plan includes both the instrumentation plan and the emergency preparedness plan as specific sections. This practice is acceptable to the Bank, provided the relevant sections are prepared and finalized according to the timetable set out in BP 4.37, Annex A.

- c) prequalification of bidders during procurement and bid tendering;⁷
and
- d) periodic safety inspections of the dam after completion.

5. The Panel consists of three or more experts, appointed by the borrower and acceptable to the Bank, with expertise in the various technical fields relevant to the safety aspects of the particular dam.⁸ The primary purpose of the Panel is to review and advise the borrower on matters relative to dam safety and other critical aspects of the dam, its appurtenant structures, the catchment area, the area surrounding the reservoir, and downstream areas. However, the borrower normally extends the Panel's composition and terms of reference beyond dam safety to cover such areas as project formulation; technical design; construction procedures; and, for water storage dams, associated works such as power facilities, river diversion during construction, shiplifts, and fish ladders.
6. The borrower contracts the services of the Panel and provides administrative support for the Panel's activities. Beginning as early in project preparation as possible, the borrower arranges for periodic Panel meetings and reviews, which continue through the investigation, design, construction, and initial filling and start-up phases of the dam.⁹ The borrower informs the Bank in advance of the Panel meetings, and the Bank normally sends an observer to these meetings. After each meeting, the Panel provides the borrower a written report of its conclusions and recommendations, signed by each participating member; the borrower provides a copy of that report to the Bank. Following the filling of the reservoir and start-up of the dam, the Bank reviews the Panel's findings and recommendations. If no significant difficulties are encountered in the filling and start-up of the dam, the borrower may disband the Panel.

7. See *Guidelines: Procurement under IBRD Loans and IDA*.

8. The number, professional breadth, technical expertise, and experience of Panel members are appropriate to the size, complexity, and hazard potential of the dam under consideration. For high-hazard dams, in particular, the Panel members should be internationally known experts in their field.

9. If the Bank's involvement begins at a later stage than project preparation, the Panel is constituted as soon as possible and reviews any aspects of the project that have already been carried out.

Existing Dams and Dams under Construction

7. The Bank may finance the following types of projects that do not include a new dam but will rely on the performance of an existing dam or a dam under construction (DUC): power stations or water supply systems that draw directly from a reservoir controlled by an existing dam or a DUC; diversion dams or hydraulic structures downstream from an existing dam or a DUC, where failure of the upstream dam could cause extensive damage to or failure of the new Bank-funded structure; and irrigation or water supply projects that will depend on the storage and operation of an existing dam or a DUC for their supply of water and could not function if the dam failed. Projects in this category also include operations that require increases in the capacity of an existing dam, or changes in the characteristics of the impounded materials, where failure of the existing dam could cause extensive damage to or failure of the Bank-funded facilities.
8. If such a project, as described in para. 7, involves an existing dam or DUC in the borrower's territory, the Bank requires that the borrower arrange for one or more independent dam specialists to (a) inspect and evaluate the safety status of the existing dam or DUC, its appurtenances, and its performance history; (b) review and evaluate the owner's operation and maintenance procedures; and (c) provide a written report of findings and recommendations for any remedial work or safety-related measures necessary to upgrade the existing dam or DUC to an acceptable standard of safety.
9. The Bank may accept previous assessments of dam safety or recommendations of improvements needed in the existing dam or DUC if the borrower provides evidence that (a) an effective dam safety program is already in operation, and (b) full-level inspections and dam safety assessments of the existing dam or DUC, which are satisfactory to the Bank, have already been conducted and documented.
10. Necessary additional dam safety measures or remedial work may be financed under the proposed project. When substantial remedial work is needed, the Bank requires that (a) the work be designed and supervised

by competent professionals, and (b) the same reports and plans as for a new Bank-financed dam (see para. 4[b]) be prepared and implemented. For high-hazard cases involving significant and complex remedial work, the Bank also requires that a panel of independent experts be employed on the same basis as for a new Bank-financed dam (see paras. 4[a] and 5).

11. When the owner of the existing dam or DUC is an entity other than the borrower, the borrower enters into agreements or arrangements providing for the measures set out in paras. 8–10 to be undertaken by the owner.

Policy Dialogue

12. Where appropriate, as part of policy dialogue with the country, Bank staff discuss any measures necessary to strengthen the institutional, legislative, and regulatory frameworks for dam safety programs in the country.

APPENDIX II

World Bank: Bank Procedure 4.37 on the Safety of Dams

THE WORLD BANK OPERATIONAL MANUAL **Bank Procedures**

BP 4.37
October 2001

These procedures were prepared for use by World Bank staff and are not necessarily a complete treatment of the subject.

Safety of Dams

Note: OP and BP 4.37 replace the versions dated September 1996. Other Bank policies that may apply to projects that involve dams include the following: OP/BP 4.01, *Environmental Assessment*; OP/BP 4.04, *Natural Habitats*; OP 4.11, *Cultural Property*; OD 4.20, *Indigenous Peoples*; OD 4.30, *Involuntary Resettlement*; and OP/BP 7.50, *Projects on International Waterways*. Questions on dam safety should be addressed to the Director, Rural Development Department (RDV).

Project Processing

1. When the Bank¹ begins processing a project that includes a dam, the processing team includes individuals who have relevant experience in dam engineering and in preparation and supervision of previous Bank-funded projects that have included dams. If such individuals are not available within the Region, the task team (TT) consults the Rural Development Department for referral to appropriate specialists inside or outside the Bank.
2. Bank projects involving dams are processed according to the procedures set forth in BP10.00, *Investment Lending: Identification to Board Presentation*.
3. As soon as a project involving a dam is identified, the TT discusses with the borrower the Bank's policy on dam safety (OP 4.37).

1. "Bank" includes IDA, and "loans" includes credits.

Preparation

4. The TT ensures that the borrower's terms of reference (TOR) for technical services to investigate the site and design the dam, supervise new or remedial construction, advise on initial reservoir filling and start-up operations, and perform inspections and safety assessments, as well as the qualifications of the professionals (e.g., engineers, geologists, or hydrologists) to be employed by the borrower are adequate to the complexity of the particular dam.
5. If an independent panel of experts (the Panel) is required, the TT advises borrower staff, as necessary, on the preparation of the TOR. The TT reviews and clears the TOR and the Panel members proposed by the borrower. Once the Panel is in place, TT staff normally attend Panel meetings as observers.
6. The TT reviews all reports relating to dam safety prepared by the borrower, the Panel, the independent specialists who assess an existing dam or a dam under construction, and the professionals hired by the borrower to design, construct, fill, and start up the dam.
7. The TT monitors the borrower's preparation of the plans for construction supervision and quality assurance, instrumentation, operation and maintenance, and emergency preparedness (see OP 4.37, para. 4, and BP 4.37, Annex A).

Appraisal

8. The appraisal team reviews all project information relevant to dam safety, including cost estimates; construction schedules; procurement procedures; technical assistance arrangements; environmental assessments; and the plans for construction supervision and quality assurance, instrumentation, operation and maintenance, and emergency preparedness. The team also reviews the project proposal, technical aspects, inspection reports, Panel reports, and all other borrower action plans relating to dam safety. If a Panel has been required, the team verifies that the borrower has taken the Panel's recommendations into

consideration and, if necessary, assists the borrower in identifying sources for dam safety training or technical assistance.

9. The TT and the assigned Bank lawyer ensure that the legal agreements between the Bank and the borrower require the borrower
 - (a) if a Panel has been required, to convene Panel meetings periodically during project implementation and retain the Panel through the start-up of a new dam;
 - (b) to implement the required plans (see Annex A) and raise to the required standard any that have not been adequately developed; and
 - (c) after filling and start-up of a new dam, to have periodic dam safety inspections performed by independent qualified professionals who have not been involved with the investigation, design, construction, or operation of the dam.

Supervision

10. During implementation, the TT monitors all activities relating to the dam safety provisions in the Loan Agreement, using technical staff and, as appropriate, consultants to assess the borrower's performance. If performance in regard to dam safety is found to be unsatisfactory, the TT promptly informs the borrower that the deficiencies must be remedied.
11. During the latter stages of project implementation, the TT discusses post-project operational procedures with the borrower, stressing the importance of ensuring that written instructions for flood operations and emergency preparedness are retained at the dam at all times. The TT also points out that the advent of new technology or new information (e.g., from floods, seismic events, or discovery of new regional or local geologic features) may in the future require the borrower to modify the technical criteria for evaluating dam safety; the TT urges the borrower to make such modifications and then apply the revised criteria to the project dam and, as necessary, to other dams under the borrower's jurisdiction.

12. To ensure that completed dams are inspected and maintained satisfactorily, Regional staff may carry out supervision beyond the closing date of the project, either during work on follow-up projects or during specially scheduled supervision missions.²

2. See OP/BP 13.05, *Project Supervision*.

APPENDIX III

World Bank: Bank Procedure 4.37 on the Safety of Dams, Annex A on Dam Safety Reports: Content and Timing

THE WORLD BANK OPERATIONAL MANUAL **Bank Procedures**

BP 4.37 – Annex A
October 2001

These procedures were prepared for use by World Bank staff and are not necessarily a complete treatment of the subject.

Dam Safety Reports: Content and Timing

1. *Plan for construction supervision and quality assurance.* This plan is provided to the Bank by appraisal. It covers the organization, staffing levels, procedures, equipment, and qualifications for supervision of the construction of a new dam or of remedial work on an existing dam. For a dam other than a water storage dam,¹ this plan takes into account the usual long construction period, covering the supervision requirements as the dam grows in height—with any accompanying changes in construction materials or the characteristics of the impounded material—over a period of years. The task team uses the plan to assess the need to fund components under the loan to ensure that dam-safety-related elements of the design are implemented during construction.
2. *Instrumentation plan.* This is a detailed plan for the installation of instruments to monitor and record dam behavior and the related hydrometeorological, structural, and seismic factors. It is provided to an independent panel of experts (the Panel) and the Bank during the design stage, before bid tendering.
3. *Operation and maintenance (O&M) plan.* This detailed plan covers organizational structure, staffing, technical expertise, and training required;

1. For example, a mine tailings, ash impoundment, or slag storage dam.

equipment and facilities needed to operate and maintain the dam; O&M procedures; and arrangements for funding O&M, including long-term maintenance and safety inspections. The O&M plan for a dam other than a water storage dam, in particular, reflects changes in the dam's structure or in the nature of the impounded material that may be expected over a period of years. A preliminary plan is provided to the Bank for use at appraisal. The plan is refined and completed during project implementation; the final plan is due not less than six months prior to the initial filling of the reservoir. Elements required to finalize the plan and initiate operations are normally financed under the project.²

4. *Emergency preparedness plan.* This plan specifies the roles of responsible parties when dam failure is considered imminent, or when expected operational flow release threatens downstream life, property, or economic operations that depend on river flow levels. It includes the following items: clear statements on the responsibility for dam operations decision making and for the related emergency communications; maps outlining inundation levels for various emergency conditions; flood warning system characteristics; and procedures for evacuating threatened areas and mobilizing emergency forces and equipment. The broad framework plan and an estimate of funds needed to prepare the plan in detail are provided to the Bank prior to appraisal. The plan itself is prepared during implementation and is provided to the Panel and Bank for review not later than one year before the projected date of initial filling of the reservoir.

2. In the dam safety practice of several countries, the operation and maintenance plan includes both the instrumentation plan and the emergency preparedness plan as specific sections. This practice is acceptable to the Bank, provided the relevant sections are prepared and finalized according to the timetable set out in this Annex.

APPENDIX IV

Republic of South Africa, 1998 National Water Act, Chapter 12: Safety of Dams

NOTE: This appendix is provided merely as an example of a statute that contains specific provisions on dam safety. There are many other examples of such statutes and the inclusion of this example in this report should not be interpreted as an endorsement of this statutory model over other models.

(English text signed by the President)

(Assented to 20 August 1998)

**REPUBLIC OF SOUTH AFRICA
NATIONAL WATER ACT
Act No. 36 of 1998**

ACT

To provide for fundamental reform of the law relating to water resources; to repeal certain laws; and to provide for matters connected therewith.

PREAMBLE

Recognising that water is a scarce and unevenly distributed national resource which occurs in many different forms which are all part of a unitary, interdependent cycle;

Recognising that while water is a natural resource that belongs to all people, the discriminatory laws and practices of the past have prevented equal access to water, and use of water resources;

Acknowledging the National Government's overall responsibility for and authority over the nation's water resources and their use, including the equitable allocation of water for beneficial use, the redistribution of water, and international water matters;

Recognising that the ultimate aim of water resource management is to achieve the sustainable use of water for the benefit of all users;

Recognising that the protection of the quality of water resources is necessary to ensure sustainability of the nation's water resources in the interests of all water users; and

Recognising the need for the integrated management of all aspects of water resources and, where appropriate, the delegation of management functions to a regional or catchment level so as to enable everyone to participate;

BE IT ENACTED by the Parliament of the Republic of South Africa, as follows:

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6. Contents of national water resource strategy
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CHAPTER 12 SAFETY OF DAMS

This Chapter contains measures aimed at improving the safety of new and existing dams with a safety risk so as to reduce the potential for harm to the public, damage to property or to resource quality. To reduce the risk of a dam failure, control measures require an owner to comply with certain directives and regulations, such as to submit a report on the safety of a dam, to repair or alter a dam, or to appoint an approved professional person to undertake these tasks. These measures are in addition to the owners' common law responsibility to ensure the safety of their dams. An approved professional person has a statutory duty of care towards the State and the general public and must fulfil, amongst other things, defined responsibilities when acting under this Chapter. Not all dams are subject to regulation under this Chapter, and the Minister may exempt certain persons from its requirements. Only dams of a defined size, dams which have been declared to be dams with a safety risk, or dams falling into a prescribed category are affected. All dams with a safety risk must be registered. Compliance with any directive or regulation

under this Chapter does not exempt an owner from complying with any other provision of this Act, such as the requirement for a licence or other authorisation for water use in respect of the dam.

Definitions

117. In this Chapter –

- (a) “approved professional person” means a person registered in terms of the Engineering Profession of South Africa Act, 1990 (Act No. 114 of 1990), and approved by the Minister after consultation with the Engineering Council of South Africa (established by section 2 of that Act);
- (b) “dam” includes any existing or proposed structure which is capable of containing, storing or impounding water (including temporary impoundment or storage), whether that water contains any substance or not;
- (c) “Dam with a safety risk” means any dam –
 - (i) which can contain, store or dam more than 50 000 cubic meters of water;
 - (ii) belonging to a category of dams declared under section 118(2) to be dams with a safety risk; or
 - (iii) declared under section 118(iii)(a) to be a dam with a safety risk;
- (d) “owner of a dam” or “owner of a dam with a safety risk” includes the person in control of that dam; and
- (e) “task” includes a task relating to designing, constructing, altering, repairing, impounding water in, operating, evaluating the safety of, maintaining, monitoring or abandoning a dam with a safety risk.

Control measures for dam with safety risk

118. (1) The owner of a dam must

- (a) within the period specified, provide the Minister with any information, drawings, specifications, design assumptions, calculations, documents and test results requested by the Minister;
or
- (b) give any person authorised by the Minister access to that dam, to enable the Minister to determine whether
 - (i) that dam is a dam with a safety risk;
 - (ii) that dam should be declared to be a dam with a safety risk;

- (iii) a directive should be issued for specific repairs or alterations to that dam; or
 - (iv) the owner has complied with any provisions of this Act applicable to that dam.
- (2) The Minister may by notice in the *Gazette* declare a category of dams to be dams with a safety risk.
- (3) The Minister may
- (a) by written notice to the owner of a dam, declare that dam to be a dam with a safety risk;
 - (b) direct the owner of a dam with a safety risk to submit, at the owner's cost, and within a period specified by the Minister, a report by an approved professional person regarding the safety of that dam; or
 - (c) direct the owner of a dam with a safety risk to undertake, at the owner's cost, and within a period specified by the Minister, any specific repairs or alterations to that dam which are necessary to protect the public, property or the resource quality from a risk of failure of the dam.
- (4) If the owner of the dam fails to comply with the directive contemplated in subsection (3)(c) within the period specified, the Minister may undertake the repairs or alterations and recover the costs from the owner.
- (5) Before issuing a directive, the Minister must
- (a) be satisfied that the repairs or alterations directed are necessary, adequate, effective and appropriate to reduce the risk to an acceptable level; and
 - (b) consider the impact on public safety, property, the resource quality and socio-economic aspects if the dam fails.

Responsibilities of approved professional persons

- 119.** (1) When carrying out a task in terms of this Chapter, an approved professional person also has a duty of care towards the State and the general public.
- (2) An approved professional person appointed to carry out a task on a dam must
- (a) ensure that the task is carried out according to acceptable dam engineering practices;

- (b) keep the prescribed records;
 - (c) compile the prescribed reports; and
 - (d) where the task includes constructing, altering or repairing a dam, issue a completion certificate to the owner of the dam to the effect that the task on that dam has been carried out according to the applicable design, drawings and specifications.
- (3) An approved professional person appointed to carry out a dam safety evaluation must –
- (a) consider whether the safety norms pertaining to the design, construction, monitoring, operation, performance and maintenance of the dam satisfy acceptable dam engineering practices; and
 - (b) compile a report on the matters contemplated in paragraph (a) according to the prescribed requirements and submit the signed and dated report to the owner of the dam within the prescribed period.

Registration of dam with safety risk

- 120.** (1) The owner of a dam with a safety risk must register that dam.
- (2) An application for registration must be made within 120 days
- (a) after the date on which the dam with a safety risk becomes capable of containing, storing or impounding water;
 - (b) after the date on which an already completed dam is declared to be a dam with a safety risk; or
 - (c) after publication of a notice declaring a category of dams to be dams with a safety risk, as the case may be.
- (3) A successor-in-title to an owner of a dam with a safety risk must promptly inform the Director-General of the succession, for the substitution of the name of the owner.

Factors to be considered in declaring dam or category of dams with safety risk

- 121.** In declaring a category of dams or a dam to be a category of dams or a dam with a safety risk, the Minister must consider
- (a) the need to protect the public, property and the resource quality against the potential hazard posed by the dam or category of dams;

- (b) the extent of potential loss or harm involved;
- (c) the cost of any prescribed measures and whether they are reasonably achievable;
- (d) the socio-economic impact if such a dam fails; and
- (e) in the case of a particular dam, also
 - (i) the manner in which that dam is designed, constructed, altered, repaired, operated, inspected, maintained or abandoned;
 - (ii) the person by whom that dam is designed, constructed, altered, repaired, operated, inspected, maintained or abandoned; and
 - (iii) the manner in which the water is contained, stored or impounded in that dam.

Exemptions

- 122.** (1) The Minister may exempt owners of dams belonging to certain categories, by notice in the *Gazette*, from compliance with any provision of this Chapter or any regulation made under this Chapter, on conditions determined by the Minister.
- (2) The Minister may in writing exempt an owner of a dam belonging to a certain category from compliance with any provision of this Chapter on conditions determined by the Minister.
- (3) The Minister may withdraw the exemption or impose further or new conditions in respect of the exemption.
- (4) Before deciding on an exemption, the Minister must consider
- (a) the degree of risk or potential risk posed by the dam or category of dams to public safety, property and the resource quality;
 - (b) the manner of design, construction, alteration, repair, impoundment of water in, operation or abandonment of the dam or category of dams;
 - (c) the supervision involved in the dam or category of dams;
 - (d) alternative measures proposed for regulating the design, construction, alteration, repair, operation, maintenance, impoundment of water in, inspection or abandonment of the dam or category of dams and the effectiveness of these measures;
 - (e) the knowledge and expertise of the persons involved in any task relating to the dam or category of dams;

- (f) the costs relating to the dam or category of dams;
- (g) any security provided or intended to be provided for any damage which could be caused by the dam or category of dams; and
- (h) whether the dam or category of dams are permitted in terms of a licence or any other authorisation issued by or under any other Act.

Regulations regarding dam safety

123. (1) The Minister may make regulations

- (a) for the establishment of a register of approved professional persons for dealing with dams with a safety risk
 - (i) providing for
 - (aa) different classes of approved professional persons;
 - (bb) the tasks or category of tasks which each class of approved professional persons may perform; and
 - (cc) the conditions under which each class of approved professional persons may perform any task or category of tasks;
 - (ii) concerning the requirements for admission to each class;
 - (iii) setting out, in respect of each class, the procedure for
 - (aa) approval;
 - (bb) withdrawal of an approval; and
 - (cc) suspension of an approval; and
 - (iv) providing for a processing fee for an approval;
- (b) regulating the approval of a person as an approved professional person for a specific task
 - (i) setting out the procedure for approval;
 - (ii) setting out the procedure for cancelling an approval;
 - (iii) requiring that the approved person be assisted in the task by another person or group of persons with specific experience and qualifications; and
 - (iv) providing for a processing fee for an approval;
- (c) in respect of dams with a safety risk
 - (i) classifying such dams into categories;
 - (ii) requiring the owner of a dam of a specific category to appoint an approved professional person to

- (aa) design that dam or any repair, alteration or abandonment of the dam;
 - (bb) ensure that a task is carried out according to the applicable design, drawings and specifications; and
 - (cc) carry out dam safety evaluations on the dam;
 - (iii) requiring that licences be issued by the Minister before any task relating to a specific category of dams may commence, and the conditions, requirements and procedure to obtain any specific licence;
 - (iv) laying down licence conditions and requirements that must be met when carrying out a task on a specific category of dams;
 - (v) requiring an approved professional person, appointed for a dam of a specific category, to keep records of information and drawings, and to compile reports;
 - (vi) requiring
 - (aa) an owner of a dam belonging to a specific category of dams; and
 - (bb) an approved professional person appointed for a specific task for a specific dam, to submit information, drawings, reports and manuals;
 - (vii) determining the duties of
 - (aa) an owner of a dam belonging to a specific category of dams; and
 - (bb) an approved professional person appointed for a specific task for a specific dam;
 - (d) requiring the owner of a dam with a safety risk to accomplish regular monitoring of the dam, to the extent and manner prescribed;
 - (e) requiring the registration of a specific dam with a safety risk, and setting out the procedure and the processing fee payable for registration; and
 - (f) specifying time periods that must be complied with.
- (2) In making regulations under subsection (1)(a), the Minister must consider

- (a) the expertise required for the effective design, construction, alteration, repair, operation, maintenance and abandonment of a dam in the category concerned; and
 - (b) the qualifications and experience needed to provide the expertise for a particular category of tasks.
- (3) Before making regulations under subsection (1), the Minister must consult the Engineering Council of South Africa, established by section 2 of the Engineering Profession of South Africa Act, 1990 (Act No. 114 of 1990), and any other appropriate statutory professional bodies.

APPENDIX V

British Columbia, Canada, Dam Safety Regulation

NOTE: This appendix is provided merely as an example of a regulation that deals exclusively with dam safety. There are many other examples and the inclusion of this example in this report should not be interpreted as an endorsement of this regulatory model over other models.

B. C. Reg. 44/00

Deposited February 11, 2002

BRITISH COLUMBIA DAM SAFETY REGULATION

CONTENTS

1. Definitions
2. Application
3. Operation and maintenance of dam
4. Alteration of a dam
5. Inspection
6. Reporting
7. Dam Safety Review
8. Hazardous conditions at a dam
9. Suspension of normal operation or removal of a dam
10. Information and evaluation
11. Instrumentation
12. Expert opinion

Schedule 1

Schedule 2

Definitions

1. In this regulation:

“**Act**” means the Water Act

“**dam**” means

- (a) a barrier constructed across a stream, or
- (b) a barrier constructed off stream and supplied by diversion of water from a stream for the purpose of enabling the storage or diversion of water, and includes all works which are incidental to or necessary for the barriers;

“**dam owner**” means with respect to a dam, any or all of the following:

- (a) the person who holds the current license or is required to hold a license for the dam;
- (b) the person who last held a license for the dam including a license that has been suspended, cancelled, abandoned and or terminated;
- (c) if there is no person whom paragraph (a) or (b) applies, the owner of the land on which the dam is located or the person who had the dam constructed;

“**dam safety officer**” means an engineer or officer, designated in writing by the comptroller as a dam safety officer;

“**emergency preparedness plan**” means a plan prepared by a dam owner under section 3 (2) (a) that describes the actions the dam owner proposes to take in the event of an emergency at a dam;

“**height**” means the vertical distance to the top (crest) of a dam measured,

- (a) in the case of a dam across a stream, from the natural bed of the stream at the downstream outside limit of the dam, or
- (b) in the case of a dam that is not across a stream, from the lowest elevation at the outside limit of the dam;

“**Instrumentation**” means, but is not limited to, survey monuments and stations, inclinometers, extensometers, piezometers or measuring weirs;

“maintain” or “maintenance” means the performance of those tasks required to keep the dam in a good operating condition;

“operation, maintenance and surveillance manual” means a manual prepared by a dam owner under section 3 (2) (b) that describes the dam owner’s operation, maintenance and surveillance procedures for the dam;

“professional engineer” means a person registered, and in good standing, as a professional engineer under the Engineers and Geoscientists Act;

“volume of water” means the total storage volume of the reservoir at full supply level measured in accordance with one of the following:

- (a) between the natural bed of the stream and the spillway crest;
- (b) between the upstream outside limit of the dam and the spillway crest;
- (c) if a low level outlet is excavated to an elevation lower than the general foundation of the dam, between the bottom of that outlet and the spillway crest.

Application

- 2. (1) This regulation applies to all of the following:
 - (a) a dam 1 meter or more in height that is capable of impounding a volume of water greater than 1,000,000 m³;
 - (b) a dam 2.5 meters or more in height that is capable of impounding a volume of water greater than 30,000 m³;
 - (c) a dam 7.5 meters or more in height;
 - (d) a dam that does not meet the criteria under paragraph (a), (b) or (c) but has a downstream consequence classification under Schedule 1 of low, high or very high.
- (2) This regulation does not relieve a dam owner from any other requirements that may be imposed under the Act, the Water Regulation or any other applicable enactment.

Operation and maintenance of a dam

- 3. (1) A dam owner must operate and maintain a dam in accordance with all of the following:

- (a) this regulation;
 - (b) any applicable license or approval;
 - (c) any order that is made under the Act;
 - (d) the emergency preparedness plan that has been prepared and accepted in accordance with subsection (2) (a);
 - (e) the operation, maintenance and surveillance manual that has been prepared and accepted in accordance with subsection (2) (b)
- (2) A dam owner must, in the form and manner and within the time period specified by the comptroller or regional water manager, prepare and submit to dam safety officer, for acceptance by the dam safety officer, the following:
- (a) if the downstream consequence classification under Schedule 1 is high or very high, an emergency preparedness plan;
 - (b) if the downstream consequence classification under Schedule 1 is low, high or very high, an operation, maintenance and surveillance manual.
- (3) Subsection (2) applies whether there is a term or condition in an approval granted or license issued that requires the preparation of such a plan or manual for the dam.
- (4) A dam owner must ensure the dam is adequately safeguarded to prevent unauthorized operation of the dam by someone other than the dam owner or an agent of the dam owner.

Alteration of dam

4. (1) Any alteration, improvement or replacement to all or any part of a dam must be authorized by an approval, license or order.
- (2) Subsection (1) does not apply to an alteration, improvement or replacement for the purpose of
- (a) maintaining the dam as authorized under section 3, or
 - (b) addressing a hazardous condition as specified in section 8.
- (3) A dam owner must submit to a dam safety officer, on completion of the alteration, improvement or replacement, a report on the work and the manner in which any such alteration, improvement or replacement to all or any part of the dam was performed.

Inspection

5. A dam owner must do all of the following:

- (a) carry out an inspection of a dam on the frequency applicable to the downstream consequences classification for the dam as set out in Schedule 2 in order to assess the condition of the dam during the construction, operation or alteration of the dam;
- (b) record the results of every inspection performed under paragraph (a);
- (c) repair any safety hazards revealed by an inspection, if authorized to do so by an approval, license or order or as authorized under this regulation.

Reporting

- 6. (1) A dam owner must, when an inspection is carried out under section 5 or when any other inspection is carried out with respect to a dam,
 - (a) submit to a dam safety officer, in the form and manner and within the time period specified by the dam safety officer,
 - (i) the record of inspection required by section 5(b), and
 - (ii) the results and analysis of any test or measurement taken including, but not limited to,
 - a) instrumentation readings and analysis,
 - b) visual records or observations,
 - c) drawings,
 - d) soil, aggregate and concrete test results, and
 - e) any other test results, and
 - (b) promptly submit to a dam safety officer the record of inspection required by section 5 (b) if the inspection reveals a potential safety hazard.
- (2) A dam owner must submit to a dam safety officer, if requested by the dam safety officer, the original or clear copies of the following documentation required for the design, construction or alteration of the dam:
 - (a) all design notes, drawings and specifications;
 - (b) hydraulic, hydrologic, geological and geotechnical data;
 - (c) reports and other similar documentation.

Dam safety review

- 7. (1) If required by Schedule 2, a dam owner must have a professional engineer, experienced in dam safety analysis, do a dam safety

review and prepare, in the form and manner and within the time period specified by the comptroller or regional water manager, a dam safety report.

- (2) The dam owner must submit to a dam safety officer a copy of the dam safety report prepared by the professional engineer who carried out the dam safety review under subsection (1).

Hazardous conditions at a dam

8. If conditions are, or may likely be, hazardous to a dam, or conditions may reasonably be anticipated to cause a dam, or any part of a dam, or any operation or action at or in connection with a dam, to be or become potentially hazardous to public safety, the infrastructure or works, other property or the environment, a dam owner must promptly do all of the following:
 - (a) if an emergency preparedness plan exists, modify the operation of the dam, or any part of the dam, in accordance with the emergency preparedness plan;
 - (b) if an emergency preparedness plan does not exist, operate the dam in a manner, and initiate any remedial actions, that will
 - (i) safeguard the public,
 - (ii) minimize damage to the infrastructure or works or to other property, including that not owned by the dam owner, and
 - (iii) minimize damage to the environment;
 - (c) contact the Provisional Emergency Program contained under the *Emergency Program Act*;
 - (d) notify a dam safety officer, or the comptroller or regional water manager, of
 - (i) the nature of existing or anticipated conditions,
 - (ii) all things done by the dam owner to rectify the conditions, and
 - (iii) the time and exact nature of any information or warning of existing or anticipated conditions issued to any person under this section;
 - (e) inform local authorities, and persons who may be in immediate danger from the potential failure of the dam, of the nature of the existing or anticipated conditions and, if necessary, advise those persons who may be in immediate danger to vacate and remove any property from the endangered area;

- (f) modify the operation of the dam to minimize or prevent damage which may be caused by the failure of the dam, and undertake any other hazard response activity if required by a dam safety officer or engineer or by the comptroller or regional water manager.

Suspension of normal operation or removal of dam

- 9. (1) A dam owner must give the comptroller or regional water manager at least 60 days written notice before undertaking any of the following activities:
 - (a) removing all or a significant part of a dam;
 - (b) decommissioning or abandoning a dam;
 - (c) stopping the normal operation of a dam for a period of time longer than one year.
- (2) The dam owner must prepare, and submit to a dam safety officer for approval,
 - (a) a plan respecting an activity under subsection (1) (a) or (b), or
 - (b) if required by the dam safety officer, a plan respecting an activity under subsection (1) (c).
- (3) The dam owner must, at least 14 days before the date on which the work is expected to commence, notify a dam safety officer before commencing any work under the approved plan.
- (4) The dam owner must submit to a dam safety officer, on the completion of the work performed under the approved plan, a report on the work and the manner in which it was performed.
- (5) The dam owner must undertake any further actions that the comptroller or regional water manager requires to alleviate any adverse consequences to any person, the infrastructure or works, other property or the environment that may be affected by any work performed on the dam.
- (6) An approval under subsection (2) respecting the decommissioning of a dam is subject to the Environmental Assessment Act and to approvals, if any, required under the Act.

Information and evaluation

- 10. (1) A dam owner must, if requested by a dam safety officer, provide the following information in order to evaluate the condition or hazard potential of a dam:

- (a) information with respect to the dam including, but not limited to,
 - (i) foundation investigation results,
 - (ii) design details and as-built plans,
 - (iii) construction records,
 - (iv) operation manuals,
 - (v) records of instrumentation,
 - (vi) inspection reports,
 - (vii) safety reports, and
 - (viii) inundation studies and emergency preparedness plans;
 - (b) information with respect to the nature of the land and the stream, and the use of the land and the stream, downstream from or adjacent to the dam or reservoir, including the hydraulic, hydrologic, geological and geotechnical characteristics and the uses of the land and stream;
 - (c) information with respect to the watershed upstream of the dam.
- (2) The information requested under subsection (1) must be submitted to a dam safety officer, in the form and manner and within the time period specified by the comptroller or regional water manager.
- (3) The dam owner must conduct any inspection, investigation, survey or test that is necessary to provide the information required by subsection (1).

Instrumentation

11. A dam owner must do all of the following:
- (a) install any instrumentation necessary to adequately monitor the performance of a dam;
 - (b) monitor, maintain or replace instrumentation installed at a dam to ensure continuity of readings;
 - (c) submit instrumentation readings and evaluations to a dam safety officer, in the form and manner and within the time period specified by the dam safety officer;
 - (d) submit, to a dam safety officer for approval by the dam safety officer,
 - (i) notice of any planned modifications to, changes to or removal of the instrumentation at least 60 days before the proposed modification, change or removal, or

- (ii) an annual plan outlining intended changes to the instrumentation.

Expert opinion

- 12. (1) If, based on information submitted in respect of a dam or related works, the comptroller or regional water manager considers that a question has arisen as to what is proper practice for resolving an issue involving a dam or related works, the comptroller or regional water manager may require a dam owner to retain an expert, satisfactory to the comptroller or regional water manager, with qualifications and experience as follows:
 - (a) In the case of a dam, in dam design, construction and analysis;
 - (b) In the case of related works, in hydraulic, hydrological, geological, geotechnical, mechanical or structural engineering or other appropriate disciplines.
- (2) The expert retained under subsection (1) must provide a report to the comptroller or regional water manager on the issue.

SCHEDULE 1 (Sections 2[1][d] and 3[2])

Downstream Consequence Classification Guide

Rating	Loss of Life	Economic and Social Loss	Environmental and Cultural Loss
VERY HIGH	Large potential for multiple loss of life involving residents and working, traveling, and/or recreating public. Development within inundation area (the area that could be flooded if the dam fails) typically includes communities, extensive commercial and work areas, main highways, railways, and locations of concentrated recreational activity. Estimated fatalities could exceed 100.	Very high economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to large residential areas, concentrated commercial land uses, highways, railways, power lines, pipelines, and other utilities. Estimated direct and indirect (interruption of service) costs could exceed \$100 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and/or practicality of restoration and/or compensation is low.
HIGH	Some potential for multiple loss of life involving residents, and working, traveling, and/or recreating public. Development within inundation area typically includes highways and railways, commercial and work areas, locations of concentrated recreational activity and scattered residences. Estimated fatalities less than 100.	Substantial economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to concentrated commercial land uses, highways, railways, power lines, pipelines, and other utilities. Scattered residences may be destroyed or severely damaged. Estimated direct and indirect (interruption of service) costs could exceed \$1 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high.
LDW	Low potential for multiple loss of life. Inundation area is typically underdeveloped except for minor roads, temporarily inhabited or non-residential farms and rural activities. There	Low economic losses to limited infrastructure, public and commercial activities. Estimated direct and indirect (interruption of service) costs could exceed \$100,000.	Loss or significant deterioration of regionally important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance.

must be a reliable element of natural warning if larger development exists.

Feasibility and practicality of restoration and/or compensation is high. Includes situations where recovery would occur with time without restoration.

VERY LOW

Minimal potential for any loss of life. The inundation area is typically undeveloped.

Minimal economic losses typically limited to owners' property and do not exceed \$100,000. Virtually no potential for future development of other land uses within the foreseeable future.

No significant loss or deterioration of fisheries habitat, wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance.

SCHEDULE 2 (Sections 5[a] and 7[1])

Minimum Inspection Frequency and Dam Safety Review Requirements

Item	Very High Consequence	High Consequence	Low Consequence	Very Low Consequence
Site Surveillance ^a	Weekly	Weekly	Monthly	Quarterly
Formal Inspection ^b	Semi-annually	Semi-annually or annually	Annually	Annually
Instrumentation	As per OMS* manual	As per OMS* manual	As per OMS* manual	N/A
Test Operation of Outlet Facilities, Spillway Gates and Other Mechanical Components	Annually	Annually	Annually	Annually
Emergency Preparedness Plan	Update communications directory semi-annually	Update communications directory semi-annually	Update communications directory annually	N/A
Operation Maintenance & Surveillance Plan	Review every 7–10 years	Review every 10 years	Review every 10 years	Review every 10 years
Dam Safety Review ^c	Every 7–10 years ^d	Every 7–10 years ^d	^d	^d

*Operation, Maintenance and Surveillance.

N/A Not available.

^aSite surveillance may consist of visual inspections and/or monitoring of automated data acquisition systems. Reduced frequencies of visual inspections may be determined by seasonal conditions.

^bFormal Inspections are intended as more thorough inspection performed by the appropriate representative of the owner responsible for safety surveillance.

^cA Dam Safety Review involved collection of all available dam records, field inspections, detailed investigation and possibly laboratory testing. It then proceeds with a check of structural stability and operational safety of the beginning with a reappraisal of basic features and assumptions. The level of detail required in a Dam Safety Review should be commensurate with the importance and complexity of the dam, as well as the consequences of failure.

^dDam owners must conduct an annual review of conditions downstream of their dam and notify dam safety officer if the downstream consequence classification level increases. The downstream consequence classification guide is shown in Schedule 1.

APPENDIX VI

Canadian Dam Association, Sample Operations, Maintenance, and Surveillance Manual

NOTE: This appendix is provided merely as an example of the table of contents of an OMS Manual. There are many other examples and the inclusion of this example in this report should not be interpreted as an endorsement of this model of an OMS Manual over other possible models.

NON-STRUCTURAL SAFETY MEASURES DAM SAFETY PLANS

Based on “Dam Safety Guidelines—Canadian Dam Association—January 1999”

OPERATION & MAINTENANCE PLAN

- General Information
- Operation
- Reservoir operational rules
- Flood forecasting (if available)
- Flood operating procedures
- Emergency operating procedures
- Maintenance
- Historical document
- Performance indicators
- Preventive measures
- Instrumentation Plan (see detail)
- Surveillance
- Standards
- Regular inspections
- Special inspections
- Tests
- Emergency Preparedness Plan (EPP) (see detail)

EMERGENCY PREPAREDNESS PLAN (EPP)

- Responsibilities
- Emergency Identification, Evaluation and Classification
- Preventive Actions
- Notification Procedures
- Notification Flowchart
- Inundation Maps and Tables
- Testing and Upgrading the EPP
- Training

INSTRUMENTATION PLAN

- Description and location of instruments and monitoring devices
- Initial datum, design limits, calibration requirements, operating ranges
- “Alarm” levels
- Mode and methodology of readings
- Data recording and storing
- Data interpretation

OPERATION AND MAINTENANCE (O&M) MANUAL

B.1. General

Dam operation, maintenance and surveillance shall be provided so that an acceptable level of dam safety is ensured.

A manual (the “O&M Manual”) shall be prepared, documenting operation, maintenance and surveillance. The O&M manual shall be implemented, followed, and updated at appropriate intervals. The manual shall contain suitable and sufficient information to allow operators to operate the dam in a safe manner, maintain it in a safe condition, and monitor its performance well enough to provide early signs of any distress.

A general description of the dam should be included to indicate such items as type, size, consequence classification, age, location, and access.

Qualified personnel shall be used for the operation, maintenance and surveillance.

The O&M Manual should state the chain of operational responsibilities and requirements for training of staff at the various levels.

As a minimum, the O&M Manual should be reviewed annually to ensure that all appropriate updates of personnel or organization have been made.

The required duties and qualifications of operators in regard to dam safety should be defined, listing the appropriate areas of involvement. The description may include details of suitable training programs.

A permanent log book should be maintained, containing information and records appropriate to the type of dam, such as:

- Weather conditions
- Changes to normal operation, unusual events, conditions or public activity
- Unusual maintenance activities
- Instructions
- Alarms or annunciation
- Inspections

The log book should not detail activities of normal operation nor records routinely being maintained elsewhere. Suitable instructions should be in place for the recording of this operating information, including references to drawings and technical operation and maintenance manuals.

B.2. Operation

B.2.1. Flood Operating Procedures

During the flood season, a sufficient number or capacity of gates and facilities necessary for discharging flows up to the Inflow Design Flood (IDF) shall be maintained in operable condition, and procedures for state operation shall be specified.

Any restrictions for gate operation shall be documented.

The reservoir shall be operated in such a manner that the Inflow Design Flood can be routed safely. Drawdown or other reservoir operating restrictions shall be documented.

Descriptions of all the various parts of the dam that affect the above requirements should be provided and where appropriate, manufacturers' operating manuals should be readily available.

Concise operating instructions should be provided for use, during normal operation as well as in the case of extreme flood, by qualified dam operators who are not necessarily familiar with the particular facility or project.

Details of normal operating conditions should be provided to indicate such items as: inflows and discharges, normal levels, storage volumes, spillway and tailwater rating curves, spillwater operating parameters, power supplies and environmental restrictions. Potential emergency conditions should be identified and listed with related recommended operating parameters and restraints.

The instructions should detail the flow capacities of the structures and related water elevations, list the hazard areas and flows at which they are affected, and provide details about warning systems as well as primary and backup power systems.

B.2.2. Emergency Operating Procedures

Procedures for reservoir control and discharge in the case of a developing breach or potential breach, and for any emergency drawdown of the reservoir, shall be established.

General procedures and considerations should be outlined, such as any special instructions for spillway operation, and instructions on reservoir drawdown to alleviate the effect of emergencies. These should include any limitations on reservoir surcharge or drawdown, implications of rising flows downstream, list of erosion-prone areas of river banks, and reservoir slopes which should be monitored. Operations during an emergency would follow procedures of the Emergency Preparedness Plan, as described in Section C.

Operation to evacuate the reservoir in the event of damage to the dam, including precautions to avoid damage to facilities and any restrictions on the rate of drawdown should be provided.

B.2.3. Ice and Debris Handling

Where reservoirs can contain significant quantities of ice or debris, procedures shall be established for safely handling ice and/or debris.

The details, functions and required operating activities of log, trash and ice booms, including trash removal and any ice-growth restrictions on structures

or gates, should be described in the O&M Manual. The operation of any required bubble systems for ice prevention and/or steam lances should be described.

B.2.4. Flood Forecasting

If available, the source of flood forecasting information shall be identified.

Authorized sources of flood forecasting should be designated, with a list of other available sources of flood forecast. The Inflow Design Flood, the basis of its estimation and the capacity of the facilities should be described.

B.3. Maintenance

Maintenance policies, procedures, records and responsibilities shall be developed and implemented to ensure that the dam, together with applicable structures and equipment required for flood discharge, is maintained in a safe and fully operable condition.

Equipment shall be inspected and tested at regular intervals to ensure safe and reliable operation.

A description of maintenance policies, procedures, records and responsibilities for dams, appurtenant structures and associated equipment (including instrumentation) essential to dam safety should be available.

Maintenance requirements should also be documented for all miscellaneous structures such as timber cribs and conduits.

All relevant manufacturers' and designers' maintenance manuals should be available.

Changing conditions in the facility must be evaluated and appropriate actions taken both in regard to design reviews and necessary construction changes and/or repairs.

Instrumentation required to verify the continuing safe operation of the dam, together with any data acquisition and transmission systems, must be maintained in good working condition.

Considerations for maintenance of different types of structures and equipment are briefly outlined below.

Concrete Structures

Uplift pressure and water seepage are the main potential causes of instability, under normal loadings, of part or all of the structures, as well as the primary cause of degradation due to leaching or frost action. In addition, the effects of freeze/thaw at the water line and alkali aggregate reaction (AAR) can have serious impacts on the safety of the structures.

Annual or long-term maintenance programs for concrete structures should include, but not be limited to, regular cleaning of drains and drainage systems, maintenance of sealing systems, pumping equipment, monitoring equipment and instrumentation required to assure the safety of the structures.

Steel Structures

Maintenance requirements for the structural steel components of items such as gates, stoplogs, guides, hoist structures, monorails, and conduits, may apply to the following: alignment, anchor bolts, bolted, riveted and welded connections, protective coatings, support details, support grouts.

Earthfill Dams

Earthfill structures require maintenance work directed essentially to controlling seepage and erosion, in order to prevent deterioration of structures and development of seepage paths.

Annual or long-term maintenance programs for earthfill structures may include regular maintenance of instrumentation, rip-rap and crest maintenance and repair, control of vegetation and burrowing animals, slope stabilization, drainage system maintenance, and removal of upstream debris, to assure the safety of the structure.

Equipment

Maintenance requirements may apply to all mechanical and electrical components which are essential to dam safety, including: spillway and conduit gates, hoists, gate and guide heating systems, stoplog hoisting facilities, bubbler systems, relevant instrumentation, normal and emergency lighting and pumps.

A preventative maintenance program should be devised based upon dam consequence classification, industry standard, manufacturer's recommendations and operating history for particular pieces of equipment.

Reference should be made (with supplementary information where necessary) to manufacturers' and designers' operating and maintenance manuals for required maintenance, spare parts, and appropriate regular tests to confirm ongoing functionality.

Communicators and Control

Operating staff should have a description, including a complete overview with system schematic diagram of all the communication and control equipment. Equipment should be operated continuously and monitored to ensure integrity. The documentation should include all current test and maintenance practices.

B.4. Surveillance

B.4.1. Standards

Standards shall be established to cover inspections, monitoring of water-retaining structures, and testing of discharge facilities.

Standards or guidelines should be provided to establish the types of inspections to be carried out, the purpose of each type of inspection, frequency of inspections, type of items to be inspected, required documentation, qualification and training of inspectors and procedures for the correction of deficiencies.

B.4.2. Regular Inspections

Requirements: Periodic inspections shall be performed to determine the condition of integral portions of water-retaining structures.

Appropriate investigations shall be undertaken of all potential deficiencies disclosed by regular inspection.

Instructions and procedures for the dam should provide the following information:

- Checklists for routine, intermediate and comprehensive inspections for all structures and equipment
- Frequency, responsibility and requirements for recording and reporting
- Description of additional inspections which may be required including

underwater inspections and inspections required during initial reservoir impounding

- Requirement and frequency of alignment and deformation surveys

The program of inspections, including the frequency of inspections, should be devised based upon the dam classification, industry standards, manufacturers' recommendations, operating history and condition of particular structures and equipment.

As a general guideline, "routine" inspections should be performed by project staff as a regular part of their maintenance activities. Such inspections should be carried out weekly or monthly as appropriate for the item being inspected. Reduced frequencies may be selected to suit seasonal restraints. "Intermediate" inspections are intended as more formal inspections, generally annual or semi-annual, performed by the appropriate representative of the owner responsible for safety surveillance. Comprehensive inspections (Dam Safety Review) should be performed by an independent expert or panel of experts at regular time intervals.¹ The review should include the O&M Plan and the EPP to determine any modifications thereof.

Procedures, including definition of responsibility, should be in place for evaluating data (obtained from visual inspections, instrumentation and design reviews of current operating conditions such as spillway capacity, freeboard, drawdown, maximum water levels) to confirm structural and operational safety and to identify areas requiring deficiency investigations. These procedures should include an "action code" to ensure that appropriate action will be taken, depending on the severity of the observed deficiency.

B.4.3. Special Inspections

Special inspections shall be performed following potentially damaging events.

Instructions and procedures for the dam should describe special inspections and other surveillance and procedures required after floods, windstorms, earthquakes and unusual observations such as cracks, settlements, sinkholes and slopes failures. The responsibility to undertake these special inspections

1. Review period depends on the consequence classification of the dam:

Consequence category:	Very High	High	Low
Period between reviews:	5	7	10 (years)

All test procedures should be specified in the O&M Manual and incorporated with the inspection checklists. Instructions and procedures should provide descriptions of operational and integrity tests for all mechanical and electrical components of water flow control equipment to ensure fully operational condition.

EMERGENCY PREPAREDNESS PLAN (EPP)

C.1. General

Potential emergencies at a dam shall be identified and evaluated, with consideration of the consequences of failure, so that appropriate preventative or remedial actions can be taken.

An Emergency Preparedness Plan (EPP) shall be prepared, tested, issued and maintained for any dam whose failure could be expected to result in loss of life as well as for any dam for which advanced warning would reduce upstream or downstream damage.

A notification process shall be initiated as specified in the EPP, immediately upon finding a hazardous condition that could lead to a dam breach, or upon discovering a potential dam breach or dam breach in progress.

The dam owner² or operator shall assess whether dam breach warnings should be issued directly to inhabitants in areas immediately downstream of a dam, due to the short period of time before the anticipated arrival of a flood wave.

Where preventative actions are available, these actions shall be initiated, as appropriate, to prevent failure or to limit damages where failure is inevitable.

An EPP is a formal written plan that identifies the procedures and processes that the dam operators would follow in the event of an emergency at a dam. The emergency could be, for example, failure of essential equipment such as flood gates, slope failure having the potential to cause dam failure, or a complete failure of the dam caused by overtopping, earthquake or piping.

2. As defined in this document, the term "owner" refers to the person or entity responsible for the safety of the dam.

should be assigned to all site staff and the engineer responsible for dam safety. This wide empowerment is intended to ensure timely inspection after all potentially damaging events.

Requirements for documentation and reporting should be specified with inspection checklists and procedures for review by the engineer responsible for dam safety, following the occurrence of the above events.

B.4.4. Instrumentation

Instrumentation shall be monitored, evaluated and maintained to assist in the safe operation of the dam.

Included with all descriptions of instruments should be their initial data, design limits, dates of and requirements for calibration, normal operating ranges, and “alarm” levels at which point detailed review of the readings is required. The responsibility should be assigned for routine instrument readings, changes to data, calibration and interpretation of the results.

The mode and methodology of readings should be described, i.e., automated or manual. If automated, the system should be described including modem telephone numbers. If manual, there should be documentation of methodology, maintenance, calibration and storage of instrumentation reading equipment.

Exact locations and details of the instrument installations should be provided, complete with plan views and cross-sectional drawings.

The documentation of instrumentation could be covered in a separate instrumentation report, with reference to it in the O&M Manual.

B.4.5. Tests

All operating equipment and facilities necessary to pass extreme floods shall be inspected and tested annually to ensure that they will function as required during an extreme flood.

Intake flow control equipment should undergo a balance pressure test annually before the flood season. Spillway gates should have annual operation tests to ensure correct operation. The frequency and level of inspection and testing should be compatible with the consequence category of the dam.

An EPP allows for planning by municipalities, local police, provincial agencies, telephone and transportation companies and other parties affected in the event of a dam break flood, and the coordination of efforts between provincial and municipal levels of government. In the event of an emergency, an effective, comprehensive, well-tested EPP will save lives and has the potential to reduce property damage.

C.2. Development of an EPP

An EPP shall describe the actions to be taken by the dam owner and operator in an emergency. The EPP shall assign responsibility for each action to be taken to an individual and/or a backup.

Input from other agencies and affected parties shall be included in the EPP, as appropriate.

Copies of the EPP, or summaries of relevant information, shall be provided to those who have responsibilities under the plan.

The steps in developing an EPP are as follows:

1. Identify those situations or events that would require initiation of an emergency action; specify the actions to be taken and by whom.
2. Identify all jurisdictions, agencies, and individuals who will be involved in implementing the EPP.
3. Identify primary and auxiliary communications systems, both internal (between persons at the dam) and external (between dam personnel and outside agencies).
4. Identify all persons and agencies involved in the notification process, and draft a notification flowchart which shows whom should be notified, in what order and what other actions are expected of downstream agencies. Each provincial and local government agency involved may have its own general emergency plan. This would normally require amending to include actions required as a result of dam break flooding.
5. Develop a draft of the EPP.
6. Hold coordination meetings with all parties included in the notification list for review and comment on the draft EPP.
7. Make any revisions, obtain any necessary regulatory approval, finalize and distribute the EPP.

C.3. Contents of an EPP

The EPP shall include the following procedures and information:

- Emergency identification and evaluation
- Preventative actions (where available)
- Notification procedure
- Notification flowchart
- Communication systems
- Access to site
- Response during periods of darkness
- Response during periods of adverse weather
- Sources of equipment
- Stockpiling supplies and materials
- Emergency power sources
- Inundation maps
- Warning systems (if used)

Emergency Identification and Evaluation

If detected early enough, potential emergencies can be evaluated and preventative or remedial actions taken. The EPP should contain clear procedures for taking action when a potential emergency is identified. Notification of emergency situations requires that a responsible contact person initiate the remedial action and decide if and when an emergency should be declared and the EPP executed. Clear guidance should be provided in the EPP on the conditions which require that an emergency be declared.

The Emergency Preparedness Plan should include a discussion of procedures for timely and reliable identification, evaluation, and classification of existing or potential emergency conditions. Major elements of these procedures are:

- Listing of the conditions or events which could lead to or indicate an existing or potential emergency. Situations involving flood emergencies due to a breach or other structural failure as well as a major flood without a breach should be included. Breach conditions could occur

as a result of such occurrences as piping, floods, earthquake, sabotage or landslide-induced waves.

- Brief description of the means by which potential emergencies will be identified, including the data and information collection system, monitoring arrangements, surveillance, inspection procedures and other provisions for early detection of conditions indicating an existing or potential emergency.
- Procedures, aids, instructions and provisions for interpreting information and data to assess the severity and magnitude of any existing or potential emergency.
- Designation of the person responsible for identifying and evaluating the emergency. This would normally be the owner or his representative: however, if the owner does not have the proper technical expertise, responsibility may need to be assigned to another individual. Appropriate alternatives should be designated to ensure that continuous coverage is provided.

Preventative Action

Where there are provisions for preventative actions available they should be clearly detailed in the EPP. These could include listings of the availability of machines, equipment, material and labour that are ready available to the dam operator in an emergency situation.

Notification Procedures

Notification Procedures must be clear and easy to follow. The EPP should contain a list of all persons to be notified in the event that an emergency is declared.

Notification Flowchart

A notification flowchart is a diagram showing the hierarchy of notification during an emergency. It is a pictorial representation of the notification procedure. The EPP should contain a notification flowchart clearly summarizing the notification procedure for each of the emergency conditions considered.

Communications Systems

Full details of internal and external communications systems as they apply to the EPP should be included.

Access to the Site

The description of access should focus on primary and secondary routes and means for reaching the site under various conditions (e.g., foot, boat, helicopter, snowmobile).

Response during Periods of Darkness

The EPP should cover the response to potential or actual emergency conditions during periods of darkness including those caused by power failure.

Response during Periods of Adverse Weather

The EPP should address emergency response under adverse weather conditions including extremes of cold, snow or storms.

Sources of Equipment

The location and availability of equipment and contractors that could be mobilized in case of an emergency should be included.

Stockpiling Supplies and Materials

The location and availability of stockpiled materials and equipment for emergency use should be addressed.

Emergency Power Sources

Details on the location and operation of emergency power sources should be included.

Inundation Maps

Inundation maps are needed by local authorities to develop an adequate evacuation plan.

Warning Systems

Warning systems are sometimes used to provide warnings to residents, campgrounds and parks that are close to the dam. Full details should be contained within the EPP.

Appendices

Additional items may be covered in appendices to the EPP. General site plans may be useful. Drawings showing the potential breach location used in the inundation study may be included. Tables showing the variation in flood stage with time at key locations in the flooded area should also be included.

C.4. Maintenance and Testing of an EPP

The EPP shall be issued to those affected, and all registered copies of the EPP shall be updated.

The EPP shall be tested.

As updates or amendments to the EPP are produced they are forwarded to each holder (as listed in the EPP) and acknowledged by the recipient. Telephone numbers and names of contact persons should be updated on a regular basis, at least annually. It is helpful to place the EPP in a loose-leaf binder so that outdated pages can be easily removed and replaced with updated information, to ensure a complete, current and workable plan. A list of planholders should appear in the EPP.

Testing is an integral part of EPP to ensure that both the document and the training of involved parties are adequate. Tests can range from a limited table-top exercise to a full-scale simulation of an emergency and can include multiple failures.

C.5. Training

Training shall be provided to ensure that dam personnel involved in the EPP are thoroughly familiar with all elements of the EPP, the availability of equipment, and their responsibilities and duties.

Technically qualified personnel should be trained in problem detection and evaluation and appropriate remedial (emergency and non-emergency) measures. This training is essential for proper evaluation of developing situations at all levels of responsibility which, initially, is usually based on observations on-site. A sufficient number of people should be trained to ensure adequate coverage at all times.

C.6. Inundation Studies

Requirement: An inundation study shall be carried out based on assumptions that will indicate all areas that could be flooded for the most severe combination of reasonably possible conditions.

Various dam failure scenarios are normally studied: these cover rapid failure times, large breach sizes and conservative antecedent conditions. The

potentially inundated area should be determined and the following conditions considered:

- Design flood failure
- Fair-weather dam failure
 - At full supply level (piping, earthquake)
 - During winter conditions where ice jam formation is possible
- Failure induced by failure of an upstream structure

Inundation maps showing the maximum flooded areas should be prepared.

Inundation maps should also be prepared for the reservoir rim and for areas affected by the backwater effect upstream of the reservoir. Two cases should be analyzed:

- Extreme flood exceeding the discharge capacity
- Reduction of discharge capacity during the passage of a large flood (for example, blockage by debris, or malfunction or non-operation of gates).

APPENDIX VII

Selected Legislation on Dam Safety and Additional Information Sources

SELECTED LEGISLATION

Argentina

- Decree no. 239/99 (Mar. 17, 1999)

Australia

New South Wales:

- Dams Safety Act (1978)

Victoria:

- Water Act (2000)

Queensland:

- Water Resources Act (1989)
- Water Act (2000)

Canada

Alberta:

- Dam and Canal Safety Regulation (1978, as revised in 1998)
- Dam Safety Guidelines (1975)
- Dams Safety Guidelines of the CDA (1995)

British Columbia:

- Dam Safety Regulations B.C. Reg 44/00, (deposited Feb. 11, 2000, issued by the Government of British Columbia in Feb. 2000)

Ontario:

- Lakes and Rivers Improvement Act (issued by the Ministry of Natural Resources in 1977)

Quebec:

- Dam Safety Act (adopted by the Quebec Parliament on May 23, 2000)

Finland

- Dam Safety Act (1.6.1984/413)
- Dam Safety Decree (27.7.1984/574)
- Water Act (19.5.1961/264)
- Dam Safety Code of Practice (1985, last revised in 1997)

France

- Law on the Organization of Civil Security, Protection against Forest Fires, and Prevention of Major Risks (Jul. 22, 1987) [*Loi du 22 juillet 1987 relative à l'organisation de la sécurité civile, à la protection de la forêt contre l'incendie et à la prévention des risques majeurs*]
- Water Law (Jan. 3, 1992)
- Circular no. 70/15 on the Inspection and Surveillance of Dams Relevant to Public Safety (Aug. 14, 1983) [*Inspection et Surveillance des barrages intéressant la Sécurité publique*]
- Circular on the Security of Zones in Proximity to and Downstream from Dams (Jul. 13, 1999) [*Circulaire de 13 juillet 1999 relative à la sécurité des zones situées à proximité ainsi qu'à l'aval des barrages et aménagements hydrauliques, face aux risques liés à l'exploitation des ouvrages*]
- Decree Creating the Permanent Technical Committee on Dams (Jun. 13, 1966)
- Intervention Plans for Hydraulic Installations (Decree 399/997, Sept. 15, 1992)

India

- Draft Dam Safety Act (2000)

Latvia

- Hydropower Plant Dam Safety Act (Dec. 2000)

Mexico

- National Water Law

New Zealand

- Resource Management Act (1991) (amended)
- Building Act (1991)
- Guidelines for Resource Consents for Dams and Associated Activities (Nov. 2000)

Norway

- Water Resources Act (Jan. 1, 2001)
- Regulations Governing the Classification of Watercourse Structures (Dec. 11, 2000)
- Regulations Governing the Safety and Supervision of Watercourse Structures (Dec. 15, 2000)
- Regulations Governing the Qualifications of Those Undertaking the Planning, Construction, and Operation of Watercourse structures (Dec. 11, 2000)

Portugal

- Decree Law (1990)
- The Portuguese Code of Practice for Observation and Inspection of Dams
- Standards for Monitoring and Surveillance of Dams

Russian Federation

- Federal Law 21.07.97, N117- OC (adopted by the State Duma on June 23, 1997)

South Africa

- Regulations, *Government Gazette* Vol. 253 (No. 10366, July 25, 1986)
- National Water Act (no. 36, 1998)

Spain

- Technical Regulation about Reservoir and Dam Safety (1996) [*Reglamento Técnico Sobre Seguridad de Presas y Embases*]
- Order of the Ministry of Public Works Approving Instructions for the Project, Construction, and Operation of Large Dams (Mar. 31, 1967)
- Basic Directive on Planning for Civil Protection against the Risk of Flood (1994) [*Directriz Básico de Planificación de Protección Civil Ante el Riesgo de Inundaciones*]

Switzerland

- Federal Law Regarding Supervision of Hydraulic Structures (June 22, 1877, as amended) [*Bundesgesetz ueber die Wasserpolizei*]
- Executive Decree (Dec. 7, 1998, went into effect Jan. 1, 1999) [*Verordnung ueber die Sicherheit von Stauanlagen, Stauanlagenverordnung*]

United Kingdom

- Reservoirs Act (1975, entered into force on Dec. 1, 1991)

United States

- National Dam Safety Program Act, (passed in 1972, revised in 1984, and incorporated as Section 215 of the Water Resources Development Act of 1996, PL104-303, October 12, 1996 [NDSPA])
- ASDO Summary of State Laws and Regulations on Dam Safety (2000)
 1. Arizona—Arizona Revised Statutes, title 45: Waters, chap. 6: Dams and Reservoirs, art. I: Supervision of Dams, Reservoirs and Projects (ARS 45:1201-1223); Arizona Rules and Regulations Pertaining to the Supervision of Dams, chapter 15 (R12-15-151 and 152-15-1201 through 1226)—adopted 1978 and substantially revised in 2000
 2. California—California Water Code, division 3, secs. 6000-6501 (last amended 1995); California Administrative Code, title 23, ch. 2, arts. 1-301 to 5-333 (adopted 1996)
 3. Idaho—Idaho Safety of Dams Rules and Regulations (amended July 1998), implementing provisions of Safety of Dams Statutes, title 42 ch. 17 Idaho Code (as amended)
 4. Iowa—ch. 455B, division III (Water Quality), pt. (Water Allocation and Use), first enacted 1949 and last amended 1986; chs. 70–75 Iowa Administrative Code, title V, Flood Plain Development (1975), amended 1994
 5. Kentucky—Kentucky Revised Statutes, ch. 151, Geology and Water Resources (1996), amended 1990; Kentucky Administrative Code, ch. 4, title 401, Water Resources
 6. Maine—Maine Revised Statutes, title 37-B, Defense, Veterans and Emergency Management, secs. 1051–1070, ch. 21, Dams and Reservoirs and ch. 22, Dam Inspection (1983 and revised 1989 to include safety components separated from title 38 art. 3-A, Dam Registration and Abandonment, secs. 815–843); title 37-B revised in 1997 with inclusion of Section 1065(5), Correction of Unsafe Conditions and 1080, Establishment of Commission); in 1999 Section 1065 updated and added 1071, Notice of Transfer of Ownership; Regulations, ch. 3, Design and Construction Standards for New or Reconstructed Dams (1990)—laws currently under revision;

- Maine Dam Registration, Abandonment, and Water Level Act of 1983, title 38, General Provisions Relating to Rivers and Streams, ch. 5, subchapter 1, Mills and Dams, secs. 611–933 (enacted in 1983 to include safety components, amended in 1987 and changed to separate safety components in 1989)
- 7. Michigan—Natural Resources and Environmental Protection Act, pt. 315, Dam Safety (1994 PA 451 as amended); draft rules promulgated
- 8. Missouri—Revised Statutes of Missouri (RSMo.), secs. 236.400–236.500 (enacted 1989, last amended 1993); Code of State Regulations, 10CSR 22-1.010 to 10 CSR 22-4.020
- 9. Montana—Dam Safety Act, ch. 15 (85-15-101 through 504), last amended 1993; Department of Natural Resources and Conservation, Title 36, ch. 25: Safety of Dams (1988)
- 10. New Hampshire—RSA Chapter 482 (1937), last amended 1998; New Hampshire Code of Administrative Rules, ch. ENV-WR 100-800 (NH Water Division, Dept. of Environmental Services), effective 1980 and 1981, last amended 1997
- 11. Ohio—Ohio Revised Code (ORC), title XV (enacted 1963, last amended 1990); administrative rules enacted by Division of Water of Department of Natural Resources (enacted 1972, revised 1981 and 1999)
- 12. Pennsylvania—Dam Safety Encroachments Act (DSE Act), enacted 1979, last amended 1985; title 25: Rules and Regulations, pt. I: Department of Environmental Resources, subpart C, Protection of Natural Resources, article II: Water Resources, ch. 105: Dam Safety and Waterway Management (the Rules), adopted 1980; rules supplemented by subsequent policy statements incorporated into ch. 105; complete revision adopted in 1991, further revisions planned in 2000 or 2001
- 13. Puerto Rico—Puerto Rico Law Number 133 of July 15, 1986; Administrative Regulations of the Dam Safety Program may be obtained through the Dam Safety Unit of the Puerto Rico Electric Power Authority (PREPA)
- 14. Utah—Utah Code, secs. 73-5a-101 through 702 (enacted 1990 and amended 1993); State of Utah Statutes and Administrative Rules for Dam Safety (1996) contains both statutes and administrative rules

15. Washington—Revised Code of Washington, chs. 90.03, 43.21A and 86.16 (1994); Washington Administrative Code, chs. 173–175 (1992); Dam Safety Guidelines (Department of Ecology)
16. West Virginia—West Virginia Dam Control & Safety Act (1973), Code of West Virginia, chs. 22–14, last amended 1992; Dam Control Regulations, title 47, Series 34 under Division of Environmental Protection (DEP) regulations (1982)
17. Wisconsin—Regulation of Dams and Bridges Affecting Navigable Waters (1971), last amended 1984, Wisconsin Statutes, ch. 31; Dam Design and Construction Standards, Wisconsin Administrative Code, ch. NR 333 (adopted 1985, last amended 1987)

Additional Information Sources
Not Appearing in Appendices or Footnotes

ANCOLD Guidelines on Dam Safety Management (1994)

Dam Safety Guidelines (Canadian Dam Association, January 1999)

Pisaniello, John D., and Jennifer M. McKay, *Models of “Appropriate” Practice in Private Dam Safety Assurance 1* Water Policy 525–530 (1998)

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Regulatory Frameworks for Dam Safety was conceived and prepared in response to growing concern over the safety of dams. Given the large number of dams around the world, the safe operation of dams has significant social, economic, and environmental relevance. A dam failure can result in extremely adverse impacts, including a large-scale loss of human life. For countries with large stocks of dams, the issue of dam safety is critical. *Regulatory Frameworks for Dam Safety* examines the dam safety regulatory frameworks of 22 countries. It draws comparisons and highlights similarities among the various systems. Most important, it identifies essential elements, desirable features, and emerging trends for dam safety regulatory frameworks.

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