State of Colorado

Department of Natural Resources

Division of Water Resources

Office of the State Engineer

Dam Safety

DRAFT

RULES AND REGULATIONS

FOR

DAM SAFETY AND DAM CONSTRUCTION

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1313 Sherman Street, Room 818 Centennial Building

Denver, Colorado

OFFICE OF THE STATE ENGINEER

RULES AND REGULATIONS FOR DAM SAFETY AND DAM CONSTRUCTION

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Rule 1. Title

1.1 ~~1.1~~ The title of these Rules and Regulations is "The Rules and Regulations for Dam Safety and Dam Construction." They may be referred to herein collectively as the "Dam Safety Rules" or "Rules" and individually as a "Rule."

Rule 2. Authority

2.1 ~~2.1~~ These Rules are promulgated pursuant to the authority granted the State Engineer in sections 37-87-102 and 37-87-105, C.R.S.; section 37-80-102 (1)(k), C.R.S.; and section 24-4-103, C.R.S.

2.2 These Rules do not change the meaning of any statute.

Rule 3. Scope and Purpose

3.1 ~~3.1~~ These Rules apply to any jurisdictional or non-jurisdictional dam constructed to impound water in Colorado. Certain structures defined in Rule 14 are exempt from these Rules.

3.2 ~~3.2~~ The purpose of these Rules is to provide for public safety by establishing reasonable standards and to create a public record for reviewing the performance of a dam.

Rule 4. Definitions

4.1 ~~4.2.1~~ **Alteration, Modification, Repair, or Enlargement of an Existing Dam and/or Appurtenant Structures**. Construction that could affect the safety of the dam.

4.2 **Annual Exceedance Probability (AEP)**. The probability of occurrence in any one year.

4.3 ~~4.2.2~~ **Appurtenant Structure**. Component other than the material structure of the dam itself such as the outlet works and controls, spillways and controls, access structures, bridges, and other systems directly related to the safe operation of a dam.

4.4 ~~4.2.3~~ **Breach Order**. An order issued by the State Engineer, or the State Engineer's designee, for removal of all or part of a dam to permanently reduce the maximum storage level, minimize the risk of failure, and/or the potential of damage downstream due to the failure of the dam.

4.5 ~~4.2.4~~ **Capacity**. As used in section 37-87-105 (1), C.R.S., the volume of water impounded by a dam at the high water line. Storage below the natural surface of the ground and low-level outlet is generally excluded.

4.6 ~~4.2.5~~ **Dam**. A constructed barrier, together with appurtenant structures, constructed above ground surface for the purpose of impounding water. Flood control and storm runoff detention dams are included.

4.6.1 ~~4.2.5.1~~ **Jurisdictional Size Dam.** A dam creating a reservoir with a capacity of more than one hundred (100) acre-feet, or a surface area in excess of twenty (20) acres at the high

water line, or where the jurisdictional height exceeds ten (10) feet. Jurisdictional height is defined in Rule 4.7.1.

4.6.2 ~~4.2.5.2~~ **Non-Jurisdictional Size Dam.** A dam creating a reservoir with a capacity of one hundred (100) acre-feet or less, and a surface area of twenty (20) acres or less, and a jurisdictional height of ten (10) feet or less. Non-jurisdictional size dams are regulated and subject to the authority of the State Engineer.

4.6.3 ~~4.2.5.6~~ **Diversion Dam.** A structure of jurisdictional size constructed for the primary purpose of diverting water from a natural watercourse into a canal, tunnel, ditch, or pipeline. Diversion dams are subject to regulation by these Rules.

4.6.4 ~~4.2.5.7~~ **Flood Control Dam.** A dam that is normally dry and has an ungated outlet structure for the controlled release of water impounded during and subsequent to a flood event.

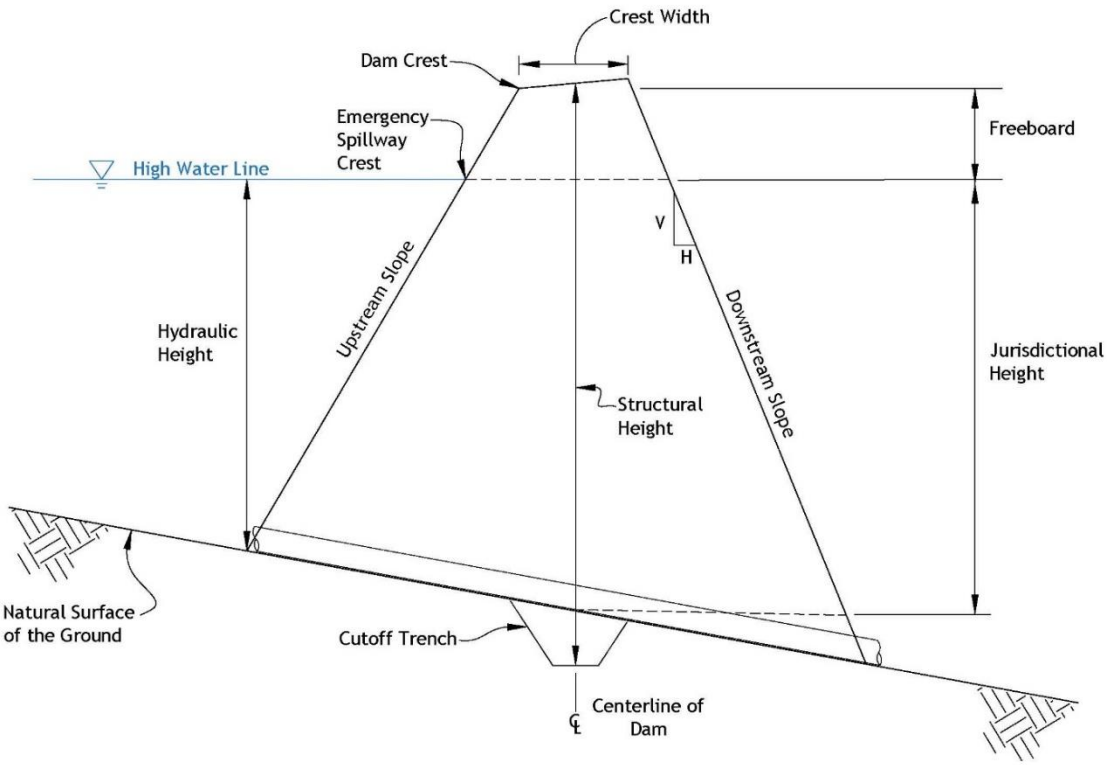
4.7 ~~4.2.19~~ Dam Height. (See Figure 4.1)

4.7.1 ~~4.2.19.1~~ **Jurisdictional Height**. The vertical dimension measured from the lowest point of the natural surface of the ground or the invert of the outlet pipe, whichever is lower, where the low point occurs along the longitudinal centerline of the dam crest, to the emergency spillway crest.

4.7.2 **Hydraulic Height**. The vertical dimension measured from the lowest point of the upstream toe of the dam to the emergency spillway crest.

4.7.3 **Structural Height**. The vertical dimension measured from the lowest point of the excavated foundation to the crest of the dam.

Figure 4.1: Determination of Dam Heights



4.8 ~~4.2.6~~ **Inundation Map.** A map depicting the area downstream from a dam that would reasonably be expected to be flooded in the event of a dam failure.

4.9 ~~4.2.8~~ **Emergency Action Plan (EAP).** A living document containing a written plan of actions used by an emergency response team to minimize property damage and loss of life in an area affected by a dam failure or large flood.

4.10 ~~4.2.9~~ **Engineer.** An Engineer registered and licensed in Colorado in accordance with article 12-25 Part 1, C.R.S. The Engineer will be in "responsible charge" of the design and construction, as defined in section 12-25-102, C.R.S. In general, the Engineer is responsible for the following:

A. ~~4.2.9.1~~ Demonstrating a minimum of five years of experience as a registered Engineer in the design, construction, and safety evaluation of the type of dam under review;
B. ~~4.2.9.2~~ Understanding all applicable regulatory requirements of the project and the required work, analyses, and oversight needed to complete a safe design and construction of the project;
C. 4.2.9.3 Using current state of the practice methods and means to site and design dams with safety as the primary goal and to complete engineering methodology that represents the professional level of care exercised by qualified engineers; and
D. ~~4.2.9.4~~ Assembling and supervising a team of qualified engineers, geologists, geological engineers, and other professionals required to address all of the disciplines necessary for the design and construction of a dam.

4.11 **Freeboard.**

4.11.1 ~~4.2.13~~ **Normal Freeboard**. The vertical dimension between a spillway crest and the lowest point on the dam crest.

4.11.2 ~~4.2.13.1~~ **Residual Freeboard.** The vertical dimension between the maximum water surface elevation during a flood event and the lowest point on the dam crest.

4.12 **Geologist**. An individual possessing specific knowledge of the geological sciences and the principles of engineering analysis and design acquired by professional education or demonstrated experience related to dams, and qualified to apply such knowledge to assure geologic elements affecting the dam are adequately accounted for in design and construction.

4.13 ~~4.2.14~~ **Hazard Classification.** One of four categories defined below as determined by analysis of potential consequences from a sunny day failure of the dam. Conditions for evaluation are absent flooding and the reservoir is assumed to be full to the high water line at the time of failure. The hazard classification establishes all the design criteria for a dam except for spillway size, which is controlled by the Hydrologic Hazard defined in Rule 4.15.

4.13.1 ~~4.2.14.1~~ **High Hazard.** A dam for which loss of human life is expected to result from failure of the dam.

4.13.2 ~~4.2.14.2~~ **Significant Hazard**. A dam for which significant damage, but no loss of human life is expected to result from failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or recreate, including public and private facilities. Significant damage is determined to be damage sufficient to render structures or facilities uninhabitable or inoperable.

4.13.3 ~~4.2.14.3~~ **Low Hazard**. A dam for which neither loss of human life nor significant damage as defined for a Significant Hazard dam are expected to result from failure of the dam.

4.13.4 ~~4.2.14.4~~ **No Public Hazard (NPH)**. A dam for which minimal damage, with no loss of human life, is expected to result from failure of the dam.

4.14 ~~4.2.15~~ **High Water Line.** The elevation of the emergency spillway crest. If no emergency spillway exists, the elevation of the dam crest.

4.15 **Hydrologic Hazard.** Potential consequences downstream of a dam caused by floodwaters released by overtopping failure of the dam. Hydrologic hazard establishes design criteria for spillway size.

4.15.1 **Extreme.** Life loss potential of 1 or more.

4.15.2 **High.** Life loss potential of less than 1.

4.15.3 **Significant.** No life loss potential but significant damage is expected to occur.

4.15.4 **Low.** No life loss potential or significant damage is expected to occur.

4.16 **Incremental Consequences.** The difference in impacts that would occur due to failure or misoperation of the dam over those that would have occurred without failure or misoperation of the dam or appurtenances.

4.17 ~~4.2.18~~ **Inflow Design Flood (IDF).** The flood hydrograph used to determine if the emergency spillway's hydraulic capacity meets the safety standards as defined in Rule 7.2.

4.18 ~~4.2.20~~ **Natural Surface of the Ground.** The undisturbed ground surface before excavation, or the undisturbed bed of a natural watercourse.

4.19 ~~4.2.21~~ **Normal Water Line.** The elevation of the service spillway crest. If there is no service spillway, the normal water line and high water line are the same.

4.20 ~~4.2.23~~ **Outlet.** A conduit (usually regulated by gates or valves) used for releasing impounded water from the reservoir.

4.21 ~~4.2.24~~ **Owner.** The person or persons in control of the physical structure of any dam in accordance with section 37-87-104.5, C.R.S. Person or persons refers to any individual, private or non-profit company, special district, federal, state, or local government agency, or any other entity in direct routine control of a dam and reservoir, and/or directly involved in the physical operation and maintenance of a dam, and/or proposes to construct a dam.

4.22 ~~4.2.26~~ **Plans.** All necessary drawings, cross-sections, tables, notes, maps and other information necessary to accompany the construction specifications for design review and approval, and construction of a dam.

4.23 **Potential Failure Mode (PFM)**. A physically plausible process for dam failure resulting from an existing inadequacy or defect related to a natural foundation condition, the design or construction of the dam or appurtenant structures, the materials incorporated, the operations and maintenance, or the aging process, which can lead to an uncontrolled release of the reservoir.

4.24 **Potential Failure Modes Analysis (PFMA)**. The process by which the site-specific PFMs are identified, described in detail, and evaluated to determine the likelihood and consequence of occurrence.

4.25 **Probable Maximum Flood (PMF).** The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin under study.

4.26 ~~4.2.27~~ **Probable Maximum Precipitation (PMP).** The theoretically greatest depth of precipitation for a given duration that is physically possible over a drainage basin.

4.27 ~~4.2.28~~ **Reservoir.** A body of water impounded by a dam.

4.28 ~~4.2.29~~ **Restriction Order.** An order issued by the State Engineer to limit the water surface elevation of a reservoir to no greater than the safe storage level.

4.29 **Risk.** The product of (1) the likelihood of a structure being loaded, (2) the likelihood of adverse structural performance, and (3) the magnitude of the resulting consequences.

4.29.1 **Risk Management.** Action implemented to communicate the risks and either accept, avoid, transfer, or control the risks to an acceptable level considering associated costs and benefits of any action taken.

4.29.2 **Risk Analysis.** Qualitative or quantitative procedures that identify potential modes of failure and the conditions and events that must take place for failure to occur.

4.30 ~~4.2.31~~ **Safe Storage Level.** The maximum reservoir water surface elevation at which the State Engineer has determined that the dam is safe to impound water based on the safety inspection and/or evaluations.

4.31 ~~4.2.32~~ **Safety Inspection.** An evaluation by an Engineer in accordance with section 37-87-107, C.R.S. used by the State Engineer to set the safe storage level. The inspection shall include a review of the Emergency Action Plan and the hazard classification of the dam.

4.32 ~~4.2.33~~ **Spillway.** An overflow structure through which inflow is discharged from a reservoir.

4.32.1 ~~4.2.33.1~~ **Service Spillway.** The overflow structure designed to limit or control the operating level of a reservoir.

4.32.2 ~~4.2.33.2~~ **Emergency Spillway**. The overflow structure designed to pass the Inflow Design Flood.

4.32.3 ~~4.2.34~~ **Spillway Crest.** The elevation of the spillway at which uncontrolled discharge begins.

4.33 ~~4.2.35~~ **Storage.**

4.33.1 ~~4.2.35.1~~ **Normal Storage.** Volume of the reservoir impounded by a dam below the normal water line.

4.33.2 ~~4.2.35.2~~ **Maximum Storage.** Volume of the reservoir impounded by a dam below the dam crest.

4.33.3 ~~4.2.35.3~~ **Flood Storage**. Volume of water temporarily stored within a reservoir between the normal water line and the crest of the dam.

Rule 5. ~~Rule 13~~ Determination of Safe Storage Level

5.1 ~~13.1~~ **Authority to Determine Safe Storage Level.** The State Engineer is assigned the responsibility to determine the safe storage level for every reservoir in the state in accordance with section 37-87-107, C.R.S. The Owner shall not store water in excess of the amount so determined by the State Engineer to be safe.

5.2 **Methods to Determine Safe Storage Level.** The State Engineer will use the following methods to determine the safe storage level.

5.2.1 ~~13.2~~ **Safety Inspection.** The State Engineer shall perform regular dam safety inspections at a frequency appropriate to the hazard classification of the dam. These inspections will be performed using current observation methods and tools, and adhere to current standards. Observations will be recorded in a standardized report format, and provided to the Owner following the inspection. Interim dam safety inspections may also be performed between regular inspection cycles when warranted by either the condition of the dam or events impacting the safety of the dam.

5.2.2 **Potential Failure Modes Analysis.** Potential Failure Modes Analysis may be performed following identification of a concerning issue during the regular or interim inspection and/or as part of a periodic comprehensive dam safety evaluation.

5.3 ~~13.2~~ **Restriction of Storage.** If problems affecting the safe storage level of the reservoir are discovered, the State Engineer will issue a restriction order as an interim measure until the problems have been resolved. The Owner shall comply with the restriction order at all times. The restriction order will be removed or revised by the State Engineer only after acceptance of repairs or approval of engineering evaluations indicating the problems have been adequately resolved.

5.4 ~~13.3~~ **Review of Hazard Classification**. As part of the determination of the safe storage level, the State Engineer will periodically review the hazard classification of existing dams by evaluating the consequences of failure applying the definitions of Rule 4.13. If the State Engineer's review indicates the consequences of failure have changed within the dam failure inundation area, the State Engineer will assign an appropriate new hazard classification. The State Engineer will require the dam to meet the requirements of these Rules as they apply to the new hazard classification within a reasonable period of time.

Rule 6. ~~Rule 5.0~~ Design Submittal Requirements

6.1 An Owner proposing to construct a new jurisdictional dam or alter, modify, repair, or enlarge an existing jurisdictional dam and/or appurtenant structures shall submit an application package in a form acceptable to the State Engineer. Construction activities may not commence until the State Engineer has provided written approval of the design.

6.2 **Pre-Design Meeting**. Prior to design commencement, the Owner and Engineer shall meet with the State Engineer to discuss the scope and objectives of the project. Meeting minutes shall be provided by the Engineer to establish a clear understanding of the project requirements.

6.3 **Application Package**. The application package shall meet the following criteria.

6.3.1 **Format.** The application package shall be submitted in portable digital file (PDF) format unless otherwise requested by the State Engineer. All electronic submissions shall consider the following:

6.3.1.1 **File Size**. Efforts shall be made to minimize digital file size from the earliest stages of document development. Efforts may include use of file compression techniques in each step of the document development.

6.3.1.2 **Appropriate Security Settings**. Security settings shall allow for the required digital review and approval process by the State Engineer.

6.3.1.3 **Appropriate Resolution**. Digital files shall include a resolution appropriate to allow for printing both 22- by 34-inch and 11- by 17-inch (half-size) drawings without losing clarity, quality, or scalability.

6.3.1.4 **Electronic Signatures**. Appropriate engineering stamps and signatures will be required on the final version of the design documents before construction approval will be granted.

6.3.1.5 **File Name**. A table with document name, document description, and document type of all materials in the application package shall be included.

6.3.1.6 **File Transfer**. Digital file transfer methods shall be discussed and arranged in consultation with the State Engineer.

6.3.2 **Content.** The application package shall include the following:

A. Application Form,
B. Engineer's Qualification Statement and Affidavit,
C. Construction Plans,
D. Construction Specifications,
E. Design Report,
F. Inundation Map (High and Significant Hazard dams only),
G. Cost Estimate, and
H. Filing Fee.

6.4 ~~5.1~~ **Application Form.** A completed application form shall be provided to the State Engineer. The application shall be signed by the Owner or an authorized representative of the Owner. The Engineer may act as the Owner's representative if authorized by the Owner.

6.5 **Engineer's Qualification Statement and Affidavit**. The Engineer shall submit qualifications and a signed affidavit attesting compliance with the requirements as defined in Rule 4.10.

6.6 ~~5.2, 5.2.1~~ **Construction Plans.** The plans shall show the design of the dam and each appurtenant structure in sufficient detail so that the contractor or builder is able to construct the proposed structure from the plans and the specifications. Construction plans shall meet the following requirements.

6.6.1 ~~5.2.2~~ **Contents.** The plan set shall contain the following features:

6.6.1.1 The Engineer's seal in accordance with current practice defined by *The Bylaws and Rules of Procedure of the State Board of Registration for Architects, Professional Engineers, and Professional Land Surveyors* (4 CCR 730-1).

6.6.1.2 A cover sheet with the following information as a minimum:

A. The name of the dam;
B. The County, Water Division, and Water District in which the dam is located;
C. DAMID;
D. State Construction File Number; and
E. A project location map.

6.6.1.3 ~~5.2.2~~ A list of the drawings that follow the cover sheet, placed on the second sheet of the plans, and a note on the cover sheet indicating the location of the list of the drawings.

6.6.1.4 ~~5.3.1.4~~ The Engineer's certification statement, the State Engineer's approval signature block, and the Engineer's as-constructed statement in the lower right quadrant of the cover sheet in the following format:

These plans have been prepared by me or under my direct supervision.

_____
[Engineer's Printed Name]
Colorado P.E. No. [xxxxx]

Engineer's Stamp (1-5/8 inches)

Approved on the _____day of _____20___

_____
State Engineer

State Engineer's Stamp (1-5/8 inches)

By:_____
[Name], Chief, Colorado Dam Safety
Colorado P.E. No.

These plans represent the AS-CONSTRUCTED conditions of _____ Dam to the best of my knowledge and judgment, based in part on information furnished by others, as of the _____ day of _____, 20__.

_____
[Engineer's Printed Name]
Colorado P.E. No. [xxxxx]

Engineer's Stamp (1-5/8 inches)

6.6.1.5 ~~5.2.9~~ When appropriate, stage discharge curves and tables for spillways and outlets shall be placed on the drawings. For spillways, the curves and tables shall include the discharge for each vertical foot between the spillway crest and dam crest. For outlets, the curves and tables shall include the discharge for each vertical foot between the invert of the outlet works intake and the dam crest. Crest elevations of all spillways and the dam, and the invert elevation of the outlet shall be clearly noted on the tables. The rating data shall be referenced to both gage height and elevation.

6.6.1.6 Area capacity and stage capacity curves and tables shall be provided for all new dams and enlargements and when otherwise determined appropriate. The curves and tables shall be provided in a format determined in consultation with the State Engineer.

6.6.1.7 The plans shall clearly identify the vertical and horizontal datum used, and to the extent possible, shall include a description of vertical and horizontal translations if the proposed datum is different from that used in past projects for the same dam.

6.6.1.8 In no cases shall construction specifications be provided on the drawings.

6.6.2 ~~5.2.3~~ **Format**. All plan sets shall meet the following format requirements:

6.6.2.1 ~~5.3.2.1~~ Drawings shall be prepared in an appropriate scale so details and text are clearly legible on an overall sheet size of 22- by 34-inches and half-size sheet size of 11- by 17-inches.

6.6.2.2 ~~5.2.5~~ Drawings shall have bar scales to allow scaling of reduced-sized drawings.

6.6.2.3 ~~5.2.6~~ Full size drawings shall have a 1/2- by 3-inch space for the State Engineer's construction file number inside the margin in the lower right-hand corner. A unique construction file number will be assigned by the State Engineer prior to final approval of the project documents for construction and shall be placed in bold characters on all of the drawings.

6.6.2.4 ~~5.2.7~~ Each sheet shall be numbered sequentially with the first sheet being sheet number one along with the total number of sheets (e.g., sheet 1 of 6).

6.7 ~~5.3~~ **Construction Specifications**. Construction Specifications shall be submitted on 8½- by 11-inch paper in PDF format, and in printed format if requested by the State Engineer. Specifications shall meet the following requirements:

6.7.1 ~~5.3.1~~ The specifications shall display the Engineer's seal in accordance with current practice defined by *The Bylaws and Rules of Procedure of the State Board of Registration for Architects, Professional Engineers and Professional Land Surveyors* (4 CCR 730-1).

6.7.2 The cover sheet shall show the following information as a minimum:

A. The name of the dam;
B. The county, Water Division, and Water District in which the dam is located;
C. DAMID;
D. State Construction File Number; and
E. Date.

6.7.3 The first page behind the cover shall show the following information as a minimum:

A. The same information as on the cover sheet; and
B. The Engineer's certification statement with seal and signature, and the State Engineer's approval statement as shown in Rule 6.6.1.4 (without the As-Constructed block).

6.7.4 ~~5.3.2~~ The specifications shall have an index.

6.7.5 ~~5.3.3~~ Printed specifications shall be bound. Loose-leaf and 3-ring binders are not acceptable.

6.7.6 ~~5.3.4~~ The specifications shall include a separate section with the following provisions stating the State Engineer's authority:

6.7.6.1 The plans and specifications cannot be significantly changed without the prior written approval of the State Engineer. If changed conditions are encountered after the State

Engineer's approval is issued, the changes shall be documented in accordance with Rule 8.2.5.

6.7.6.2 ~~5.3.5~~ Construction shall not be considered complete until the State Engineer has accepted the construction in writing.

6.7.6.3 ~~5.3.6~~ The Engineer will monitor the quality of construction as specified in Rule 8.1.2. The Engineer monitoring the construction for the Owner is responsible for the quality of construction, compliance with the approved design and specifications, preparation of the necessary documentation for the State Engineer's review and approval of all construction change orders, and preparation of the project completion documents.

6.7.7 ~~5.3.7~~ The specifications shall include the following at a minimum:

A. ~~5.3.7.1~~ Quality of materials used in construction,
B. ~~5.3.7.2~~ Acceptable quality of workmanship,
C. ~~5.3.7.3~~ References to applicable standards as appropriate,
D. ~~5.3.7.4~~ Required tests and estimated frequency of testing, and
E. ~~5.3.7.5~~ Action to be taken if unsatisfactory materials or workmanship are discovered in the construction.

6.7.8 ~~5.3.8~~ Only technical specifications shall be submitted. No contract documents or extraneous specifications unrelated to the project shall be included.

6.8 ~~5.4 & 5.4.4~~ **Design Report.** A design report shall be submitted with the application package. The purpose of the design report is to present the project design criteria and all supporting engineering analyses including applicable design standards and references. The design report shall display the Engineer's seal in accordance with current practice defined by *The Bylaws and Rules of Procedure of the State Board of Registration for Architects, Professional Engineers and Professional Land Surveyors* (4 CCR 730-1). The following topics shall be addressed in the design report when applicable to the proposed project. Stand-alone reports addressing individual topics shall be sealed by the responsible engineer and summarized in the design report.

6.8.1 ~~5.4.4.1~~ **Introduction**. This section shall describe the project and review process, including a discussion of the project objectives and how the proposed design will meet those objectives.

6.8.2 ~~5.4.4.2~~ **Project Components**. This section shall describe the dam, spillway, outlet works, and other appurtenant structures.

6.8.3 ~~5.4.4.3~~ **Site Requirements**. This section shall describe any site improvements and unusual construction considerations required to construct the project.

6.8.4 **Hazard Classification.** This section shall identify the hazard classification for the dam. This may be submitted, reviewed, and approved as a stand-alone report prior to submittal of the application package. A detailed analysis is not required for dams that are declared as High Hazard; however, a dam failure inundation map will be required for the Emergency Action Plan pursuant to Rule 13.6.

6.8.5 ~~5.4.4.4~~ **Hydrology**. This section shall include all pertinent design analyses and assumptions necessary to determine the inflow design flood (IDF) for sizing the spillway in

accordance with Rule 7.2. This may be submitted, reviewed, and approved as a stand-alone report prior to submittal of the application package.

6.8.6 ~~5.4.4.5~~ **Hydraulics**. This section shall discuss how the proposed spillway design will protect the dam from damage during the IDF and how the proposed outlet will comply with the downstream delivery and reservoir evacuation requirements.

6.8.7 ~~5.4.4.6~~ **Geotechnical Design**. This section shall include all pertinent geotechnical and engineering geology considerations for a given project. Documentation and interpretation of all appropriate field and laboratory testing programs shall be sufficiently comprehensive to support the basis of design for dam and appurtenant structure foundations. This may be submitted and reviewed as a stand-alone report prior to submittal of the application package.

6.8.8 ~~5.4.4.9~~ **Structural Design**. This section shall include discussion of the design and analyses for all structural components.

6.8.9 ~~5.4.4.10~~ **Instrumentation Plan**. This section shall describe the objectives and details of the proposed instrumentation.

6.8.10 ~~5.4.4.11~~ **Mechanical and Electrical Design**. This section shall include discussion of designs and analyses for all mechanical and electrical systems including, but not limited to gates, valves, trash racks and mechanical systems, systems for operating gates and valves, electrical power requirements and emergency backup power or manual override.

6.8.11 ~~5.4.4.13~~ **River Diversion during Construction**. This section shall describe the means to protect the proposed work, the stream, and public safety during the proposed construction period as required by Rule 8.1.1.

6.9 ~~5.6~~ **Cost Estimate**. A detailed cost estimate of the construction of the dam including the engineering and construction oversight tasks. The cost estimate will remain confidential until after the construction contract is executed.

6.10 ~~5.7~~ **Fee.** A fee shall be assessed in accordance with section 37-80-110 1(e), C.R.S. A check for the fee shall accompany the application form and be made payable to Colorado Division of Water Resources.

6.11 ~~5.8~~ **Design Review Approvals and Limitations.**

6.11.1 ~~5.8.2~~ **Approval of Plans and Specifications.** The State Engineer will approve acceptable plans and specifications for construction. Unacceptable submittals will be rejected.

6.11.2 ~~5.8.4~~ **Design Review Limitation.** Re-submittal of the design package shall be required if resolution of the design review comments does not occur within three years. Resubmitted designs shall be accompanied by a new application package and fee.

6.11.3 ~~5.8.3~~ **Approval Limitation**. Construction shall commence within five years of approval of the application, after which time the State Engineer's approval shall be void. The new application will be reviewed and reevaluated against current standards. Resubmitted designs shall be accompanied by a new application package and fee.

6.11.4 ~~5.8.4~~ **Resubmittal of Rejected Designs and Expired Approvals**. The Owner is required to submit a complete application package and fee, addressing any previously identified

deficiencies, before the design will be reconsidered. The new application will be reviewed and reevaluated against current standards.

6.12 ~~6.1.3~~ **Application and Approval Requirements for Low Hazard and NPH Dams.** Plans for alteration, modification, repair, or enlargement of an existing Low Hazard or NPH dam and/or appurtenant structures of Low Hazard dams or NPH dams will be reviewed in accordance with the following procedure.

6.12.1 ~~6.1.3.1~~ **Notice**. The Owner shall provide written notice to the State Engineer at least thirty (30) days in advance of construction. The written notice shall contain the name of the dam, the location of the dam, the name of the Owner, contact information for the Owner, and a clear description of the work to be performed.

6.12.2 ~~6.1.3.2~~ **Determination**. The State Engineer will notify the Owner whether plans and specifications are required.

6.12.2.1 If plans and specifications are required, Rules 6, 7, and 8 will apply.

6.12.2.2 If plans and specifications are not required, the State Engineer will inform the Owner of any engineering, construction, and project documentation requirements, and will perform construction inspections as determined necessary.

Rule 7. ~~5.9~~ Design Requirements

7.1 This Rule applies to design of new dams and alteration, modification, repair, or enlargement of existing dams. In the case of existing dams, only the pertinent sections will apply.

7.2 ~~5.9.1~~ **Inflow Design Flood (IDF) for Spillway Sizing.**

7.2.1 **Prescriptive Method**. Table 7.1 provides rainfall requirements for the Inflow Design Flood (IDF) based on Hydrologic Hazard. The spillway must safely route a flood generated by Critical[1] Rainfall shown in Table 7.1.

Table 7.1: Prescriptive IDF Requirements

Hydrologic Hazard	Critical[1] Rainfall
Extreme	Probable Maximum Precipitation (PMP)
High	0.01% AEP
Significant	0.1% AEP
Low	1% AEP

7.2.2 ~~5.9.1.7~~ **Incremental Damage Analysis (IDA) Method.** An IDA may be used to justify an IDF that is smaller than the prescriptive requirement in Table 7.1; however, in no case shall the IDF be less than the flood generated by the Critical[1] 1% AEP Rainfall. An IDA determines incremental consequences caused by an overtopping dam failure flood beyond that caused by the

[1] Critical refers to the controlling storm duration, spatial pattern, temporal distribution and other storm variables that result in the highest maximum reservoir water surface elevation during reservoir routing.

spillway base flood immediately prior to such overtopping failure. Spillway size is acceptable when incremental consequences by overtopping failure are expected to cause no additional life loss and no additional significant property damage when compared to the spillway base flood.

7.2.3 Allowable Rainfall Estimates for developing the IDF.

7.2.3.1 ~~5.9.1.4~~ Probable Maximum Precipitation (PMP).

The Probable Maximum Flood (PMF) shall be developed using the most current PMP estimates approved by the State Engineer.

7.2.3.2 ~~5.9.1.2~~ Precipitation Frequency Estimates.

Frequency-based IDFs shall be developed using the most current precipitation frequency estimates approved by the State Engineer.

7.2.3.3 ~~5.9.1.6~~ Site-Specific Extreme Precipitation Studies (SSEPS).

SSEPS may be used to determine the appropriate site-specific extreme storm precipitation (PMP or precipitation frequency estimates) for the determination of the IDF. The SSEPS must be approved by the State Engineer prior to acceptance.

7.2.4 Atmospheric Moisture Factor.

All rainfall depth estimates calculated by means acceptable to the State Engineer shall be multiplied by a factor of 1.07 prior to calculating runoff to account for expected increases in temperature and associated increases in atmospheric moisture availability over the 50-year period 2020 to 2070.

7.2.5 Flood Frequency Analysis.

Using systematic records, historical flood information, and paleoflood and botanical information, flood frequency analysis may be used to determine a required frequency flood for spillway sizing purposes. Flood frequency analysis shall follow applicable, current, published guidelines and procedures, such as *Guidelines For Determining Flood Flow Frequency* (ACWI Bulletin 17C, USGS, 2018).

7.2.6 ~~5.9.1.1~~ Hydrologic Basin Response Requirements.

Rainfall-runoff modeling used to develop an IDF shall consider basin size, elevation of the basin, various soil permeabilities, various vegetative covers, and other factors related to the routing of the storm event. Snowmelt conditions and rain-on-snow events shall be considered as base flow when appropriate.

7.3 Geological and Geotechnical Investigations.

7.3.1 ~~5.9.3.2~~

Geological and geotechnical engineering investigations shall be conducted under the supervision of an Engineer or Geologist experienced in geotechnical or geological engineering for dams.

7.3.2 ~~5.4.3.1~~ Geological Site Characterization.

A geological assessment of the dam and reservoir site is required for all dams classified as High or Significant Hazard. The geological assessment shall include, at a minimum:

A. Regional geologic setting;
B. Local and site geology;
C. Geologic suitability of the dam foundation, reservoir rim stability, and reservoir area leakage;
D. Regional and site seismicity;
E. All other potential geological hazards affecting the project; and

F. ~~5.9.3.3~~ A site-specific geologic map based upon published records and field observations. The geologic mapping shall cover the reservoir area, dam, abutments, and the locations of all appurtenant structures.

7.3.3 **Subsurface Investigation Plans**. A subsurface investigation plan must be approved by the State Engineer prior to mobilization for all proposed subsurface investigations. The plan shall include the following:

A. Objective(s) of the investigation and descriptions of the specific Potential Failure Modes being addressed in the investigation;
B. Names and qualifications of the investigation team including lead geotechnical or geological engineer, field engineers, and geologists;
C. Figures and description of the existing conditions;
D. Drilling, test pits, and other in-situ testing procedures; and
E. Contingency plans.

7.3.3.1 Drilling methods in all dams and dam foundations shall be chosen to minimize the risk of hydraulic fracturing or otherwise damaging the strata or formations being drilled. Drilling on or within 200 feet of existing dams is prohibited unless approved by the State Engineer.

7.3.4 ~~5.9.3.4~~ **Subsurface Geotechnical Investigations**. Subsurface investigations shall be conducted for all new dams and for all modifications to existing dams where appropriate. The subsurface investigation shall include a characterization of the geotechnical and geologic foundation conditions as follows. More extensive investigation and reporting may be required, depending on project-specific needs.

7.3.4.1 ~~5.4.3.2~~ **High and Significant Hazard Dams**. Subsurface geotechnical investigations for High and Significant Hazard dams shall require the following, at a minimum:

A. Drilling at least three borings along the dam centerline to a depth 1.5 times the height of the dam and at least 10 feet into competent bedrock;
B. Additional borings or test pits within or near the dam footprint, as required;
C. Logs of borings and test pits;
D. Standard Penetration Testing;
E. Field density tests, as appropriate;
F. Field classification of rock and soil;
G. Measurement of the water level in each drill hole; and
H. In-situ permeability tests.

7.3.4.2 ~~5.4.3.4~~ **Low Hazard and NPH Dams**. Subsurface geotechnical investigations for Low Hazard and NPH dams shall require the following, at a minimum:

A. Drilling at least three borings along the dam centerline to a depth 1.5 times the height of the dam or at least 10 feet into bedrock;
B. Field classification of rock and soil;
C. Logs of borings and test pits; and
D. Standard Penetration Testing.

7.3.4.3 **Spillways, Outlet Works, and Appurtenant Structures.** Subsurface geotechnical investigations for spillways, outlet works and appurtenant structures shall include the following, at a minimum:

A. An evaluation of the site's suitability to accommodate the spillway or structure;
B. ~~5.4.3.6.1~~ Field classification of soils along the alignment of the spillway or under the structure;
C. ~~5.4.3.6.2~~ A profile of soils along the spillway channel extending to a depth of at least five feet below the bottom of the spillway;
D. ~~5.4.3.6.3~~ Density or bearing capacity of foundation soils beneath structures except for riprapped or unlined sections of the spillway channel;
E. Erodibility of unlined natural spillway channels; and
F. For structures founded on rock, a geologic description of the foundation rock including a description of the bedding and jointing patterns.

7.3.4.4 ~~5.4.3.2~~ **Underground Construction**. Where tunneling or other underground construction is anticipated, subsurface investigation depths, orientations, methods, and testing shall be tailored to the geologic setting and details of the underground construction anticipated at each site, as recommended by a Geologist.

7.3.4.5 **Borrow Sources.**

7.3.4.5.1 Subsurface geotechnical investigations for borrow sources shall include an evaluation of the availability, suitability, and quantity of all earth and rock materials proposed for construction of the dam as designed. Determination shall be based on field and laboratory testing.

7.3.4.5.2 ~~5.10.1.2~~ Borrow areas shall be located so they do not negatively impact the dam stability or foundation seepage. Borrow areas shall be located at least 200 feet outside the dam footprint, unless an analysis approved by the State Engineer indicates a lesser distance is acceptable.

7.3.5 **Laboratory Testing.** Laboratory testing of all proposed native and imported construction materials, and foundation and abutment materials, shall be performed to provide engineering justification for the selected design criteria.

7.3.5.1 ~~5.4.3.3, 5.4.3.3.1, 5.4.3.3.2, 5.4.3.3.3, 5.4.3.3.4, 5.4.3.3.5, 5.4.3.3.6., 5.9.3.6~~ **High and Significant Hazard Dams**. Laboratory testing for High and Significant Hazard earth and rockfill embankment dams shall include the following tests, as a minimum:

A. Classification of all soil and rock materials based on standard index tests, including hydrometer tests as necessary for clay soils;
B. Directly measured shear strengths of all materials using test methods appropriate for the material tested;
C. Residual strength of high plasticity soils or weak rock;
D. Compressibility of all soil and rock materials;
E. Consolidation and expansion characteristics of all soil and rock materials;
F. Permeability of all in-situ and placed materials;
G. Moisture/density relationships of all materials to be compacted;
H. Potential dispersiveness and erodibility of all soils;
I. Solubility of all rock materials;

J. Density, quality, soundness, and durability of all rock materials; and

K. Corrosion potential.

7.3.5.2 ~~5.4.3.4~~, ~~5.4.3.5~~ **Low Hazard and NPH Dams**. Laboratory testing for Low Hazard and No Public Hazard earth and rockfill embankment dams shall include the following tests, as a minimum:

A. Classification of all soil and rock materials based on standard index tests, and

B. Moisture/density relationships of all materials to be compacted.

7.4 Embankment Dam Design.

7.4.1 ~~5.4.4.6~~, ~~5.4.3~~ **Foundation and Abutment Design**. The dam foundation and abutments shall be analyzed and design criteria selected to meet the following requirements.

7.4.1.1 Unsuitable materials shall be removed from the dam foundation and abutments, unless appropriate analyses demonstrate the unsuitable material can be adequately treated so it will not adversely affect the safety and performance of the dam. Unsuitable materials include, but are not limited to liquefiable, dispersive, organic, expansive, and collapsible soils; slaking shales; soluble rock; clay seams in rock; and poor-quality rock.

7.4.1.2 The dam foundation geometry shall be designed to prevent the creation of low stress zones in the embankment that could cause differential settlement and cracking of the dam.

7.4.1.3 The foundation shall be treated as required to prevent deformation or instability of the dam caused by foundation movement as a result of heave, swell, rebound, settlement, or collapse.

7.4.1.4 **Seepage Control and Foundation Drainage Design Criteria.**

7.4.1.4.1 ~~5.9.4.2.2,~~ ~~5.9.4.3.1.11~~ The design shall include quantification of the anticipated seepage beneath and around the dam. Seepage through the abutments and foundation shall be minimized through adequate treatment. Foundation and abutment seepage shall be controlled through filtered exits to prevent piping and internal erosion.

7.4.1.4.2 ~~5.9.3.9~~ Foundation drainage design shall be provided to reduce or control uplift pressures that would affect the stability of the dam. The efficiency of the drainage system to reduce uplift pressures under the dam shall be based upon the geology of the dam foundation. The ability to maintain the drainage system to meet the requirements assumed for the design of the dam shall be addressed.

7.4.2 ~~5.4.4.8~~ **Embankment Design Requirements**. The dam embankment shall be analyzed and designed to meet the following requirements.

7.4.2.1 ~~5.9.4.3.1~~ **Crest Design.**

7.4.2.1.1 ~~5.9.4.3.1.1~~ The crest width shall be equal to the jurisdictional height of the dam in feet divided by 5, plus 10 feet. The maximum crest width required shall be 25 feet.

7.4.2.1.2 ~~5.9.4.3.1.2~~ The crest shall have a camber sufficient to maintain the design freeboard, based on the anticipated magnitude of crest settlement. The anticipated magnitude of crest settlement shall be based on engineering analyses. In no case shall the camber be less than 0.5 feet.

7.4.2.1.3 ~~5.9.4.3.1.5~~ The crest design shall include details to protect impervious cores from desiccation or frost penetration.

7.4.2.1.4 ~~5.9.4.3.1.6~~ The crest shall be provided with adequate cross slopes to the upstream edge to prevent ponding and facilitate drainage.

7.4.2.1.5 ~~5.9.4.3.1.4~~ Roads located on the dam crest shall have appropriate surfacing to provide a stable base that resists rutting and provides adequate traction for safety in wet conditions.

7.4.2.2 **Freeboard Design.** Freeboard for earth and rockfill embankment dams shall be designed in accordance with *Freeboard* (Design Standard No. 13, Chapter 6, Reclamation, 2012), except as follows:

7.4.2.2.1 The minimum normal freeboard shall be the greater of 3 feet or a 100 mile per hour wind generated setup and runup.

7.4.2.2.2 The minimum residual freeboard shall be the greater of 1 foot or a 10 percent AEP wind generated setup and runup.

7.4.2.3 **Embankment Zoning**. Shells, cores, filters, and drains for embankment dams shall be designed using industry standards consistent with the current state of the practice.

7.4.2.3.1 All dam embankments shall be protected against internal erosion and piping with suitable filters and drains.

7.4.2.3.2 Shells shall be designed to support the core/impermeable barrier. Transition zones shall be provided as necessary to prevent migration of core material.

7.4.2.4 ~~5.9.4.2~~ **Seepage and Internal Drainage Design**. Evaluation of steady state seepage and internal drainage conditions shall be performed. The seepage and internal drainage design shall include, but not be limited to, the following:

7.4.2.4.1 ~~5.9.4.2.1~~ Steady state seepage shall be analyzed using numerical modeling. All modeling input parameters shall be justified and clearly documented.

7.4.2.4.2 All seepage exit points shall be filter protected.

7.4.2.4.3 Drains shall collect and convey seepage to designated monitoring points.

7.4.2.4.4 ~~5.9.4.2.3~~ The filter compatibility of the drain, transition zone, and embankment materials shall be evaluated utilizing current state of the practice methodologies. Granular filter materials must be self-healing and free of cementitious properties.

7.4.2.4.5 Drains shall consist of slotted or perforated pipe surrounded with filter-compatible free draining gravel. The gravel shall be filter-compatible with the surrounding filter material.

7.4.2.4.6 ~~5.9.4.3.5~~ Pipes to collect and safely route seepage flows from internal filters and drains shall:

A. ~~5.9.4.3.5.6~~ Be no smaller than 6 inches in diameter;
B. Accommodate internal inspection of the entire drain system;
C. ~~5.9.4.3.5.5~~ Be designed to flow with a water depth no greater than ¼ of the diameter of the pipe for the estimated seepage flows;
D. ~~5.9.4.3.5.4~~ Be provided with cleanouts and access points for internal camera inspection, cleaning, and repair;
E. ~~5.9.4.3.5.1~~ Be comprised of material that is non-corrodible and non-collapsible for the estimated overlying earth pressures and anticipated settlement or ground movement associated with dam construction;
F. ~~5.9.4.3.5.7~~ Discharge freely into locations where flow rates can be measured, such as galleries, manholes, vaults, or headwalls;
G. ~~5.9.4.3.5.7~~ Project beyond vertical walls to facilitate discharge measurement;
H. ~~5.9.4.3.5.8~~ Be inspected after a maximum of 3 to 5 feet of fill placed over pipe, and again after remaining fill has been placed;
I. ~~5.9.4.3.5.9~~ Be equipped with rodent screens in locations where the discharge ends of the pipes are accessible to animals; and
J. ~~5.9.4.3.5.10~~ Be designed with multiple discharge points in order to isolate seepage to various sections of the dam and foundation.

7.4.2.4.7 All penetrations through embankments shall be filter protected against concentrated leakage along the conduit.

7.4.2.5 ~~5.9.4.1~~ Embankment Stability.

7.4.2.5.1 **High and Significant Hazard Dams**. Stability analyses shall be performed for all High and Significant Hazard dams to demonstrate that embankments are stable during construction and under all conditions of reservoir operation.

7.4.2.5.1.1 ~~5.9.4.1.1~~ Analyses shall represent the critical cross section(s). Where appropriate, the analyses shall consider non-circular or wedge-shaped failure surfaces, as well as circular failure surfaces.

7.4.2.5.1.2 ~~5.9.4.1.2~~ Loading conditions selected for evaluation shall be based on the full range of conditions anticipated before, during and after construction is complete. Soil strength parameters, pore pressure characteristics, and target minimum factors of safety for the required loading conditions shall be selected in accordance with the principles provided in *Static Stability Analysis*, (Design Standards No. 13, Chapter 4, Reclamation, 2011) or *Slope Stability*, (EM 1110-2-1902, U.S. Army Corps of Engineers, 2003).

7.4.2.5.2 ~~5.9.4.1.3~~ **Low Hazard and NPH Dams.** Low Hazard or NPH dams shall be designed with upstream slopes no steeper than 3H:1V and downstream slopes no steeper than 2H:1V unless it can be demonstrated that steeper slopes will be stable.

7.4.2.6 **Settlement and Consolidation**. All dams shall be analyzed and designed to prevent deformation or instability caused by movement as a result of settlement, consolidation, or collapse.

7.4.2.7 **Cracking**. All dams shall be analyzed and designed to prevent the formation of cracks due to differential settlement or creation of low stress zones that could lead to hydraulic fracturing.

7.4.2.8 **Upstream Slope Erosion Protection.** Embankments shall be protected against external erosion. Slope protection for wave action is required to be provided on the entire upstream slope of the dam, unless lesser coverage is justified based on engineering analysis and reservoir operational criteria.

7.4.2.8.1 ~~5.9.4.3.3~~ **Rock Riprap**. Rock riprap shall be well-graded, durable, sized to withstand design wave action, and shall be placed on a well-graded pervious sand and/or gravel bedding or acceptable geotextile fabric that is filter compatible with the underlying embankment zone.

7.4.2.8.2 ~~5.9.5.6.1, 5.9.5.6.2~~ **Soil Cement**. Soil cement slope protection design and construction specifications shall be based on the principles provided in *Soil Cement Slope Protection* (Design Standards No. 13, Chapter 17, Reclamation, 2013).

7.4.2.9 ~~5.9.4.3.1.9~~ **Downstream slope erosion protection**. The downstream slope of earth embankment dams shall be provided with a well maintained vegetative cover to prevent surface erosion.

7.4.2.10 ~~5.9.4.3.6, 5.9.4.3.6.1~~ **Geosynthetics**. The use of geosynthetics shall be evaluated by the State Engineer on a case-by-case basis. Geosynthetics will not be accepted where failure of the geosynthetic could jeopardize the safety of the dam. Geosynthetic materials shall be used in accordance with the manufacturers' recommendations and intended use for each product.

7.4.3 ~~5.9.4.3.2~~ **Material Placement and Compaction Requirements.** Material placement and compaction shall meet the minimum requirements:

7.4.3.1 ~~5.9.4.3.2.1~~ Minimum compacted density for embankment materials shall be 95 percent of maximum dry density for ASTM D698 (Standard Proctor).

7.4.3.2 Impervious zones with clay fines shall be placed at close to optimum moisture content to prevent overcompacted, brittle zones.

7.4.3.3 ~~5.9.4.3.2.2~~ The density for cohesionless filter and drain materials shall range between 65- and 75-percent relative density as determined by ASTM D4253 and D4254, or other method(s) approved by the State Engineer.

7.4.3.4 Construction of filters and drains shall be based on placement procedures developed through a test fill program to verify acceptable density and avoid excessive particle breakdown.

7.4.3.5 ~~5.9.4.2.2~~ Filter and drain zones shall be constructed with sufficient thickness to prevent contamination or loss of continuity that would adversely impact the performance of these features.

7.5 Concrete Dam Design Requirements.

7.5.1 ~~5.9.5.1~~ For all concrete dams, the following design considerations shall be addressed and documented in the Design Report.

7.5.1.1 ~~5.9.5.1.2~~ The crest of the dam shall have a width of not less than 15 feet.

7.5.1.2 ~~5.9.5.1.3~~ If the crest of the dam is designed to function as the emergency spillway, it shall not be overtopped by floods more frequent than the one percent AEP flood.

7.5.1.3 Emergency spillway discharge for flows up to the inflow design flood shall not cause excessive downstream erosion of the abutments and foundation.

7.5.1.4 ~~5.9.5.1.4~~ If the design of the dam includes drainage features and the reduction in uplift pressures is required to meet factors of safety and stress requirements, a gallery shall be provided in the dam to access, monitor and clean or re-drill the drains. ~~5.9.5.4.5~~ Dams in excess of one hundred feet in height shall include a drainage gallery.

7.5.1.5 ~~5.9.5.4.1~~ A concrete mix design containing proposed aggregate properties, source of aggregate, concrete properties, and proposed cementitious contents shall be provided.

7.5.1.6 ~~5.9.5.4.2~~ ~~5.9.5.4.6~~ Specifications shall include provisions for placing concrete under cold weather, hot weather, and rain.

7.5.2 ~~5.9.5.2~~ **Arch Dams**. Concrete arch dams shall be designed in accordance with principles provided in *Arch Dam Design* (EM 1110-2-2201, U.S. Army Corps of Engineers,1994).

7.5.3 ~~5.9.5.3~~ **Gravity Dams**. Concrete gravity dams shall be designed in accordance with the following Rules and *Gravity Dam Design* (EM 1110-2-2200, U.S. Army Corps of Engineers, 1995), with the following additions:

7.5.3.1 ~~5.9.5.3.3~~ When the design relies on the reduction of uplift pressures from dam and foundation drains, the effectiveness of the drains shall be verified and monitored for the life of the dam via the installation of piezometers.

7.5.3.2 If the seismic loading scenario shows a crack may form along the base of the dam or the foundation may sustain damage, a post-earthquake analysis will be required to show that the dam and foundation can withstand the usual and unusual loading conditions in their “damaged” state.

7.5.4 ~~5.9.5.4~~ **Roller Compacted Concrete Dams**. Roller compacted dams shall be designed in accordance with the following Rules and *Roller-Compacted Concrete* (EM 1110-2-2006, U.S. Army Corps of Engineers, 2000), with the following additions:

7.5.4.1 ~~5.9.5.4.2.~~ The dam design shall include adequate control of cracking in the upstream facing system and concrete mass caused by thermal shrinkage of the concrete. Crack control provisions shall include controlling excessive heat of hydration by use of fly ash and limiting in-place concrete temperature.

7.5.4.2 ~~5.9.5.4.4~~ Adequate cold joint treatment shall be provided in the specifications to prevent formation of unbonded lift joints that could become potential paths for seepage.

7.5.4.3 ~~5.9.5.4.3~~ Design dimensions shall be able to be constructed with conventional earthwork equipment, particularly between the upstream face of the dam and the drainage gallery, and within the chimney section.

7.5.4.4 ~~5.9.5.4.7~~ RCC shall be protected with conventional facing concrete, or equivalent protection.

7.5.4.5 ~~5.9.5.5~~ **Material Placement.** The construction of RCC dams shall meet the following requirements.

7.5.4.5.1 ~~5.9.5.5.1~~ An RCC test section shall be constructed outside the dam footprint at least twenty one (21) days before production placement of the RCC. The final mix design and method of construction shall be approved by the State Engineer prior to production placement.

7.5.4.5.2 ~~5.9.5.5.2~~ The Engineer shall provide full-time observation by qualified field staff during RCC test section and production placement.

7.5.4.5.3 ~~5.9.5.5.3~~ Locations of all cold joints shall be documented.

7.5.4.5.4 ~~5.9.5.5.4~~ Representative RCC cores shall be taken from the completed dam to verify design strengths. RCC cores shall be 6-inch diameter.

7.5.4.5.5 ~~5.9.5.5.5~~ The dam shall be allowed to reach design strength before initial filling of the reservoir.

7.6 **Seismic Design Requirements.** Seismic stability shall be evaluated for all concrete dams and High and Significant Hazard embankment dams. The level of analysis required shall be commensurate with the known and anticipated site conditions and the level of effort given to developing input parameters. In general, analyses should start at a screening level and progress to more detailed analyses only when necessary. Seismic stability analyses shall be based on the principles provided in *Earthquake Analyses and Design of Dams* (FEMA-65, Federal Guidelines for Dam Safety, FEMA, 2005), *Best Practices Chapter II-3* (Reclamation and U.S. Army Corps of Engineers, 2015), *Seismic Analysis and Design* (Design Standards No. 13 Chapter 13, Reclamation, 2015), *Earthquake Design and Evaluation for Civil Works Projects* (Engineering Regulation 1110-2-1806, U.S. Army Corps of Engineers, 2016), or *Earthquake Design and Evaluation of Concrete Hydraulic Structures* (Engineering Manual 1110-2-6053, U.S. Army Corps of Engineers, 2007).

7.6.1 **Seismic Hazard Analysis**. The seismic hazards, consisting of the design earthquakes and associated ground motions, shall be determined. The seismic hazards shall be justified with due consideration to the hazard classification of the structure, regional and site-specific seismic hazard considerations, and the designated operational function of the dam.

7.6.2 **Dynamic Response Analysis**. Analyses to predict the structural response to seismic loading are required except as described in Rule 7.6.2.1. All seismic analyses shall be evaluated assuming loading and pore pressure conditions expected immediately prior to the earthquake. Acceptable methods for predicting structural response to seismic loading include, but are not limited to, post-earthquake stability, embankment deformation, and probabilistic analyses. Pseudostatic analyses are not an acceptable means of predicting structural response to seismic loading.

7.6.2.1 Dynamic Response Analyses are not required for embankment dams meeting all of the following conditions. The potential for embankment cracking (transverse or

longitudinal), damage to appurtenant features (e.g. outlet-works tunnels), and overtopping due to seiche waves as the result of seismic activity are not addressed by these exceptions and shall be considered separately.

A. The dam and foundation materials are not subject to liquefaction and do not include sensitive clays;
B. The dam is reliably compacted to at least 95 percent of the laboratory maximum dry density, or to a relative density greater than 65 percent;
C. The slopes of the dam are 2.5H:1V or flatter, and/or the phreatic line is well below the downstream face of the embankment;
D. The peak ground acceleration (PGA) at the base of the embankment is less than or equal to 0.35g;
E. The static stability factor of safety for all potential failure surfaces involving loss of crest elevation (i.e., slides other than shallow surficial slides) are greater than 1.5 under loading and pore-pressure conditions expected immediately prior to the earthquake;
F. The minimum freeboard is at least 3 to 5 percent of the embankment height and never less than 3 feet; and
G. There are no appurtenant features that would be harmed by small movements of the embankment, or that could create potential for internal erosion or other potential failure modes.

7.7 Instrumentation and Monitoring Requirements.

7.7.1 The Owner shall submit a plan for installation of all new instrumentation and flow measurement devices for review and approval.

7.7.2 ~~5.5~~ **Instrumentation Plan**. An instrumentation plan is required and shall meet the following requirements.

7.7.2.1 ~~5.5.1~~ All instrumentation shall be properly identified in the field to correspond to the identification of the instrumentation in the long-term monitoring plan required in Rule 13.4.

7.7.2.2 ~~5.5.2~~ Gage rods shall be installed at all dams to accurately measure reservoir levels. The zero mark of the gage shall be aligned vertically with the invert elevation of the entrance to the outlet. The gage rod shall be located in an easily accessible location and clearly marked in feet and tenths of feet, and extend to within one foot of the crest of the dam. If the Division Engineer so requires, the gage shall be marked in hundredths of a foot.

7.7.2.3 ~~5.5.3~~ **High and Significant Hazard Dams**. High and Significant Hazard dams shall have the following minimum instrumentation:

7.7.2.3.1 ~~5.3.1~~ Monuments that allow measurement of the horizontal and vertical movements of the dam, installed in accordance with industry standards and in a manner acceptable to the State Engineer. Monuments shall be located with such spacing as deemed appropriate by the Engineer and approved by the State Engineer. Control or benchmark monuments shall be placed off the dam on natural ground in areas not subject to movement.

7.7.2.3.2 ~~5.5.3.2~~ Weirs, flumes, or other measuring devices to provide for monitoring of seepage through the embankment or foundation, installed in a manner

acceptable to the State Engineer. Positive drainage away from all seepage monitoring devices shall be provided to prevent the device from becoming submerged.

7.7.2.3.3 ~~5.5.3.3~~ Station markers at least every 100 feet along the crest of the dam.

7.7.2.3.4 ~~5.5.3.4~~ Piezometers to allow monitoring of the phreatic surface within the dam or uplift pressures within the foundation, installed in accordance with industry standards and in a manner acceptable to the State Engineer. A Subsurface Investigation Plan shall be submitted for approval by the State Engineer pursuant to Rule 7.3.3 prior to new piezometer construction.

7.7.2.3.5 ~~5.5.3.6~~ Where drainage galleries are provided for concrete dams, seepage measuring devices shall be provided at the appropriate locations and be accessible for making the necessary readings.

7.7.2.4 ~~5.5.4~~ **Low Hazard Dams**. Low Hazard dams shall have weirs, flumes or other measuring devices to provide for monitoring and measurement of seepage through the embankment or foundation, installed in a manner acceptable to the State Engineer.

7.8 ~~5.9.6~~ Spillway and Outlet Works Design Requirements.

7.8.1 ~~5.9.6.1~~ **Spillway Design**. All spillways shall be designed and constructed in a manner acceptable to the State Engineer and meet the following criteria.

7.8.1.1 The starting water surface elevation when routing the IDF shall be the emergency spillway crest.

7.8.1.2 ~~5.9.6.1.1~~ The spillway shall safely route the IDF back to the natural channel or drainage way that would exist if the dam were not built. The Owner shall possess title to the property, a right-of-way, or easement from the high water line in the reservoir to the natural channel, including the stilling basin downstream.

7.8.1.3 ~~5.9.6.1.2~~ Log booms or other methods approved by the State Engineer shall be installed in the spillway approach where logs and other debris may block spillway flow or damage the spillway structure.

7.8.1.4 ~~5.9.6.1.3~~ Pipe emergency spillways are not acceptable.

7.8.1.5 ~~5.9.6.1.4~~ The design report shall include discharge tables (in cubic feet per second) for all spillways showing the discharge for each foot of head between the crest of the spillways and dam. The equation(s) used for determining the discharge shall also be included. Crest elevations of all spillways and the dam shall be clearly noted on the tables.

7.8.1.6 Design of stilling basins for RCC stepped chute spillways shall include assumptions, calculations, and applicable references for estimating energy dissipation and stilling basin entrance velocities.

7.8.1.7 ~~5.9.5.6~~ **Overtopping Protection Design**. Overtopping protection for existing embankment dams may be used to safely route the IDF only where no other alternatives are feasible. The design of overtopping protection shall be based on the principles provided in *Overtopping Protection for Dams* (P-1015, FEMA, 2014).

7.8.1.7.1 ~~5.9.5.6.3, 5.9.5.6.4, 5.9.5.6.5~~ Soil-cement shall not be used for emergency spillway or embankment overtopping protection.

7.8.2 ~~5.9.6.2~~ **Outlet Works Design.** All outlet systems shall be designed and installed in a manner acceptable to the State Engineer and shall meet the following criteria.

7.8.2.1 ~~5.9.6.2.1~~ Outlets shall be capable of releasing the top five feet of the reservoir capacity in five (5) days. Final outlet size should reflect consideration of seasonal reservoir inflows and consequences of releases or dam failure. The outlet shall be capable of releasing the entire reservoir in a reasonable period of time. In addition, outlets shall be capable of passing inflow to the reservoir with a minimum of ten feet of head, in order to meet the demands of downstream senior water rights and the Owner's release requirements. The minimum size required for outlet conduits and controls is 12 inches.

7.8.2.2 ~~5.9.6.2.2~~ All outlets connected to a pipeline shall have a bypass valve near the dam that will meet the capacity criteria as defined in Rule 7.8.2.1.

7.8.2.3 ~~5.9.6.2.3~~ Outlet conduits for all dams, except for dams with ungated outlets, shall have a guard gate installed at the upstream end of the conduit.

7.8.2.4 ~~5.9.6.2.4~~ Intake structures for outlet works shall have trash racks.

7.8.2.5 ~~5.9.6.2.5~~ The Design Report shall include an outlet discharge table (in cubic feet per second) showing the discharge for each foot of head between the invert of the intake structure and the crest of the dam. The equation(s) used for determining the discharge shall also be included. Elevations of all outlets and spillways shall be clearly noted on the table.

7.9 ~~5.10~~ Reservoir and Site Requirements.

7.9.1 ~~5.10.1.1~~ The area to be submerged by the new or enlarged reservoir shall be cleared of trees and debris.

7.9.2 ~~5.10.1.3~~ Site access roads shall be designed with appropriate grades and surfacing to provide a stable base that resists rutting and provides adequate traction for safety in wet conditions. The dam crest and appurtenant structures shall be accessible by equipment and vehicles for emergency operations and maintenance in all weather conditions.

7.9.3 The Owner shall demonstrate ownership or recorded easement for the following:

7.9.3.1 ~~5.10.1.4~~ Footprint of the dam, appurtenant structures, and permanent access for a minimum distance of 50 feet or the height of the dam, whichever is greater, extending downstream from the toe of the dam.

7.9.3.2 ~~5.10.1.7~~ Spillway discharge channels meeting the requirements of Rule 7.8.1.2.

7.9.3.3 ~~5.10.1.6~~ All areas inundated by the reservoir and IDF surcharge.

7.9.4 ~~5.10.1.5~~ Pipelines, utility lines, or any other construction that penetrates through dam, abutment areas below the dam crest elevation, or that are within a distance of 50 feet or the

height of the dam, whichever is greater, from either toe of the dam shall not be allowed without prior written approval by the State Engineer.

Rule 8. ~~5.9~~ Construction Requirements

8.1 Pre-Construction.

8.1.1 ~~5.10.2~~ Water Diversion Plan.

8.1.1.1 ~~5.10.2.1~~ A plan to control surface water during construction shall be developed by the construction contractor based on information and requirements provided by the Engineer. The plan shall state the return interval or annual exceedance probability for the storm event the system is designed to protect against. The plan shall be prepared under the direction of an Engineer meeting the requirements of Rule 4.10.

8.1.1.2 ~~5.10.2.4~~ The plan shall be approved by the Engineer and submitted to the State Engineer in advance of construction of the diversion facilities.

8.1.1.3 A hazard classification evaluation shall be performed by the contractor's engineer based on consequences to the public for any proposed cofferdam. If the water diversion system is found to be High or Significant Hazard, the design shall meet the requirements of Rule 7.

8.1.1.4 ~~5.10.2.5.4~~ The water diversion plan shall address the removal or abandonment of cofferdams, spillways, conduits, or other temporary features after construction is complete.

8.1.2 ~~9.1.1~~ **Construction Observation Plan**. Not less than thirty (30) days prior to construction, the Engineer shall submit a construction observation plan to the State Engineer. The construction observation plan shall include, as a minimum:

A. ~~9.1.1.1~~ The anticipated date of the start of construction;
B. ~~9.1.1.2~~ Names and resumes of the Engineer and staff to be used on the project;
C. ~~9.1.1.3~~ A construction observation schedule for the Engineer and staff;
D. ~~9.1.1.4~~ For dams on rock foundations, a schedule for observations of the foundation by a Geologist;
E. ~~9.1.1.6~~ Identification of the firm and qualifications of the personnel that will conduct the construction material tests in the field and in the laboratory; and
F. ~~9.1.1.7~~ A schedule of the construction material tests.

8.1.2.1 ~~9.1.2~~ **Approval.** Within fourteen (14) days of receipt, the State Engineer shall provide written comments and approval, or conditions for approval, of the construction observation plan. Construction shall not commence without approval of the observation plan by the State Engineer.

8.1.3 ~~9.1.3~~ **Pre-Construction Meeting**. Prior to commencement of construction, a meeting shall be held between the Engineer, Owner, State Engineer, and contractor. The State Engineer shall be notified at least fourteen (14) days prior to the meeting. The contractor shall present and thoroughly explain its construction work plan along with any anticipated construction difficulties. The name of the subcontractors shall be furnished to the State Engineer at the meeting. Project communication protocol between the Owner, Engineer, and the State Engineer shall be established at the pre-construction meeting.

8.2 ~~9.0~~ Construction.

8.2.1 ~~9.1.4~~ Engineer's Observation.

The Engineer shall observe the progress and quality of the construction in accordance with the approved construction observation plan. The Engineer shall endeavor to prevent defects and deficiencies in the construction of the dam and appurtenant structures, and shall disapprove or reject work failing to conform to the approved plans and specifications. In cases where the Engineer has a contractual relationship with the contractor to provide engineering services, the Owner shall provide an independent, third-party engineer to perform the engineering quality assurance observations.

8.2.2 ~~9.1.5~~ Construction Records.

The Engineer shall maintain a record of construction that, as a minimum, shall include daily activity and progress reports, change orders, all materials testing results, gate and valve installation certifications, photographs sufficient to provide a record of foundation conditions and various stages of the construction through completion, all geologic information obtained, and documentation of any construction problems and remedies.

8.2.3 ~~9.1.6~~ Progress Reports.

Progress reports summarizing the status of the work shall be submitted to the State Engineer during the project at a minimum frequency and in a format agreed upon during the pre-construction meeting. The progress report shall include the contractor's three week look-ahead schedule.

8.2.4 ~~9.1.7~~ Notice for Inspection.

The Engineer shall give the State Engineer at least five (5) days advance notice of any work items listed by the State Engineer in the pre-construction meeting, to allow for observation by the State Engineer.

8.2.5 ~~9.1.8~~ Change Order.

When unforeseen site conditions or material availability require that the construction work differ significantly from the approved plans and specifications, a change order, including details, shall be provided by the Engineer to the State Engineer. No change shall be executed until approved by the State Engineer. Major changes shall be submitted in writing with supporting documentation, and approved in writing by the State Engineer. Minor changes, as determined by the State Engineer, may be approved verbally and documented in the final construction documents.

8.2.6 ~~9.1.9~~ Final Inspection.

The Engineer shall give the State Engineer at least fourteen (14) days advance notice prior to the project's final construction inspection. The Engineer shall document the completion of any punch list items.

8.3 ~~10.1~~ Acceptance of Construction.

Construction shall not be deemed complete nor shall storage of water be permitted until the State Engineer furnishes to the Owner a written statement of acceptance. The acceptance shall state the as-constructed dam dimensions, the capacity of the reservoir, and any limitations upon or requirements for the use of the dam. The State Engineer shall furnish the acceptance or denial within sixty (60) days of receipt of construction completion documents as outlined below.

8.3.1 ~~10.2~~ Construction Completion Documents.

The Engineer shall provide the following construction documentation within sixty (60) days of the final construction inspection:

8.3.1.1 ~~10.2.1~~

A written notification that the project is complete and in general conforms with the approved plans, specifications, and change orders.

8.3.1.2 ~~10.2.5~~

A schedule for the first filling of the reservoir specifying fill rates, water level elevations to be held for observation, and a schedule for inspecting and monitoring the dam.

8.3.1.3 ~~10.2.2~~ As-constructed plans showing the original approved plans amended to include any major or minor changes.

8.3.1.4 ~~10.2.3~~ A final construction report summarizing construction, problems encountered and solutions implemented to resolve the problems, and compiling the construction records as identified in Rule 8.2.2.

8.3.1.5 ~~10.2.4~~ A record of the location of permanent monuments and instrumentation as well as installation details and initial surveys and readings, if applicable.

8.3.1.6 ~~10.2.6~~ The approved dam observation and monitoring plan in accordance with Rule 13.4.

8.3.1.7 ~~10.2.8~~ A new or updated Emergency Action Plan including current inundation map in accordance with Rule 13.6.

8.3.2 ~~10.3~~ For new dams and enlargements, the Engineer shall provide periodic review of the data included in the dam observation and monitoring plan on at least an annual basis for the first five years following construction completion. The Engineer shall submit the data and a written assessment of the dam's performance to the State Engineer annually.

8.3.3 ~~10.4~~ **Temporary Approval**. Upon written request by the Owner and for good cause shown, the State Engineer may temporarily approve storage of water prior to submitting the construction completion documents. Only a partial reservoir filling will be granted under this Rule. Final acceptance of the construction for full use of the reservoir will not be granted until the requirements of Rule 8.3 have been satisfactorily completed. The written request shall include, as a minimum:

A. A schedule for compliance with Rule 8.3;
B. A notification letter signed and sealed by the Engineer in accordance with Rule 8.3.1.1;
C. A schedule for the first filling of reservoir in accordance Rule 8.3.1.2;
D. A monitoring plan for observing the behavior of the dam and appurtenances during the initial filling or refilling of the reservoir; and
E. A new or updated EAP prepared in accordance with Rule 13.6.

Rule 9. ~~Rule 7.~~ Requirements for Removing or Breaching an Existing Dam

9.1 ~~7.1~~ **Breach Plan and Application**. An Owner proposing to permanently remove or breach a dam shall submit an application package to be approved by the State Engineer prior to commencing work. The application shall be completed on a form provided by the State Engineer and shall include the following:

9.1.1 ~~7.1.2.1~~ Documentation demonstrating that notice has been given to land owners and agencies potentially impacted by removal or breach of the dam.

9.1.2 ~~7.1.2.2A.~~ Documentation showing that all permitting requirements by local, state and federal agencies have been satisfied.

9.1.3 A breach plan meeting the following requirements:

9.1.3.1 ~~7.1.2.3~~ The breach shall be designed to prevent silt previously deposited in the reservoir and material excavated for the breach from washing downstream.

9.1.3.2 ~~7.1.2.4~~ Water impounded in the reservoir area shall be released in a controlled manner that will not endanger lives or damage downstream properties.

9.1.3.3 ~~7.1.3.1~~ The minimum bottom width of the breach shall be one-half the height of the dam or 10 feet, whichever is greater.

9.1.3.4 ~~7.1.2.5~~ The sides of the breach shall be excavated to a slope that is stable, but not steeper than 2H:1V (horizontal:vertical). A slope stability analysis that demonstrates an adequate factor of safety for slopes steeper than 2H:1V may be accepted by the State Engineer. The breach dimensions shall meet water administration requirements of the Division Engineer. The dam shall be excavated down to the level of the natural ground at the maximum section, or as necessary to comply with Rule 9.1.3.

9.1.3.5 ~~7.1.3.6~~ The excavated material shall not be placed in the stream channel.

9.1.3.6 ~~7.1.2~~ **High and Significant Hazard Dams**. The breach plan for High and Significant Hazard dams shall meet the following additional requirements.

9.1.3.6.1 The plan shall be prepared by an Engineer.

9.1.3.6.2 ~~7.1.2.1A~~ The breach shall be of sufficient width to pass the twenty four (24) hour, one percent AEP flood with a maximum increase in reservoir depth of five (5) feet. However, the maximum breach width shall not be required to exceed the width of the original natural channel before the dam was constructed, regardless of the one percent AEP flood.

9.1.3.6.3 ~~7.1.2.1B~~ Breach side slope and channel protection may be required to prevent erosion and provide long term stability.

9.1.3.6.4 ~~7.1.2.1C~~ Remaining infrastructure shall be left in a safe condition.

9.1.3.6.5 ~~7.1.2.5~~ Construction plans shall meet the requirements of Rule 6 that are applicable to support the scope of work as described on the application.

9.1.3.6.6 ~~7.1.2.6~~ The dewatering and removal or breaching of the dam shall be overseen by an Engineer.

9.1.3.6.7 ~~7.1.2.7~~ A written notification that the project is complete and in general conformance with the approved breach plan shall be provided within sixty (60) days of completion of construction. The State Engineer will provide acceptance upon review and receipt of these documents.

Rule 10. ~~Rule 11.~~ Construction, Modification, Alteration, Repair, and Breach of Non-Jurisdictional Size Dams

10.1 ~~11.1~~ **Notice of Construction.** Any person intending to construct a non-jurisdictional size dam other than a Livestock Water Tank or Erosion Control Dam, shall submit notice of the intent to construct the dam on forms provided by the State Engineer not less than forty five (45) days prior to

the proposed construction. The State Engineer shall determine the potential hazard for loss of life or significant damage due to failure of the structure, and if the submittal and approval of plans and specifications is required prior to construction. The forms shall be submitted to the Division Engineer of the Water Division in which the dam is to be located. The Division Engineer shall respond to the Owner within forty five (45) days after receipt of the complete notice of intent to construct form. All Owners shall be required to comply with the applicable dam safety and water administration requirements.

10.2 ~~11.2~~ **Modification or Alteration of Non-Jurisdictional Size Dams.** Jurisdictional size dams proposed to be modified or altered to non-jurisdictional size shall comply with the following requirements:

10.2.1 ~~11.2.1~~ For High or Significant Hazard dams, the Owner shall submit plans for approval in accordance with Rule 6. As-constructed documents are required in conformance with Rule 8.3.1.

10.2.2 ~~11.2.2, 11.2.3~~ For Low Hazard or NPH dams, the Owner shall submit written notice of the intent to alter the dam to the State Engineer. The Owner shall submit written notice of the completion of the project.

10.3 ~~11.3~~ **Repair or Breaching of Non-Jurisdictional Dams.** Repair or breaching of existing non-jurisdictional size dams shall meet the following requirements.

10.3.1 ~~11.3.1~~ In cases where a non-jurisdictional dam has been found unsafe, the Owner shall submit written notice to the State Engineer to repair, modify, breach or entirely remove the dam prior to construction.

10.3.2 Removal or breaching of a non-jurisdictional dam shall comply with Rule 9.

10.3.3 ~~11.3.2~~ Modifications to, or repair of, High or Significant Hazard non-jurisdictional size dams shall be performed in accordance with Rule 6.

10.4 ~~11.4~~ **Spillway Requirements.** Spillway sizing requirements shall meet the criteria for the appropriate hazard classification.

10.5 ~~11.5~~ **Enlargement of Non-Jurisdictional Size Dams.** The modification of a non-jurisdictional size dam to a jurisdictional size dam shall meet the requirements of Rule 6.

Rule 11. ~~Rule 12.~~ General Maintenance, Ordinary Repairs, and Emergency Actions

11.1 ~~12.1~~ General maintenance and ordinary repairs that do not require prior approval of the State Engineer include those activities that do not impair the safety of the dam. When questions arise concerning this Rule, the determination of general maintenance and ordinary repair will be made by the State Engineer. General maintenance and ordinary repair activities include the following:

11.1.1 ~~12.1.1~~ Removal of brush or tall weeds.

11.1.2 ~~12.1.2~~ Cutting of trees with trunk diameter less than 6-inches and removing slash from the embankment or spillway.

11.1.3 ~~12.1.3~~ Rodent control, removal or extermination and repair of minor rodent damage. Damage that has already weakened the dam shall be repaired in accordance with Rule 6.

11.1.4 ~~12.1.4~~ Repair of erosion gullies on the embankment or in the spillway. Large gullies that have already weakened the dam shall be repaired in accordance with Rule 6.

11.1.5 ~~12.1.5~~ Surface grading of the embankment crest or spillway to eliminate potholes and provide proper drainage with properly compacted material, provided that the freeboard is not reduced. Placement of material in excess of 1 foot in depth to provide freeboard is not considered general maintenance and shall be performed in accordance with Rule 6.

11.1.6 ~~12.1.6~~ Placement of additional riprap and bedding on the upstream slope, or in areas of the spillway that have sustained minor damage. Such placement shall be limited to restoring the original riprap protection. Repair of the underlying embankment is not considered general maintenance and shall be performed in accordance with Rule 6.

11.1.7 ~~12.1.7~~ Painting or caulking metal structures, or lubricating mechanical equipment.

11.1.8 ~~12.1.8~~ Patching, sealing, or caulking spalled or cracked concrete surfaces to prevent deterioration.

11.1.9 ~~12.1.9~~ Removing debris, rock, or earth from outlet conduits, outlet channels, or spillway channels.

11.1.10 ~~12.1.10~~ Patching or sealing surface damage to prevent further deterioration within outlet conduits.

11.1.11 ~~12.1.11~~ Replacement of worn or damaged parts of outlet valves or controls to restore to original condition.

11.1.12 ~~12.1.12~~ Repair or replacement of fences intended to keep traffic or livestock off the dam or spillway.

11.1.13 ~~12.1.13~~ Landscaping of new and existing dams and spillway channels is not general maintenance and will not be allowed without the prior approval of the State Engineer. No trees or large vegetation shall be planted within 25 feet of the footprint of the dam.

11.2 ~~12.3~~ **Emergency Action.** Emergency actions not impairing the safety of the dam may be taken before consultation and guidance can be provided by an Engineer, and do not require prior approval of the State Engineer. Emergency actions are interim solutions only and may not serve as a permanent solution to the problem(s) being addressed. Additional remedial actions may be required after the emergency passes. Emergency actions may include:

A. ~~12.3.1~~ Stockpiling materials such as riprap, earthfill, sand, sandbags, and plastic sheeting;
B. ~~12.3.2~~ Lowering the reservoir level by making controlled releases through the outlet or a gated spillway, by pumping, or by siphoning. Where large releases are to be made, the Division Engineer shall be notified;
C. ~~12.3.3~~ Armoring eroding areas by placing sandbags, riprap, plastic sheeting, or other available material;
D. ~~12.3.4~~ Plugging leakage entrances on the upstream slope;

E. ~~12.3.5~~ Increasing freeboard by placing sandbags or temporary earthfill on the dam;

F. ~~12.3.6~~ Diverting flood waters around the reservoir or closing inflow diversions;

G. ~~12.3.7~~ Constructing training berms to control flood waters;

H. ~~12.3.8~~ Placing sandbag ring dikes around boils at the downstream toe to provide back pressure; and/or

I. ~~12.3.9~~ Removing obstructions from outlet or spillway flow areas.

11.3 ~~12.4~~ **Emergency Excavation.** Lowering the water level by excavating the spillway or embankment is prohibited unless failure of the dam is imminent.

11.4 ~~12.5~~ **Emergency Notification.** The State Engineer shall be notified as soon as reasonably possible of any emergency condition that exists and any emergency action taken with or without prior approval of the State Engineer.

11.5 ~~12.6~~ **Emergency Action Plan.** For all High and Significant Hazard dams, the Emergency Action Plan shall be implemented in conjunction with any emergency actions taken.

Rule 12. ~~Rule 14.~~ Safety Inspections Performed by the Owner's Engineer

12.1 ~~14.1~~ **Owner Safety Inspection.** An Owner may provide a safety inspection report to the State Engineer recommending the safe storage level of a reservoir. The State Engineer may utilize the Owner's safety inspection report in lieu of a State Engineer safety inspection if the inspection is performed, and the report written, by an Engineer meeting the requirements of Rule 4.10. The Owner's Engineer shall notify the State Engineer at least fourteen (14) days prior to the scheduled safety inspection. Inspections shall be conducted in accordance with current State Engineer policies and these Rules.

12.2 ~~14.3~~ **Scope of Inspection.** Dam safety inspections by the Owner's Engineer shall meet the requirements of Rule 4.31. The Engineer shall prepare an inspection report that describes the findings and lists actions the Owner must take to improve the safety of the dam to an acceptable level. The report shall provide the information necessary to allow the State Engineer to make a determination of the safe storage level of the reservoir.

12.3 **State Engineer Acceptance.** The report will be reviewed by the State Engineer prior to acceptance. If the report and findings are accepted, the State Engineer will provide the Owner with a list of required actions and will notify the Owner of the safe storage level.

Rule 13. ~~Rule 15.~~ Owner's Responsibilities

13.1 **Liability**. The sole responsibility for the safety of the dam rests with the Owner and operator, who should take every step necessary to prevent damages caused by leakage or overflow of waters from the reservoir or floods resulting from a failure of the dam. Therefore, it is in the Owner's best interest to operate and maintain the facility in a manner such that the safety of the dam and the general public are not jeopardized.

13.2 ~~15.6~~ **Change in Ownership.** Changes in ownership of a dam shall be immediately filed with the State Engineer.

13.3 **Site Security**. The Owner shall maintain reasonable security measures to prevent intentional misoperation and damage to the facility.

13.4 **Dam Observation and Monitoring Plans**. All dams shall have an observation and monitoring plan that shall include the following minimum requirements:

13.4.1 ~~15.2~~ **Owner Observations.** The Owner is responsible for ensuring frequent observation of the dam, especially at times when the reservoir is full, during heavy rains or flooding, and following an earthquake. The observations shall be conducted in accordance with methods acceptable to the State Engineer. Conditions which threaten the safety of the dam shall be reported to the State Engineer immediately.

13.4.1.1 High and Significant Hazard dams shall be observed at least twice a month when the reservoir water level is greater than half the full storage capacity. High Hazard dams that are seasonally inaccessible shall be provided with remote reservoir level monitoring at a minimum.

13.4.1.2 Low Hazard dams shall be observed at least once every three months.

13.4.1.3 For all dams, routine outlet observations shall include observation of exposed surfaces of the inlet and discharge structures, control valves, gates and vaults; observation of the downstream end of the conduit and adjacent embankment for leakage; and observation of the dam (upstream slope, crest, downstream slope, and natural ground) in the vicinity of the outlet alignment for signs of distress or changed conditions.

13.4.2 ~~15.3~~ **Monitoring Instrumentation.** The Owner is responsible for installing, maintaining, and monitoring the instrumentation required to adequately monitor the performance of the dam. The instrumentation shall be monitored at a frequency detailed in the approved observation and monitoring plan.

13.4.2.1 Monument surveys accurate to 0.01 foot are required annually for five years (including the year of installation of the monuments) on new and recently enlarged dams, and then once every five years thereafter. Monitoring of movement monuments for Significant Hazard dams is not required beyond the first five years unless otherwise deemed necessary by the State Engineer. The State Engineer may also approve other methods for monitoring movement monuments on the dam and may require monitoring at any frequency deemed necessary based upon review of inspection data and past measurement results.

13.4.2.2 ~~15.3.3~~ The Owner is responsible for ensuring that all instrumentation data is properly recorded in an acceptable format and sent to the State Engineer annually. The State Engineer may require that instrumentation data for High and Significant Hazard dams be evaluated by the Owner's Engineer and the analysis sent to the State Engineer annually, unless more frequent reporting is required.

13.4.2.3 ~~15.3.4~~ The Owner shall promptly notify the State Engineer of any abnormal changes in the instrumentation data, as compared to historical patterns and trends.

13.4.3 **Outlet Operation**. The Owner shall maintain the outlet works in an operable condition.

13.4.4 ~~15.1~~ **Outlet Inspections.** The requirements of outlet inspections are as follows:

13.4.4.1 **Outlet Exercise**. An annual test of the outlet gate(s) and valve(s) for proper operation is required. The Owner shall notify all potentially impacted parties prior to exercising the outlet gate in cases where sediment release, water quality, or downstream flooding is a concern.

13.4.4.2 ~~15.1.1~~ **Outlet Inspection Access**. Outlet structures for all dams will be observed during safety inspections. Owners shall provide safe access for inspection of outlet facilities.

13.4.4.3 ~~15.1.2~~ **Internal Outlet Inspections**. Internal outlet inspections shall consist of a close inspection of the interior of the conduits, outlet wells, and access ways. In cases where it is unsafe or not possible for a person to enter, the Owner shall provide for an inspection using video or other remote sensing equipment capable of detecting flaws or imperfections within the conduit. An Engineer shall oversee the inspection and provide a written report of inspection findings to the State Engineer. The State Engineer shall coordinate with the Owner and make all reasonable efforts to minimize expense and waste of water while ensuring dam safety.

13.4.4.3.1 ~~15.1.2.1~~ High and Significant Hazard dams shall receive an internal outlet inspection at least once every ten (10) years unless the condition indicates that more frequent inspections are necessary. An inspection of the entire outlet conduit shall only be required on dams without upstream gates if ordered by the State Engineer.

13.4.4.3.2 ~~15.1.2.2~~ Low Hazard and NPH dams shall receive an internal outlet inspection when required by the State Engineer to determine the safe storage level.

13.4.4.3.3 ~~15.1.3~~ The Owner shall inform the State Engineer any time the water level in a dam without upstream gates on the outlet conduit will be lowered to the invert of the conduit, or the normally inundated conduit will be otherwise dewatered and available for inspection.

13.5 ~~15.4~~ **Responsibility for Maintenance.** The Owner is responsible for adequate and timely maintenance of the dam. The Owner shall establish a maintenance plan to ensure that the maintenance, as identified in Rule 11, is accomplished.

13.6 ~~Rule 16.~~ **Emergency Preparedness.** Owners shall be prepared to take emergency actions to prevent unusual or emergency situations at their dams from escalating to dam failure. To the extent possible, Owners shall also make preparations to reduce the consequences of potentially dangerous reservoir releases when such is unavoidable or necessary.

13.6.1 ~~16.1~~ **Emergency Action Plans (EAP).** An EAP shall be developed and distributed by the Owner for all High and Significant Hazard dams. The EAP shall contain the following information, at a minimum.

13.6.1.1 **Essential Dam Information.** This section shall include a description of ownership and operations personnel (dam tenders/caretakers), the dam location including a vicinity map and site map, and the characteristics of the dam and appurtenant structures.

13.6.1.2 **Event Level Determination and Expected Actions.** This section shall include a description of the emergency level classifications and the expected actions of each of the agencies included in the emergency response team for each of the event levels. The following emergency level classifications shall be included, as a minimum:

A. ~~16.1.2.1~~ High flow below dam – Non-failure,
B. ~~16.1.2.2~~ Unusual condition at dam – Non-failure,
C. ~~16.1.2.3~~ Potential Dam Failure - Immediate action required, and
D. ~~16.1.2.4~~ Evacuation Required - Dam failure in progress or unavoidable.

13.6.1.3 ~~16.1.3~~ **Notifications**. This section shall include a list of all members of the emergency response team. The appropriate individuals from each agency on the emergency response team shall be identified and included as well as at least one backup individual. The notification list shall include representatives from each of the following agencies/entities, as a minimum:

A. Dam Owner,
B. Local Communications Dispatch Center,
C. Local Sheriff's Office,
D. Local Emergency Managers. (County, City),
E. State Division of Homeland Security and Emergency Management (DHSEM),
F. Colorado Department of Transportation (CDOT),
G. Colorado State Patrol (CSP),
H. Colorado Department of Public Safety (CDPS),
I. Division of Water Resources (DWR), and
J. National Weather Service (NWS).

13.6.1.4 ~~16.1.3~~ **Communication**. This section shall include a description of how communication with each of the agencies on the emergency response team shall be made when the EAP is activated at any of the emergency response levels described.

13.6.1.5 ~~16.1.5~~ **Locally Available Resources**. This section shall identify locally available or pre-positioned equipment, manpower and materials to be used to prevent incident escalation and when possible, prevent the dam from failing. Resources typically identified in this section include:

A. Heavy equipment contractors;
B. Rental equipment suppliers for pumps and heavy equipment;
C. Material suppliers for sand and gravel, concrete, sand bags, plastic sheeting; and
D. Diving Contractors.

13.6.1.6 ~~16.1.6.5~~ **Evacuation Information**. This section shall present information provided to aid the emergency response team with the evacuation of the inundation zone below the dam. The following information shall be included, as a minimum.

13.6.1.6.1 ~~16.1.6.2~~ **Inundation Mapping**. Dam failure inundation maps shall be provided for High and Significant Hazard dams. Inundation maps shall be provided in electronic PDF and GIS shape file formats. Inundation maps shall include the following information, as a minimum:

A. Lateral limits of the dam breach flood extending downstream from the dam to a location where the potential for loss of life and significant property damage no longer exist; and
B. Cross sections at critical locations along the flood path showing lateral extents of flooding, depth of flooding, arrival time of the initial and peak flood wave (from the start of the dam breach), and flood wave velocity.

13.6.1.6.2 ~~16.1.6.1~~ **Critical Infrastructure List**. From examination and study of the inundation maps and consultation with local entities, a listing of critical infrastructure shall be developed and provided to aid an efficient emergency evacuation. The critical infrastructure list shall generally contain inhabited structures and infrastructure located in

close proximity to the dam. These structures require special consideration due to limited notification time or complicated evacuation circumstances. Structures described in the critical infrastructure list shall include, as a minimum:

A. Population centers,
B. Roadways,
C. Schools,
D. Hospitals,
E. Police and fire stations, and
F. Utilities (water, sewer, gas electric providers).

13.6.1.6.3 ~~16.1.5.3~~ **Spillway and Outlet works discharge rating tables/curves**. Spillway and outlet discharge rating curves and tables shall be provided to aid emergency response for the high flow conditions EAP activation level.

13.6.2 ~~16.1.6~~ **Termination**. The responsibilities for termination of an EAP activation shall be described.

13.6.3 ~~16.3~~ **EAP Distribution.** The Owner shall submit an electronic copy of the EAP to all members of the emergency response team as shown on the notification list.

13.6.4 ~~16.4~~ **EAP Updates.** The Owner shall review the EAP annually and update as necessary and appropriate. EAP updates shall be included in a single PDF containing the complete EAP and distributed electronically to all emergency response team members shown on the notification list.

13.6.5 ~~16.5~~ **EAP Testing.** The Owner shall test the EAP periodically to ensure the effectiveness of the EAP. The contact information shown in the notification list shall be reviewed annually to ensure it is up to date, and to obtain information for revisions or corrections as necessary.

Rule 14. ~~Rule 17.~~ Exempt Structures

14.1 ~~17.1~~ **Exempt Structures.** See section 37-87-114.5, C.R.S., with the following clarifications:

14.1.1 ~~17.1.1~~ Highways, road-fills, and railroad embankments with ungated culverts are exempt.

14.1.2 ~~17.1.4~~ Structures that store water only below the lowest point of the natural ground are exempt from these Rules, unless an outlet works is constructed to release water.

14.2 ~~17.4~~ **Livestock Water Tanks.** Livestock Water Tanks as defined in the Livestock Water Tank Act of Colorado, Title 35, Article 49, C.R.S. are exempt from these Rules.

14.3 ~~17.5~~ **Erosion Control Dams.** Erosion Control Dams, as defined in section 37-87-122, C.R.S., are exempt from these Rules.

14.4 Dams or other water impounding structures regulated by other State agencies (e.g. COGCC, CDPHE, DRMS, etc.) may be exempt from these Rules to avoid dual regulation. The State Engineer may provide technical consultation as necessary for the permitting of such structures.

Rule 15. ~~Rule 18.~~ Restriction of Recreational Facilities within Reservoirs

15.1 ~~18.1~~ No person, including any state or federal agency, quasi-municipal corporation, or political subdivision, shall construct any permanent recreational structure within a reservoir below the elevation of the crest of the spillway unless all of the following apply:

A. ~~18.1.1, 18.1.2~~ The facility is constructed to withstand partial or complete inundation with minimal or no damage,

B. The facility is necessary to the operation of the reservoir, and

C. ~~18.1.3~~ The facility is capable of being restored with a minimum amount of cleaning or expense.

15.2 **Notice**. Any person planning to construct, enlarge, or modify any facility under this Rule shall provide written notice to the State Engineer at least one hundred eighty (180) days in advance of construction. State Engineer approval shall be obtained prior to construction.

15.3 **Exemptions.** Exemptions to this Rule include the following:

A. Boat ramps;

B. Docks;

C. Marinas; and

D. Facilities completed prior to July 1, 1984, excluding subsequent enlargements or modifications to such facilities.

Rule 16. ~~Rule 19.~~ Waiver or Delay of Enforcement of Rules by the State Engineer

The State Engineer may waive or delay the enforcement of any of the responsibilities of Owners under the foregoing Rules if, in the State Engineer's judgment, dam safety will not be reasonably impaired and the circumstances of the individual case so warrant. The State Engineer's decision will take into account the benefits that would be realized by full enforcement, the cost or difficulty of complete compliance, the Owner's good faith efforts to comply, the expected remaining life of the structure, and the impacts to beneficial use of water in Colorado.

Rule 17. ~~Rule 20.~~ Appeal of Requirements or Approval

The applicant or any other person affected or aggrieved by the State Engineer's approval or disapproval of plans and specifications for construction of a reservoir/dam, or the alteration, modification, repair or enlargement of a reservoir or dam which will affect the safety of the structure may request an adjudicatory hearing before the State Engineer pursuant to Rule 10 of the Division of Water Resources' Procedural Regulations, 2 CCR 402-5. All adjudicatory hearings will be conducted pursuant to the requirements of the Division of Water Resources' Procedural Regulations and the State Administrative Procedures Act, section 24-4-105, C.R.S.

Rule 18. ~~Rule 21.~~ Rules by Reference

Certified copies of the complete text of the materials incorporated by reference in these Rules shall be maintained by the Office of the State Engineer and State Publications Depository and Distribution Center, and shall be available for public inspection during business hours. The title and address of the Office of the State Engineer is: 1313 Sherman Street, Room 818, Denver, CO 80203.

Rule 19. ~~Rule 22.~~ Severability

If any portion of these Rules and Regulations for Dam Safety and Dam Construction is found to be invalid, the remaining portion of the Rules shall remain in force.

Rule 20. ~~Rule 23.~~ Revision

The State Engineer may revise these Rules and Regulations for Dam Safety and Dam Construction in accordance with section 24-4-103, C.R.S. Such revisions may be the result of new data or technology, or the submittal of a petition by an interested person pursuant to section 24-4-103 (7), C.R.S. and 2 C.C.R. 402-5 Rule 7.B.2.

Rule 21. ~~Rule 24.~~ Statement of Basis and Purpose Incorporated by Reference

The Statement of Basis and Purpose for the adoption of these Rules and Regulations for Dam Safety and Dam Construction is incorporated by reference as part of these Rules.

Rule 22. ~~Rule 25.~~ Effective Date

These Rules shall become effective on TBD.