DEPARTMENT OF NATURAL RESOURCES

Division of Water Resources

OFFICE OF THE STATE ENGINEER RULES AND REGULATIONS FOR DAM SAFETY AND DAM CONSTRUCTION

2 CCR 402-1

[Editor's Notes follow the text of the rules at the end of this CCR Document.]

Rule 1. Title:

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:

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

Rule 3. Scope and Purpose:

3.1 These Rules apply to any dam constructed or used to store water in Colorado. These Rules apply to applications for review and approval of plans for the construction, alteration, modification, repair, enlargement, and removal of dams and reservoirs, quality assurance of construction, acceptance of construction, non-jurisdictional dams, safety inspections, owner responsibilities, emergency action plans, fees, and restriction of recreational facilities within reservoirs. Certain structures defined in Rule 17 are exempt from these Rules.

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

Rule 4. Definitions:

4.1 **Statutory Definitions -** The terms are defined in section 37-87-102, C.R.S., 37-87-122 C.R.S. and 35-49-103 C.R.S. and shall have the identical meanings when used in these Rules.

4.2 **Specific Definitions -** Unless expressly stated otherwise, the following terms when used in these Rules shall have the meaning indicated by this Rule. Words in the singular shall include the plural. Words in the masculine gender include the feminine and neuter.

4.2.1 **"Alteration, Modification, or Repair of an Existing Dam and Appurtenant Structures"** means to make different from the originally approved construction plans and specifications or the existing configuration, except for ordinary repairs and general maintenance as defined in Rule 12.

4.2.2 **"Appurtenant Structure"** means components 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.

4.2.3 **"Breach Order"** is 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.

4.2.4 **"Capacity"** is the volume of water a reservoir is capable of impounding at the high-water line, expressed in acre-feet. Dead storage below the natural surface of the ground or low-level outlet is generally excluded.

4.2.5 **"Dam"** means a man-made barrier, together with appurtenant structures, constructed above the natural surface of the ground for the purpose of impounding water. Flood control and storm runoff detention dams are included.

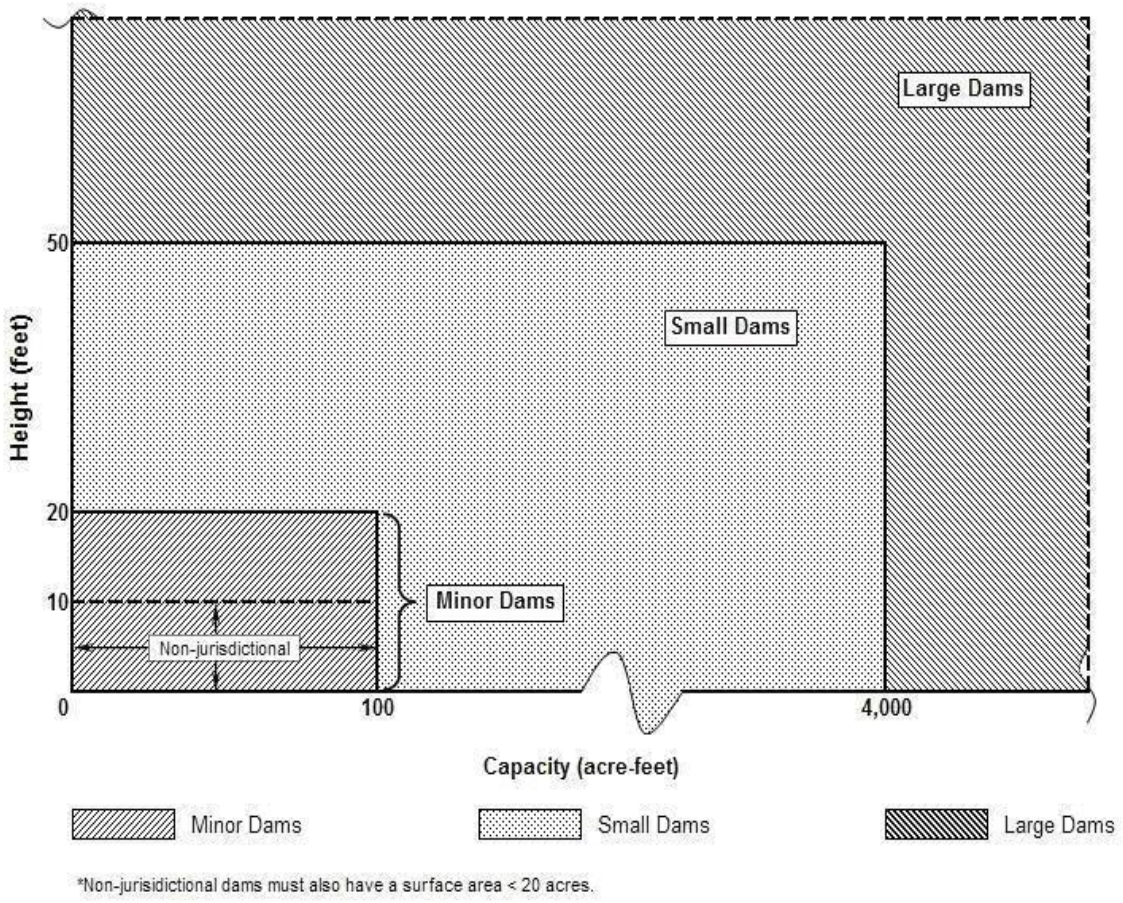
4.2.5.1 **"Jurisdictional Size Dam"** is a dam creating a reservoir with a capacity of more than 100 acre-feet, or creates a reservoir with a surface area in excess of 20 acres at the high-water line, or exceeds 10 feet in height measured vertically from the elevation of the lowest point of the natural surface of the ground where that point occurs along the longitudinal centerline of the dam up to the crest of the emergency spillway of the dam. For reservoirs created by excavation, or where the invert of the outlet conduit is placed below the surface of the natural ground at its lowest point beneath the dam, the jurisdictional height shall be measured from the invert of the outlet at the longitudinal centerline of the embankment or from the bottom of the excavation at the longitudinal centerline of the dam, which ever is greatest. Jurisdictional height is defined in Rule 4.2.19. The State Engineer shall have final authority over determination of the jurisdictional height of the dam.

4.2.5.2 **"Non-jurisdictional Size Dam"** is a dam creating a reservoir with a capacity of 100 acre-feet or less and a surface area of 20 acres or less and with a height measured as defined in Rules 4.2.5.1 and 4.2.19 of 10 feet or less. Non-jurisdictional size dams are regulated and subject to the authority of the State Engineer consistent with sections 37-87-102 and 37-87-105 C.R.S.

4.2.5.3 **"Minor Dam"** is a jurisdictional size dam that does not exceed 20 feet in jurisdictional height and/or 100 acre-feet in capacity (see Figure 1).

4.2.5.4 **"Small Dam"** is a dam with a jurisdictional height greater than 20 feet but less than or equal to 50 feet and/or a reservoir capacity greater than 100 acre-feet, but less than 4,000 acre-feet (see Figure 1).

4.2.5.5 **"Large Dam"** is a dam greater than 50 feet in jurisdictional height, and/or greater than 4,000 acre-feet in capacity (see Figure 1).



DAM SIZE DETERMINATION

Figure 1

4.2.5.6 **"Diversion Dam"** is a dam constructed for the purpose of diverting water from a natural watercourse into a canal, tunnel, ditch, or pipeline that typically impounds an insignificant volume of water, and for which the impacts of failure are not a significant public safety hazard.

4.2.5.7 **"Flood Control Dam"** is a special purpose dam that is normally dry and has an un-gated outlet structure for the controlled release of water impounded during and subsequent to a flood event. The jurisdictional size and classification of the dam are determined using the height and capacity of the reservoir to the emergency spillway elevation, or using the elevation of the maximum routed water surface elevation if no emergency spillway is provided.

4.2.6 **"Dam Failure Inundation Map"** is a map depicting the area downstream from a dam that would reasonably be expected to be flooded in the event of a failure of the dam.

4.2.7 **"Day"** as used in these Rules means a calendar day. For computation of time periods as used in these Rules, Colorado Rules of Civil Procedure 6(a) shall apply.

4.2.8 **"Emergency Action Plan (EAP)"** is a written document prepared by the dam owner, describing a detailed plan of actions for response to emergency or unusual events,

including alerting and warning emergency officials in the event of a potential or imminent dam failure or other emergency related to the safety of the dam and public.

4.2.9 **"Engineer"** means a Professional Engineer registered and licensed in Colorado in accordance with section 12-25-101, C.R.S. The Engineer must be sufficiently qualified and experienced in the design, construction, and safety evaluation of the type of dam under consideration. The Engineer will be the Professional Engineer responsible for the design. In general, the Engineer is responsible for the following:

4.2.9.1 Demonstrating a minimum of five years of experience as a Professional Engineer in the design, construction, and safety evaluation of the type of dam under review.

4.2.9.2 Understanding all applicable regulatory requirements of the project and the required work and analyses needed to complete a safe design of the project.

4.2.9.3 Using current state of the practice methods and means to locate and design dams with safety as the primary goal and complete engineering methodology that represents the professional level of care exercised by qualified engineers.

4.2.9.4 Assembling and supervising a team of qualified engineers, engineering geologists/geological engineers and other professionals required to address all of the disciplines necessary for the design and construction of a dam.

4.2.10 **"Enlargement of an Existing Dam or Appurtenant Structure"** means any alteration, modification, or repair that increases the reservoir volume and/or jurisdictional height of a dam as defined in Rules 4.2.4 and 4.2.19.

4.2.11 **"Extreme Precipitation Event"** means a precipitation event based on Colorado extreme storm data approved by the State Engineer, maximized through modern meteorological techniques.

4.2.12 **"Extreme Storm Precipitation (ESP)"** means the maximum precipitation possible, as developed using the Dam Safety Branch's Extreme Precipitation Analysis Tool (EPAT) or a site-specific hydrometeorologic analysis. The greatest depth of precipitation for a given duration that is physically possible over a drainage basin through the application of modern meteorological techniques, based on Colorado extreme storm data approved by the State Engineer.

4.2.13 **"Freeboard"** means the vertical dimension between the crest (or invert) of the emergency spillway and the crest of the dam.

4.2.13.1 **"Residual Freeboard"** means the vertical dimension between the maximum water surface elevation at the peak of the inflow design flood and the lowest point on the crest of the dam at which the dam would be first overtopped.

4.2.14 **"Hazard Classification of a Dam"** is the placement of a dam into one of four categories based on the hazard potential derived from an evaluation of the probable incremental adverse consequences due to failure or improper operation of the dam. Conditions for evaluation are absent flooding, and the reservoir is assumed to be full to the high water line. The hazard potential classification does not reflect the current condition of the dam with regard to safety, structural integrity, or flood routing capacity. (See Rule 5.4, Hazard Classification Study, for a more detailed description of determining which hazard category a given dam shall be placed.) The Hazard Classification evaluation method must be approved by the State Engineer.

4.2.14.1 **"High Hazard Dam"** is a dam for which loss of human life is expected to result from failure of the dam. Designated recreational sites located downstream within the bounds of possible inundation should also be evaluated for potential loss of human life.

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

4.2.14.3 **"Low Hazard Dam"** is a dam for which loss of human life is not expected, and significant damage to structures and public facilities as defined for a "Significant Hazard" dam is not expected to result from failure of the dam.

4.2.14.4 **"No Public Hazard (NPH) Dam"** is a dam for which no loss of human life is expected, and which damage only to the dam owner's property will result from failure of the dam.

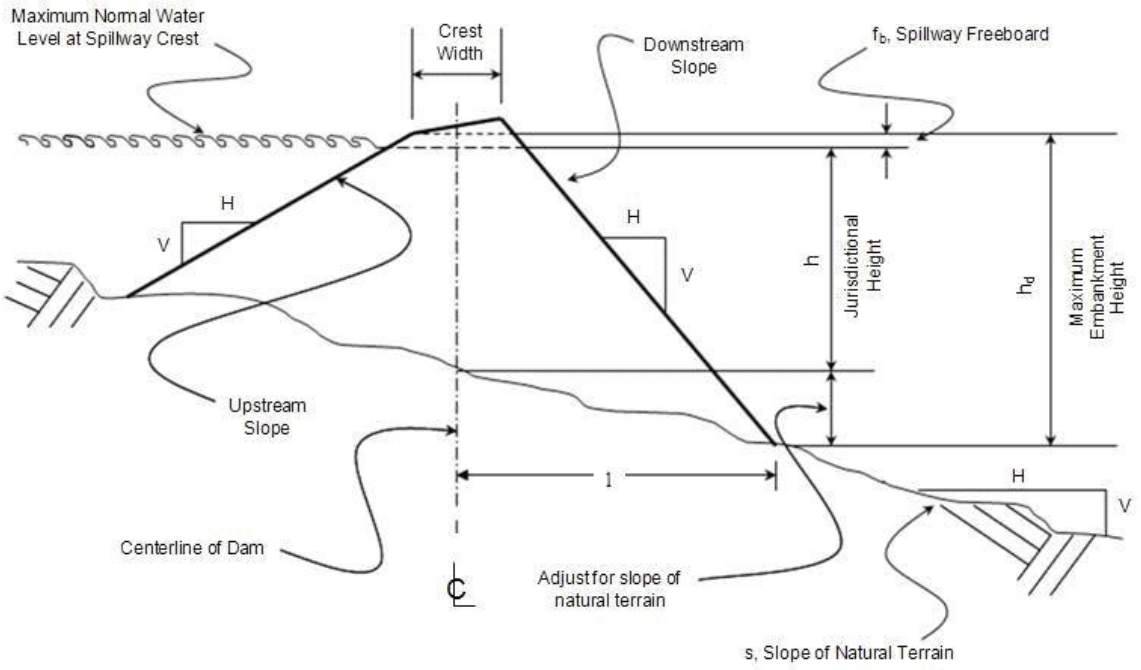
4.2.15 **"High Water Line"** is the water surface elevation of the reservoir at the crest (or invert) of the emergency spillway, or, if no emergency spillway exists, at the crest of the dam.

4.2.16 **"Impound Water"** means to accumulate water in a reservoir for immediate or future use, including the purpose of flood control and detention.

4.2.17 **"Incremental Damage Analysis"** means a comparative study of two floods of differing magnitude used to identify differential impacts for loss of human life and property damage in the zone above the lesser magnitude flood (incremental zone).

4.2.18 **"Inflow Design Flood" (IDF)** means the flood hydrograph used to determine if the emergency spillway's hydraulic capacity meets the safety standards as defined in Rules 5 and 6 (or in absence of a spillway, the reservoir is capable of *storing* the IDF). The required magnitude of the IDF is defined by these Rules.

4.2.19 **"Jurisdictional Height"** means the vertical dimension measured from the elevation of the lowest point of the natural surface of the ground, or from the invert of the outlet pipe if excavated below the natural surface of the ground, whichever is lower, where the low point occurs along the longitudinal centerline of the dam, up to the spillway crest of the emergency spillway. For existing dams, the jurisdictional height shall be measured by using the slope of the downstream channel and the height of the dam at the downstream toe by extrapolating the measured height to the longitudinal centerline of the dam. The formula for determining the vertical height of existing dams is: h = hd-fb-(s*l); where h = jurisdictional height, hd = height of dam from downstream toe, fb = freeboard, s = slope of the natural surface of the ground downstream of the dam, and l = measured or computed horizontal distance between the downstream toe and the longitudinal centerline of the dam. The State Engineer shall have final authority over determination of the height of the dam (see Figure 2).



Determination of Dam Vertical Height at the Maximum Cross Section

Figure 2

4.2.20 **"Natural Surface of the Ground"** means the undisturbed ground surface before excavation, or the undisturbed bed of a natural watercourse.

4.2.21 **"Normal Water Line"** means the elevation of the water at the crest of the principal or service spillway.

4.2.22 **"One-hundred-year Flood"** means a potential flood having a magnitude (peak discharge) which is expected to be equaled or exceeded on the average once during any one-hundred-year period (recurrence interval) and has a one percent chance of being equaled or exceeded during any year (0.01 exceedance probability). The terms “one-hundred-year flood" and "one percent chance flood” are synonymous.

4.2.23 **"Outlet"** means a conduit (usually regulated by gates or valves) used for controlled or regulated releases of impounded water from the reservoir.

4.2.24 **"Owner"** means any person, 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, or proposes to construct a dam. Changes in ownership shall be immediately filed with the State Engineer.

4.2.25 **“Permit”** means a written approval for dam construction, which will be provided by the State Engineer upon approval of the dam plans and specifications. The written approval may be signed by the State Engineer or Deputy State Engineer and identify all contingencies.

4.2.26 **"Plans"** means all necessary drawings, cross-sections, tables, notes, maps and other information necessary to accompany the construction specifications for design review and approval and construction observation and approval.

4.2.27 **"Probable Maximum Precipitation (PMP)"** means the theoretically greatest depth of precipitation for a given duration that is physically possible over a drainage basin at any specific time of year. The PMP values are normally determined from the appropriate Hydrometeorological Report (HMR) (HMR 49 for west of the continental divide, HMR 52 for the eastern plains and HMR 55A for the Front Range). The 100-year, 50-year, and 25-year events are normally determined from the National Weather Service NOAA Atlas #2 "Precipitation-Frequency Atlas of the Western United States" Volume III-Colorado, U.S. Department of Commerce, NOAA, National Weather Service, Silver Springs, Maryland, 1973, (later amendments, editions, or subsequent publications not included).

4.2.28 **"Reservoir"** means a body of water impounded by a dam.

4.2.29 **"Restriction Order"** means an order issued by the State Engineer to limit the maximum water surface elevation of a reservoir as an interim measure to immediately reduce the possibility of failure and risk to the public and property until investigations of a problem can be performed or structural modifications can be made to repair the problem or breach the dam.

4.2.30 **"Routing Capacity"** means the capability of a reservoir and spillway system to attenuate flood inflows, and is calculated as the sum of the spillway discharge(s) and surcharge storage for a specific time increment, expressed in acre-feet.

4.2.31 **"Safe Storage Level"** means 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.

4.2.32 **"Safety Inspection"** means an evaluation by an engineer to be used by the State Engineer in determining the reservoir's safe storage level. The safety inspection includes, but is not limited to, the review of previous inspections, instrumentation results, reports and drawings; visual inspections of the dam and appurtenances, seepage control and measurement systems, and any permanent monument or monitoring installations.

4.2.33 **"Spillway"** means an appurtenant structure that conducts overflows from a reservoir.

4.2.33.1 **"Principal or Service Spillway"** means the overflow structure designed to limit or control the operating level of a reservoir, and first to be activated in runoff conditions. The principal or service spillway is designed to pass normal flows, and may not be designed to pass the entire Inflow Design Flood. The principal or service spillway is usually an open channel, pipe, or culvert.

4.2.33.2 **"Emergency Spillway"** means the appurtenant structure designed to pass the Inflow Design Flood in conjunction with the routing capacity of the reservoir and any principal or service spillway(s). Pipe or culvert spillways are not considered acceptable emergency spillways.

4.2.34 **"Spillway Crest"** means the elevation of the floor of a spillway, grade control structure, or ogee crest above which spillway flow begins.

4.2.35 **"Surcharge Storage"** means the volume of water temporarily stored within a reservoir between the high water line and the crest of the dam.

Rule 5. Requirements for Construction or Enlargement of Jurisdictional Size Dams or Reservoirs:

An owner proposing to construct or enlarge a jurisdictional dam or reservoir shall submit an application package, in a form acceptable to the State Engineer, and shall receive approval of the construction plans and specifications and Permit for Dam Construction from the State Engineer prior to commencing construction. The application package shall be prepared by an engineer and shall consist of the following:

1. Application Form
2. Construction Plans
3. Construction Specifications
4. Hazard Classification Report
5. Hydrology Report
6. Geotechnical Report
7. Design Report
8. Instrumentation Plan
9. Cost Estimate
10. Filing Fee

The requirements for each of these items are as follows:

5.1 **Application Form -** A completed application form provided by the State Engineer. This form will be the only information normally available to the public before the project is approved for construction. The application form shall be signed by the dam owner or an authorized representative of the dam owner. The engineer responsible for the preparation of the design and construction may not act as an authorized representative of the dam owner unless written authorization for the engineer to act as the owners' representative is provided by the dam owner.

5.2 **Construction Plans -** Construction plans/drawings shall meet the following requirements:

5.2.1 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.

5.2.2 The front cover sheet of the plans shall have as a minimum, the name of the dam; the county, Water Division and Water District in which the dam is located; and a project location map. A list of the drawings that follow the cover sheet should be provided on the second sheet of the plans and a note should be added to the cover sheet indicating the location of the list of the drawings. The construction drawings and plans shall display the design engineer's seal (crimp type not acceptable) in accordance with current practice defined by The Bylaws and Rules of Procedure of the State Board of Registration for Professional Engineers and Professional Land Surveyors. The original signed mylar coversheet will be returned to the engineer after being approved and signed by the State Engineer. The original signed mylar cover sheet with any appropriate revisions is required to be returned to the State Engineer at the completion of the construction project in accordance with Rule 10. The design engineer's certification statement, the State

Engineer's approval signature block, and the design engineer's AS-CONSTRUCTED statement shall be located in the lower right quadrant of the cover sheet in the following format:

Design engineer signature

Printed Name, Colo. P.E. No. xxxxx

Approved on the _____day of _____20___.

_____

State Engineer

By:_____

Deputy State Engineer

And,

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

_____ _____

(Engineer's printed name) (Signature)

5.2.3 Drawings filed with the State Engineer shall be originals, drawn with permanent ink on high quality mylar or equivalent, or a high quality reproducible archival copy of the original, and shall be prepared in an appropriate scale so details are legible with an overall size of 24 inches high and 36 inches wide or 22 inches high and 34 inches wide.

5.2.4 Drawings shall have a minimum margin of two inches on the left and 1/2-inch on the right, top, and bottom.

5.2.5 All drawings shall have bar scales to allow scaling of reduced drawings.

5.2.6 All drawings shall have a 1/2- by 3-inch space for the State Engineer's file number inside the margin in the lower right-hand corner. A unique project 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.

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., 1 of 6.

5.2.8 Minimum lettering size on full size drawings (24 inches high and 36 inches wide or 22 inches high and 34 inches wide) shall be 12 pitch.

5.2.9 Spillway and outlet discharge rating curves and tables, and reservoir area-capacity curves and tables meeting requirements of Rule 5.9.6 shall be placed on the drawings.

5.3 **Construction Specifications -** Construction Specifications shall meet the following requirements:

5.3.1 The front cover of the specifications shall show the title or name of the dam (identical to the title on the plans), the county, the Water Division and the Water District in which the dam is located. The specifications shall display the design engineer's seal (crimp type not acceptable) in accordance with current practice defined in The Bylaws and Rules of Procedure of the State Board of Registration for Professional Engineers and Professional Land Surveyors. The first page behind the front cover shall show the name of the dam (identical to the name on the plans), the county, Water Division and Water District in which the dam is located, the engineer's certification statement, seal and signature, and the State Engineer's approval statement as follows:

Approved on the _____ day of _____, 20__

_____, State Engineer

By: _____, Deputy State Engineer

5.3.2 The specifications shall have an index.

5.3.3 Final specifications shall be bound and submitted on white 8 1/2 by 11-inch paper. Specifications bound in a loose or loose-leaf manner, including 3-ring binders, are not acceptable.

5.3.4 The general conditions shall include statements that the plans and specifications cannot be significantly changed without the prior written approval of the State Engineer in accordance with Rule 9.1.8.

5.3.5 The general conditions shall include the provision that construction shall not be considered complete until the State Engineer has accepted the construction in writing.

5.3.6 The specifications shall provide that the owner's engineer will monitor the quality of construction as specified in Rule 9. 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 required in Rule 10.

5.3.7 The specifications shall include as a minimum, but are not limited to, the following:

5.3.7.1 The quality of materials used in construction;

5.3.7.2 The acceptable quality of workmanship;

5.3.7.3 The reference to applicable standards, if any;

5.3.7.4 The required tests and estimated frequency of testing; and,

5.3.7.5 The action to be taken if unsatisfactory materials or workmanship are discovered in the construction.

5.4 Project Design Reports

5.4.1 **Hazard Classification Report -** The hazard classification report shall identify the size and hazard classification category for the proposed dam, or enlarged existing dam. A report 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 16. The

report shall include sufficient information regarding assumptions, calculations and data used to develop the dam failure flood hydrograph and an assessment of the impact of the dam failure upon the downstream floodplain. The dam shall be classified according to the definitions of Rule 4. The hazard classification report must be approved by the State Engineer, and shall be in a form that meets the State Engineer's requirements, including, but not be limited to:

5.4.1.1 Dam failure inundation maps are required for all dams classified as High and Significant Hazard. Inundation maps are required for dams classified as Low Hazard unless the dam is located in a remote area where no development exists downstream of the dam;

5.4.1.2 Cross-sections along the watercourse, drawn to scale, showing water surface elevations at critical locations where structures may be impacted by the flood wave. Cross-sections shall show discharge in cubic feet per second, average velocity in feet per second, and structures located in the flooded section. References to all computer programs, data sources and related documents used in the evaluation shall be included; and

5.4.1.3 Supporting documentation and tabulation of assumed parameters, including Manning's "n" values for the stream channel and the floodplain shall be included.

5.4.2 **Hydrology Report -** A hydrology report is required that presents the inflow design flood (IDF) for determining the required spillway capacity. The IDF may be determined through any of the four methods described in Rule 5.9.1; Extreme Precipitation Analysis Tool (EPAT), site specific hydrometeorologic analysis (SSHMA), Hydrometeorological Report (HMR), and Incremental Damage Analysis (IDA). The precipitation determined through use of the Extreme Precipitation Analysis Tool (EPAT) and site specific hydrometeorologic analysis is the most probable extreme precipitation event for the specific basin determined through modern meteorologic techniques and therefore, the IDF determined from the analysis is probable. No reduction of IDF is allowed for dams classified as High hazard or large size Significant hazard dams. The reduction in the IDF determined through the use of Hydrometeorological Report (HMR), is allowed as provided in Rule 5.9.1.5. Spillways designed in accordance with these Rules will not be required to be enlarged due to subsequent revisions to the IDF as a result of changes to the probable maximum precipitation estimates or EPAT extreme storm database unless, in the opinion of the State Engineer, there is a substantial threat to public safety.

5.4.2.1 The hydrology report is required to be reviewed and approved by the State Engineer and shall be in a form acceptable to the State Engineer and shall include, but not be limited to the following:

5.4.2.1.1 A topographical map delineating the drainage area tributary to the dam, with the drainage area size labeled in square miles; the location of the proposed dam by quarter section, section, township, range, and principle meridian; the bearing and distance from Station 0+00 on the dam to a section corner, or, the location of Station 0+00 on the dam determined by GPS, NAD83 datum, provided as UTM coordinates; the name of the natural watercourse on which the dam is located or indicate the dam is off-stream, and the name of the primary watercourse which the dam is tributary, or the name of the drainage basin in which the dam is located; and the elevation of the dam crest;

5.4.2.1.2 A description of all basin response factors, including the topography, geology, and vegetative cover of the tributary drainage area;

5.4.2.1.3 A summary of all hydrologic parameters for the method used, the inflow design flood hydrograph, volume of the flood, and hazard classification of the dam;

5.4.2.1.4 A spillway discharge rating table (in cubic feet per second) for each foot of elevation above the spillway crest up to the crest of the dam, including the equations used for determining the discharge rate; and

5.4.2.1.5 A table showing the reservoir area (in acres) and storage capacity (in acre-feet) for each foot of elevation from the invert of the outlet to the crest of the dam; and indicating the amount of dead storage (in acre-feet), elevation of the invert of the outlet, elevation(s) of the spillway crest(s), and elevation of the dam crest. All elevations shall be based on USGS datum, referenced to the invert of the outlet.

5.4.3 **Geotechnical Report -** A geotechnical report is required that evaluates the suitability of the foundation, stability of the dam and the slopes along the reservoir rim, and addresses issues regarding suitability and quantity of material available for construction of the dam as designed. The geotechnical report shall include, but not be limited to, the following:

5.4.3.1 A geological assessment of the dam and reservoir site is required for all dams classified as High or Significant Hazard. The geological assessment shall address at a minimum regional geologic setting; local and site geology; geologic suitability of the dam foundation and reservoir area; slope stability and seepage potential of the reservoir and abutment areas; seismic history and potential; and other potential geological hazards posed by the site and proposed construction. The geological assessment shall include the preparation of a site-specific geological map based upon field observations and mapping by a geologist or geological engineer.

5.4.3.2 Foundation investigations for High and Significant Hazard dams shall include drilling to a depth 1.5 times the height of the dam or at least 10 feet into bedrock, whichever is less; logs of borings and test pits; standard penetration or other field density tests; field and laboratory classification of soils; measurement of the water level in each drill hole; in-situ permeability tests; gradation tests of foundation materials, especially at the locations of proposed drains; determination of liquefaction potential; and whether clay type foundation materials exhibit residual strength properties and dispersivity. 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 underground construction anticipated at each site. All investigations for underground facilities shall be performed under the direction of a qualified professional engineering geologist with prior relevant underground experience. The boring logs in the geotechnical report shall include detailed written descriptions of each sample and stratum encountered including observations of the drilling action, drilling and sampling methods and any other observations pertinent to developing a detailed understanding of the subsurface conditions. Graphical “stick” logs alone are not acceptable.

5.4.3.3 The report shall document the suitability of proposed borrow materials or other material sources to be used in construction for High and Significant Hazard dams. The following information and data are required, as a minimum, to be included in the Geotechnical Report:

5.4.3.3.1 Standard index tests and soil classification of all materials;

5.4.3.3.2 Compressibility and/or consolidation tests of soils;

5.4.3.3.3 Permeability of placed materials;

5.4.3.3.4 Shear strength of natural and placed materials (dynamic shear strength tests if applicable);

5.4.3.3.5 Proctor Compaction tests; and

5.4.3.3.6 Identification of potentially dispersive clays.

5.4.3.4 For Low Hazard dams, the report shall include field classification of soils, logs of borings and test pits, standard penetration test results, and the requirements of Rules 5.4.3.3.1, 5.4.3.3.2, and 5.4.3.3.5. The foundation exploration shall include drilling to a depth 1.5 times the height of the dam or 10 feet into bedrock, whichever is less.

5.4.3.5 For NPH dams, the report shall include, as a minimum, field and laboratory classification of natural and placed soils.

5.4.3.6 For all dams, except Minor Low Hazard and all NPH, with a spillway located on a soil foundation, the report shall include the following:

5.4.3.6.1 Laboratory Classification of soils along the alignment of the spillway;

5.4.3.6.2 A profile of soils along the channel extending to a depth of at least five feet below the bottom of the spillway; and

5.4.3.6.3 Density or bearing capacity of foundation soils beneath spillway structures except for riprapped or unlined sections of the channel.

5.4.3.7 For all dams, except minor Low Hazard and all NPH, with spillways located on a rock foundation, the report shall include a geologic description of the rock, description of the bedding and jointing patterns, and an evaluation of the site's suitability to accommodate the spillway.

5.4.4 **Design Report -** A Design Report shall be submitted with the application package. The report shall include information sufficient to evaluate the design of the dam and appurtenances, including references and page numbers, to support any assumptions or criteria used in the design. The report shall also include information on the construction sequence needed to complete the dam along with a summary of any water quality permits that will be required prior to the start of construction. The report shall include calculations and be sufficiently detailed to accurately define the final design of the proposed dam as represented in the construction plans. The following is a typical list of topics to be addressed in the design report:

5.4.4.1 Introduction - Project description and review process.

5.4.4.2 Project Components - Main dam, spillway, and outlet works.

5.4.4.3 Site Requirements - The dam site and reservoir area design requirements.

5.4.4.4 Flood Hydrology and Results of Flood Routings (a summary of Hydrology Report) - This section should include the final results of the routing of the IDF

through the reservoir and spillway system for the purpose of determining the size of the spillway or spillways.

5.4.4.5 Spillway and Outlet Works Hydraulics - This should include spillway hydraulics and the development of a spillway discharge rating curve, stilling basin hydraulics, a tailwater rating curve including effects of streambed degradation, hydraulic design assumptions for the design of entire outlet system, and development of an outlet works discharge curve. Design of stilling basins for stepped chute spillways shall include assumptions, calculations, and applicable references for estimating energy dissipation and stilling basin entrance velocities.

5.4.4.6 Foundation Designs - These designs are to include information of local geology (alluvium and topsoil nature and engineering properties), bedrock nature and engineering properties, groundwater impacts, dam foundation requirements, foundation excavation requirements, surface treatment of foundation, seepage control and foundation drainage, piping control measures, downstream erosion, and overtopping control measures. (Refer to the Geotechnical Report requirements for additional requirements, Rule 5.4.3).

5.4.4.7 Seismic Hazard Assessment - This section include seismic sources (seismotectonic setting, historical seismicity, earthquake sources), ground motion hazard (ground motion attenuation, deterministic analysis, probabilistic analysis), and recommended ground motions (time histories).

5.4.4.8 Dam Analysis and Design - This section should include material properties (earth and/or concrete, foundation geology for dam, foundation strength parameters), analysis methodology and model results (load combinations, static analysis, dynamic analysis), conclusions and recommendations. In addition for Roller Compacted Concrete (RCC) dams, this section should also include required in-situ material properties for concrete or RCC, RCC trial mix program, mix proportions, and RCC placement requirements (RCC joint treatment, contraction joint spacing, upstream and downstream facing systems).

5.4.4.9 Structural Design - This section should include structural design criteria and allowable stresses, design of spillway crest, spillway walls and slabs, design of spillway foundation anchors, design of outlet works intake and outlet structures, and outlet conduit.

5.4.4.10 Dam Instrumentation - This section should include a description of the instrumentation per the requirements of Rule 5.5 and including any other monitoring devices and equipment such as automatic data acquisition system.

5.4.4.11 Mechanical and Electrical Design - Design of gates, valves, trash racks and mechanical systems, systems for operating gates and valves, and electrical power requirements and emergency backup power.

5.4.4.12 Quality Assurance and Quality Control Plan - Project management plan, project quality plan, and testing procedures and frequency requirements.

5.4.4.13 River Diversion During Construction - Anticipated construction scheduling and historical river flows, diversions hydrology and selection of diversion flood, proposed diversion system, and potential risks to public safety during construction.

5.4.5 **Project Design Report -** A Project Design Report incorporating all of the aforementioned reports into one design document is permitted. The report should fully document and provide defendable reasoning for the design of the dam and appurtenant structures.

5.5 **Instrumentation Plan -** An instrumentation plan is required and shall meet the following requirements:

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 10.

5.5.2 Gage rods shall be installed in the close proximity to the outlet on all dams. The zero mark of the gage shall be aligned with the invert elevation of the entrance to the outlet. The gage shall be 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. Markings and numbers on the gage rod shall be of sufficient size to allow for the reading of the gage rod from a distance 50 feet or further if the gage rod is placed on an intake tower within the reservoir.

5.5.3 High and Significant Hazard dams shall have the following minimum instrumentation:

5.5.3.1 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. Control or benchmark monuments shall be placed on the abutments in areas not subject to movement;

5.5.3.2 Weirs, flumes, or other measuring devices installed in a manner acceptable to the State Engineer, to allow monitoring of seepage through the embankment or foundation. Positive drainage away from all seepage monitoring devices should be provided to prevent the device from becoming submerged;

5.5.3.3 Station markers at least every 100 feet along the crest of the dam; and

5.5.3.4 Piezometers to allow monitoring of the phreatic surface within the dam, installed in accordance with industry standards and in a manner acceptable to the State Engineer. As a minimum, the construction of the open well piezometers shall be in accordance with the requirements of a monitoring well as presented in the Division of Water Resources' "Rules and Regulations for Water Well Construction, Pump Installation and Monitoring an Observation Hole/Well Construction," later amendments, editions or subsequent publications are not included.

5.5.3.5 Piezometers or equivalent instruments shall be installed to measure uplift pressures in the dam and foundation for concrete dams, when the reduction of uplift pressures are required to meet the factors of safety and stress requirements of the design of the dam.

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

5.5.4 Low Hazard dams shall have weirs, flumes or other measuring devices installed, as approved by the State Engineer, to allow monitoring and measurement of leakage through the embankment or foundation.

5.5.5 NPH dams are not required to have instrumentation other than gage rods in accordance with Rule 5.5.2.

5.6 **Cost Estimate -** A detailed cost estimate of the construction of the dam including the engineering fees. The cost estimate will remain confidential until after the construction contract is executed.

5.7 **Fees -** A filing fee of $3.00 per $1,000.00 (or fraction thereof) of the cost estimate, limited to a maximum of $3,000.00, with a minimum filing fee of $100.00.

5.8 Design Review Approvals and Limitations

5.8.1 **Approval of Plans and Specifications -** Acceptable plans and specifications will be certified by the State Engineer or designee and approved for construction.

5.8.2 **Approval Limitation -** If construction, alteration, or repair of a reservoir dam is not commenced within five years of approval of the application, the State Engineer's approval shall be void. The owner must resubmit the application and receive approval before commencing construction, and shall meet the requirements of the current Rules.

5.8.3 **Design Review Limitation -** The design review performed by the State Engineer shall be limited to three years from the date of the review. Re-submittal of the design package shall be required if resolution of the design review comments does not occur within three years.

5.9 Design Requirements

5.9.1 Inflow Design Flood (IDF) Requirements

5.9.1.1 The IDF shall be determined considering basin size, the elevation of the basin, various soil permeabilities, the various vegetative covers, and other factors related to the routing of the storm event. Historical precipitation data of the National Weather Service may be used for determining the IDF provided applicable stochastic procedures are used as outlined in the National Weather Service NOAA Atlas #2 "Precipitation-Frequency Atlas of the Western United States" Volume III-Colorado, U.S. Department of Commerce, NOAA, National Weather Service, Silver Springs, Maryland, 1973, or other methods approved by the State Engineer.

5.9.1.2 The National Weather Service, NOAA, Atlas #2 "Precipitation-Frequency Atlas of the Western United States" Volume III-Colorado, U.S. Department of Commerce, NOAA, National Weather Service, Silver Springs, Maryland, 1973, may be used for determining the precipitation for l00-year, 50-year and 25-year rainstorm events for the purpose of calculating the magnitude of the resulting flooding.

5.9.1.3 Extreme Precipitation Analysis Tool - The Inflow Design Flood (IDF) requirements for determining the spillway capacity may be developed through the use of the Extreme Precipitation Analysis Tool (EPAT). The process and procedures for use of the EPAT are available from the State Engineer. The IDF requirement determined through the use of the EPAT Extreme Storm Precipitation (ESP) for determining spillway capacity are summarized in Table 5.1:

TABLE 5.1 INFLOW DESIGN FLOOD REQUIREMENTS USING EPAT

DAM SIZE	HAZARD CLASSIFICATION			
	High	**Significant**	**Low**	**NPH**
Large	ESP	ESP	100 YR	50 YR
Small	ESP	0.5 ESP	100 YR	25 YR
Minor	ESP	100 YR	50 YR	25 YR

5.9.1.3.1 New Large, Small, and Minor High Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by the Extreme Storm Precipitation (ESP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser inflow design flood is applicable.

5.9.1.3.2 New Large, Significant Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by the Extreme Storm Precipitation (ESP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser inflow design flood is applicable.

5.9.1.3.3 New Small, Significant Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the inflow design flood generated by 50 percent of the Extreme Storm Precipitation (ESP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser inflow design flood is applicable.

5.9.1.3.4 New Minor, Significant Hazard plus new Large and Small, Low Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the inflow design flood generated by a 24-hour, l00-year rainstorm event.

5.9.1.3.5 New Minor, Low Hazard dams and new Large, NPH Dams and enlargements shall have spillways capable of passing the inflow design flood generated by a 24-hour, 50-year rainstorm event.

5.9.1.3.6 New Small and Minor NPH dams and enlargements shall have spillways capable of passing the Inflow Design Flood (IDF) generated by a 24-hour, 25 year rainstorm event.

5.9.1.3.7 The minimum size spillway for all High Hazard, Significant Hazard, and Large and Small, Low Hazard jurisdictional size dams for which an IDA shows a smaller spillway is justifiable under Rule 5.9.7.1 shall be capable of passing the inflow design flood generated by a 24-hour, 100-year rainstorm event. For all other jurisdictional size dams, the minimum size spillway shall be capable of passing the IDF generated by the appropriate rainstorm event presented in the above table.

5.9.1.4 Hydrometeorological Report PMP - The Inflow Design Flood (IDF) requirements for determining the spillway capacity may be developed through the use of the

most current Probable Maximum Precipitation (PMP) estimates from the Office of Hydrology, National Weather Service, NOAA Hydrometeorological Report Series. The PMP values are normally determined from the appropriate Hydrometeorological Report (HMR). Currently, HMR 52 and 55A are applicable for drainage basin located to the east of the Continental Divide and HMR 49 for drainage basin west of the Continental Divide. The IDF requirements for determining the spillway capacity using the appropriate HMR are summarized in Table 5.2:

TABLE 5.2 INFLOW DESIGN FLOOD REQUIREMENTS USING HYDROMETEOROLOGICAL REPORTS (HMR)

DAM SIZE	HAZARD CLASSIFICATION			
	High	Significant	Low	NPH
Large	0.90 PMP	0.68 PMP	100 YR	50 YR
Small	0.90 PMP	0.45 PMP	100 YR	25 YR
Minor	0.45 PMP	100 YR	50 YR	25 YR

5.9.1.4.1 New Large and Small, High Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by 90 percent of the Probable Maximum Precipitation, unless an incremental damage analysis demonstrates a lesser inflow design flood is applicable.

5.9.1.4.2 New Minor, High Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood generated by 45 percent of the Probable Maximum Precipitation (PMP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser IDF is applicable.

5.9.1.4.3 New Large, Significant Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by 68 percent of the Probable Maximum Precipitation (PMP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser IDF is applicable.

5.9.1.4.4 New Small, Significant Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by 45 percent of the Probable Maximum Precipitation (PMP), unless an Incremental Damage Analysis (IDA) demonstrates a lesser IDF is applicable.

5.9.1.4.5 New Minor, Significant Hazard and new Large and Small, Low Hazard dams and enlargements shall have spillways capable of passing, as a minimum, the Inflow Design Flood (IDF) generated by a 24-hour, l00-year rainstorm event.

5.9.1.4.6 New Minor, Low Hazard dams, and new Large, NPH Dams and enlargements shall have spillways capable of passing the Inflow Design Flood generated by a 24-hour, 50-year rainstorm event.

5.9.1.4.7 New Small and Minor, NPH dams and enlargements shall have spillways capable of passing the Inflow Design Flood (IDF) generated by a 24-hour, 25-year rainstorm event.

5.9.1.4.8 The minimum size spillway for all High Hazard, Significant Hazard, and Large and Small, Low Hazard jurisdictional size dams for which an IDA shows a smaller spillway is justifiable under Rule 5.9.7.1 shall be capable of passing the Inflow Design Flood (IDF) generated by a 24-hour, 100-year rainstorm event. For all other jurisdictional size dams, the minimum size spillway shall be capable of passing the IDF generated by the appropriate rainstorm event presented in the above table.

5.9.1.5 Elevation Reduction - The HMR PMP used to determine the IDF may be reduced based on the average elevation of the drainage basin. The HMR PMP value may be adjusted for the determination of the IDF for drainage basins above 5,000 (ft) MSL in accordance with Table 5.3:

TABLE 5.3 HMR PMP INFLOW DESIGN FLOOD REQUIREMENTS REDUCED FOR ELEVATION

DAM SIZE	STORM TYPE	ELEVATION	HAZARD CLASSIFICATION - High	HAZARD CLASSIFICATION - Significant
Large	General Storm East	6,000 - 12,000 ft MSL	0.80 PMP	0.60 PMP
		Above 12,000 ft MSL	0.70 PMP	0.53 PMP
	General Storm West	5,000 - 8,000 ft MSL	0.80 PMP	0.60 PMP
		Above 8,000 ft MSL	0.70 PMP	0.53 PMP
	Local Storm	10,000 - 11,500 ft MSL	0.80 PMP	0.60 PMP
		11,501 - 13,000 ft MSL	0.70 PMP	0.53 PMP
		Above 13,000 ft MSL	0.60 PMP	0.45 PMP
Small	General Storm East	6,000 - 12,000 ft MSL	0.80 PMP	0.40 PMP
		Above 12,000 ft MSL	0.70 PMP	0.35 PMP
	General Storm West	5,000 - 8,000 ft MSL	0.80 PMP	0.40 PMP
		Above 8,000 ft MSL	0.70 PMP	0.35 PMP
	Local Storm	10,000 - 11,500 ft MSL	0.80 PMP	0.40 PMP
		11,501 - 13,000 ft MSL	0.70 PMP	0.35 PMP
		Above 13,000 ft MSL	0.60 PMP	0.30 PMP

Minor	General Storm East	6,000 - 12,000 ft MSL	0.40 PMP	Not Applicable
		Above 12,000 ft MSL	0.35 PMP	Not Applicable
	General Storm West	5,000 - 8,000 ft MSL	0.40 PMP	Not Applicable
		Above 8,000 ft MSL	0.35 PMP	Not Applicable
	Local Storm	10,000 - 11,500 ft MSL	0.40 PMP	Not Applicable
		11,501 - 13,000 ft MSL	0.35 PMP	Not Applicable
		Above 13,000 ft MSL	0.30 PMP	Not Applicable

5.9.1.6 Site Specific Hydrometeorologic Analysis - Site Specific Hydrometeorologic Analysis (SSHMA) may be used to determine the appropriate site specific extreme storm precipitation (SSESP) for the determination of the IDF. Site-specific evaluations are subject to approval by the State Engineer. Any procedures developed and approved by the State Engineer shall be used to determine the applicable Extreme Precipitation Event. Snowmelt conditions shall be considered as base flow when appropriate. The percentage reduction of the PMP as shown in Rule 5.9.1.5 are not applicable or allowed in the determination of site specific extreme storm precipitation or PMP values determined by the procedures and analysis provided for in this Rule for all High Hazard dams and Large Significant Hazard dams. The IDF requirement developed through the use of site specific analyses for determining spillway capacity are summarized in Table 5.4:

TABLE 5.4 INFLOW DESIGN FLOOD REQUIREMENTS FOR SSHMA

DAM SIZE	**HAZARD CLASSIFICATION**			
	High	**Significant**	**Low**	**NPH**
Large	SSESP	0.75 SSESP	100 YR	50 YR
Small	SSESP	0.5 SSESP	100 YR	25 YR
Minor	SSESP	100 YR	50 YR	25 YR

5.9.1.7 Incremental Damage Analysis - An Incremental Damage Analysis (IDA) used to justify an Inflow Design Flood (IDF) less than the requirements of Rule 5.9.1.3 through Rule 5.9.1.6, shall be based on a comparison of two floods: first, a base

flow flood of the minimum magnitude which exceeds the capacity of all spillways, resulting in overtopping of the dam routed through the downstream floodway assuming no dam is in place; and second, the dam failure flood which occurs due to overtopping, and is routed downstream with the base flow flood. The spillway capacity and IDF will be acceptable where it can be shown that the dam failure flood would cause no additional loss of life nor additional significant property damages downstream within the zone between the two floods.

5.9.1.7.1 No loss of life or significant damage is expected to occur if the increased depth of flow is two feet or less and the product of the flood flow velocity in the incremental zone and the depth of flow at critical locations along the floodway is less than seven.

5.9.1.7.2 Documentation for the IDA shall include but not be limited to: a plot showing both the base flow and dam break flood on topographic maps of the affected areas; cross-sections of the downstream channel showing flood stages, velocities, and discharges for the two floods at the critical locations; incremental damage and loss of life determinations; and a summary of all assumed hydraulic parameters. A table summarizing the results of the IDA at the various downstream cross sections showing that the criteria in Rule 5.9.1.7.1 has been satisfied shall be included in the IDA study report. Documentation shall also include, if deemed necessary by the State Engineer, channel profiles with the various flood stages, aerial photographs of the affected areas, and computer printouts showing flood discharges, stage, and velocities with respect to time.

5.9.1.8 The minimum freeboard requirements for new or enlarged dams shall be based upon the dam height required to prevent overtopping by wave action, or the sum of the inflow design flood maximum water surface level plus one foot of residual freeboard, but not less than five feet unless the State Engineer approves a lesser amount. Except for concrete dams where the design engineer has demonstrated that overtopping of the dam will not be detrimental to the safety of the dam, the inflow design flood can be accommodated with zero residual freeboard or the overtopping depth at which the dam still meets the stability and stress requirements of Rule 5.9.5.

5.9.1.9 For any dam whose spillway is not designed to pass the inflow design flood as defined previously in Rule 5.9.1, the engineer may as an alternative, provide documentation of the analysis that overtopping of the dam by floods which exceed the spillway capacity up to the design flood will not cause failure of the dam. Otherwise, overtopping protection shall be provided.

5.9.1.10 Spillway Design Exemption - Spillways designed and constructed in accordance with the requirements of the Rules dated September 30, 1988 are exempt from the requirements of these Rules.

5.9.2 **Seismicity Design Requirements**

5.9.2.1 Dams classified as High or Significant hazard shall be analyzed for seismic stability. Seismic analysis for water storage dams shall be based on full reservoir under steady state seepage conditions. Flood control dams with ungated outlets shall be designed for earthquake loads under empty reservoir conditions and need not consider steady-state seepage for seismic analysis. Dams sited on active faults shall obtain a waiver from the State Engineer. To obtain a waiver, the analysis shall show that the location of the dam is unavoidable and the dam must be designed to withstand anticipated fault movement without compromising

its integrity. Appropriate data sheets, calculation sheets and computer program output computations from manual or computerized analysis shall be provided. The seismic analysis shall meet the following minimum requirements:

5.9.2.1.1 A seismological investigation for the dam area and reservoir area. This study may be part of the geotechnical report for the structure, or may be a separate report. The study shall determine and justify the appropriate seismic parameters to be used for design. The seismic parameters shall be based on the following design earthquake:

5.9.2.1.1.1 Dams classified as High Hazard and with a height greater than or equal to 30 feet, other than flood control structures, shall be designed for the maximum credible earthquake or for an earthquake with a minimum 5000-year return frequency.

5.9.2.1.1.2 Dams classified as High Hazard and with a height less than 30 feet, other than flood control structures, shall be designed for either: a) the maximum credible earthquake or an earthquake with a minimum 5000-year return frequency, or b) for a peak ground surface acceleration equal to twice the acceleration for the site with a 2% chance of exceedance in 50 years (approximately 2500-year return frequency), as estimated and published by the U.S. Geological Survey.

5.9.2.1.1.3 Dams classified as Significant Hazard or High Hazard dams whose sole purpose is for flood control shall be designed for a 2% chance of exceedance in 50 years (approximately 2500-year return frequency).

5.9.2.2 An analysis of materials in the foundation, reservoir area and proposed embankment shall be completed to determine the potential for liquefaction, earthquake-induced sliding, or other seismic sensitivity, which may be accomplished as part of the geotechnical investigation.

5.9.2.3 Pseudostatic analysis for embankment dams will be acceptable for the following cases:

5.9.2.3.1 The embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D698, or at least 90% of the maximum modified Proctor density, ASTM D1557 or at least 70% relative density per ASTM D4253 and ASTM D4254, if Proctor testing is not appropriate; no materials prone to liquefaction are present in the foundation and the design peak bedrock acceleration is 0.20g or less; or

5.9.2.3.2 The embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D698, or at least 90% of the maximum modified Proctor density, ASTM D1557; potentially submerged portions of the embankment except for internal drain elements are constructed of clayey material; the dam is constructed on clayey soil or bedrock foundation and peak bedrock acceleration is 0.35g or less; and

5.9.2.3.3 All static stability safety factor requirements of these Rules are met; minimum freeboard requirements of these Rules are met; and the pseudostatic coefficient selected for analysis must be at least 50% of the

design peak bedrock acceleration, but not less than 0.05g and the factor of safety under pseudostatic analysis shall be 1.0 or greater. In determining the factor of safety for pseudostatic analysis, a search for the critical failure surface shall be made.

5.9.2.4 Pseudostatic analysis for concrete dams will be acceptable and shall meet the requirements Rule 5.9.5.

5.9.2.5 For dams not satisfying the requirements for pseudostatic analysis, a deformation analysis is required. The resulting embankment must be capable of withstanding the design earthquake without breaching and with at least 3 feet of freeboard remaining after deformation. The analysis shall also assess the potential for internal erosion as a result of cracking during earthquake-induced deformation.

5.9.2.6 The seismic assessment shall also address the stability of appurtenant structures to the dam during the design earthquake, as appropriate, unless failure of an appurtenance due to earthquake does not represent an immediate threat to the dam, in which case a lesser operating basis earthquake may be used, as approved by the State Engineer.

5.9.3 **Geotechincal Investigation and Foundation Requirements**

5.9.3.1 Geological and geotechnical investigations are required to describe the geology and geotechnical conditions for construction of the dam and reservoir. The report shall include the geological and geotechnical analyses required for the design and construction of the dam. The report shall describe the foundation conditions for the dam and provide justification for foundation strength, deformation, sliding stability and seepage parameters assumed for design. The foundation requirements for design of the dam will vary based upon the foundation conditions, geology, rock jointing and faulting, dam size and use of the reservoir.

5.9.3.2 Geological and geotechnical engineering exploration shall be conducted under the supervision of a Licensed Professional Engineer or an Engineering Geologist experienced in geotechnical or geological engineering for dams.

5.9.3.3 Geological mapping is required for the dam and reservoir area. The geological mapping shall include the dam, dam abutments and the locations of appurtenant structures.

5.9.3.4 Subsurface investigations shall be conducted for all new dams and for all major modifications to existing dams. The subsurface investigation is typically required to evaluate the depth and geologic classification of the bedrock foundation excavatability and characterize the foundation competency under the dam. The subsurface investigation shall include, test holes, test pits, geophysical survey, insitu testing, water packer test, pressure meter, and block shear tests.

5.9.3.5 The number and depth of test holes and test pits are typically based on the geological conditions, the complexity of the geological conditions and the size of the dam and depth of the reservoir. The number of foundation drill holes shall not be less than three.

5.9.3.6 Direct shear strength testing and compressive strength testing is required to evaluate design values for shear strength and bearing capacity. Strength

properties of discontinuities and the weakest foundation materials are required, as these will generally control foundation behavior. Shear strength testing is also required on rock discontinuities including pre-existing shear planes or faults in the dam foundation. Typical test requirements could include stress-strain properties, shear wave velocity, density and tensile strength.

5.9.3.7 The geological and geotechnical basis for the foundation grouting design for the dam should be prepared. This documentation includes the basis for the design of the curtain grouting and consolidation grouting of the dam footprint.

5.9.3.8 Foundation excavation requirements necessary to provide a firm foundation for the dam shall be documented in the Geotechnical Report. The Geotechnical Report shall provide excavation requirements for shaping of the foundation to provide more uniform foundation stresses or to minimize dam cracking.

5.9.3.9 Foundation drainage design shall be provided including justification for reduction in uplift pressures on 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.

5.9.3.10 Confirmation of foundation design assumptions is required after the foundation for the dam has been exposed. The project geologist and design engineer shall confirm foundation conditions assumed for the design. Changes in foundation conditions from assumptions made in the Geotechnical Report shall be communicated to the State Engineer when they are identified during construction. Changes to the foundation design for the dam shall be submitted to State Engineer's Office in a formal Change Order Request during construction per the requirements of Rule 9.

5.9.4 **Embankment Dam Design Requirements**

5.9.4.1 Stability Analysis - Embankment dams shall be designed to have stable slopes during construction, and under all conditions of reservoir operation, including rapid draw-down of the reservoir.

5.9.4.1.1 Factors of safety shall be evaluated by slope stability analyses methodologies that are acceptable to the State Engineer. The analysis models shall adequately represent, for the critical cross section (or sections) of the dam, the embankment geometry and internal zoning; shear strengths and unit weights of each material; pore water pressures; and external loading or other relevant factors. Shear strength and pore pressure assumptions used in stability analyses should be obtained from tests that appropriately model the loading condition being analyzed. Where appropriate, the analyses shall consider non-circular or wedge-shaped failure surfaces, as well as circular failure surfaces. All parameters and assumptions used in the analysis shall be summarized in a table, and justified in the Geotechnical Report. A scale drawing, utilizing the same scale for vertical and horizontal dimensions, shall be provided for each cross-sectional model used in the analysis, with the critical failure surface(s) identified. Appropriate data sheets and representative computer program output shall be provided in the report.

5.9.4.1.2 Minimum factors of safety for slope stability of embankment dams for various loading conditions other than seismic loading are summarized in Table 5.5.

TABLE 5.5 MINIMUM FACTORS OF SAFETY FOR SLOPE STABILITY OF EMBANKMENT DAMS

Loading Condition	Minimum Factor of Safety [1]
Steady seepage with phreatic surface fully developed for reservoir at normal pool elevation	1.5
End of Construction	1.3
Rapid draw-down (upstream slope)	1.2

1 Not applicable for embankment dams on clay shale foundations; residual shear strength may be appropriate and required factors of safety shall be determined on a case-by-case basis by the State Engineer.

5.9.4.1.3 For Low hazard or NPH dams, the State Engineer may waive the requirements for stability analysis if it can be demonstrated that conservative slopes and competent materials are used in the dam design. Dams classified as Low hazard or NPH shall have upstream slopes no steeper than 3:1 (horizontal:vertical), and downstream slopes no steeper than 2:1 (horizontal:vertical).

5.9.4.2 Seepage and Internal Drainage Design - The evaluation of the steady state seepage and internal drainage conditions shall be performed for all High and Significant Hazard Dams. The seepage and internal drainage analyses shall include, but not be limited to, the following:

5.9.4.2.1 Flow nets or numerical analysis computer programs shall be used in the analyses. Data sheets and output files from these analyses shall be provided or made available where requested. The hydraulic conductivity parameters used in these analyses shall be obtained from field permeability tests, laboratory permeability tests, or empirical/correlative permeability determinations, and the sources of the estimated hydraulic conductivities shall be clearly documented.

5.9.4.2.2 The analyses shall quantify the anticipated seepage beneath, around and through the dam. Seepage exiting on the downstream face of the dam shall not be permitted. Internal drains and filters shall be constructed of granular soil materials (sands and gravels), and the filter and drain zones shall be of sufficient thickness to be constructed without significant contamination or loss of continuity that would adversely impact the performance of these features.

5.9.4.2.3 The filter compatibility of the drain and embankment material shall be evaluated utilizing current state of the practice methodologies, such as those published by the Natural Resources Conservation Service, the U.S. Bureau of Reclamation or the U.S. Army Corps of Engineers.

5.9.4.3 For embankment dams, the following design considerations must be addressed and documented in the Design Report.

5.9.4.3.1 Geometric and Design Requirements - Dam geometry shall be supported by the slope stability and seismic analysis, and shall meet the following minimum requirements:

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.

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.

5.9.4.3.1.3 Guidelines for minimum dimensions of impervious core zones for zoned embankment dams up to 50 feet high are defined in the "Design of Small Dams," United States Department of the Interior, Bureau of Reclamation, Third Edition, 1987, U.S. Government Printing Office, Washington, D.C., 20402, (later amendments, editions or subsequent publications not included). Zone dimensioning for dams over 50 feet shall be evaluated using industry standard analyses.

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.

5.9.4.3.1.5 The crest design shall include details to protect impervious cores from desiccation or frost penetration, as approved by the State Engineer.

5.9.4.3.1.6 The crest shall be provided with adequate cross slopes to the upstream edge to prevent ponding.

5.9.4.3.1.7 Minimum dimensions for internal granular filter and drain zones shall meet requirements of Rule 5.9.4.2.

5.9.4.3.1.8 The embankment shall be protected against external erosion.

5.9.4.3.1.9 The downstream slope of the embankment dams shall be provided with a well maintained vegetative cover to prevent surface erosion from occurring. No landscaping or planting of trees or large vegetation shall be permitted within 25 feet of the footprint of the dam.

5.9.4.3.1.10 The shear strengths of the foundation soils (including suitable factors of safety) shall not be exceeded under any foreseeable loading conditions.

5.9.4.3.1.11 Seepage through the embankment, abutments, and foundation shall be controlled to prevent internal erosion and external sloughing.

5.9.4.3.2 Compaction Requirements - Material compaction requirements shall meet the minimum requirements:

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) or 90 percent for ASTM D1557 (Modified Proctor), as found in the 2006 "Annual Book of ASTM Standards", Section 04.08, Soil and Rock; 100 Barr Harbor Drive, West Conshohocken, PA 19428, (later amendments, editions or subsequent publications not included). Impervious zones with clay fines shall be controlled using Standard Proctor criteria to maintain the plastic nature of the material; and

5.9.4.3.2.2 The minimum density for cohesionless materials shall be 65 to 75 percent relative density as determined by ASTM D4253 and D4254 as found in the 2006 "Annual Book of ASTM Standards," Section 04.08, Soil and Rock; 100 Barr Harbor Drive, West Conshohocken, PA 19428, (later amendments, editions or subsequent publications not included).

5.9.4.3.3 Rock Riprap - Rock Riprap shall be well graded, durable and sized to withstand design wave action or channel velocities, and shall be placed on a well-graded pervious sand and gravel bedding or geotextile fabric. Soil cement for erosion protection may be used in lieu of rock riprap, but shall be designed and constructed in accordance with standards acceptable to the State Engineer. Slope protection for wave action is required to be provided on the entire upstream face of the dam, unless lesser coverage is justified based on engineering analysis and reservoir operational criteria and approved by the State Engineer.

5.9.4.3.4 Filters and Drains - The design of all drains, filter blankets, and toe drains shall be performed in accordance with Rule 5.9.4.2 and must be acceptable to the State Engineer.

5.9.4.3.5 Internal Drain Pipes - Pipes to collect and distribute seepage flows from internal filters and drains shall:

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.

5.9.4.3.5.2 Be surrounded with free-draining material that is filter compatible with the surrounding earth material in accordance with current filter criteria of such organizations as the Natural Resources Conservation Service, the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers.

5.9.4.3.5.3 Have slots or perforations that are filter compatible with the surrounding free-draining material in accordance with current filter criteria of such organizations as the Natural Resources Conservation Service, the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers.

5.9.4.3.5.4 Be installed in such a manner to be accessible for internal camera inspection and repair.

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.

5.9.4.3.5.6 Be no smaller than 6 inches in diameter.

5.9.4.3.5.7 Discharge into locations where discharge flows can be evaluated and monitored, such as galleries, manholes, or daylight (ground surface) areas.

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.

5.9.4.3.5.9 Be equipped with rodent screens in locations where the discharge ends of the pipes are accessible to animals.

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.

5.9.4.3.6 Geosynthetics - The use of geosynthetics shall be evaluated by the State Engineer on a case-by-case basis for each dam. Geosynthetics materials shall be used in accordance with the manufacturers' recommendations and intended use for each product. Use of geosynthetics shall comply with the following general design considerations:

5.9.4.3.6.1 Geosynthetics will not be accepted where the geosynthetic is the sole element employed to perform a function that is an element of the dam were failure of the geosynthetic, could result in a catastrophic release of the reservoir. Redundant design features are required whenever geosynthetics are used for these functions.

5.9.4.3.6.2 The use of a geotextile as a filter layer may be allowed if the geotextile is placed such that it does not jeopardize the stability or safety of the dam or appurtenant structures due to failure of the geotextile (such as clogging), and the geotextile can be repaired or replaced without jeopardizing the stability or safety of the dam.

5.9.5 **Concrete Dam Design Requirements**

5.9.5.1 For concrete dams, the following design considerations must be addressed and documented in the Design Report

5.9.5.1.1 Access to the dam crest shall be provided from at least one of the abutments of the dam. Access shall be provided to the side of the dam where the control of the outlet works used for the emergency release of the reservoir volume is situated.

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

5.9.5.1.3 Concrete dam crests, if designed as emergency spillway, shall not be overtopped for floods more frequent than the 100-year storm. Emergency spillway discharge for flows up to the inflow design flood shall not cause excessive downstream erosion of the abutments and foundation.

5.9.5.1.4 If the design of the concrete 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 dam and foundation drains.

5.9.5.2 Arch Dam Design - Concrete arch dams are not specifically addressed in these Rules and shall be designed in accordance with principles provided in U.S. Bureau of Reclamation publication "Design of Arch Dams," 1977 or U.S. Army Corps of Engineers publication “Arch Dam Design” EM 1110-2-2201 1994, (later amendments, editions, or subsequent publications not included).

5.9.5.3 Gravity Dam Design - Concrete gravity dams (conventional or roller compacted concrete (RCC)) shall be designed in accordance with the following Rules and with principles provided in U.S. Bureau of Reclamation publication "Design of Gravity Dams," 1976, or U.S. Army Corps of Engineers publications “Gravity Dam Design” EM 1110-2-2200 1995 and “Roller-Compacted Concrete” EM 1110-2-2006 2000 (later amendments, editions or subsequent publication not included).

5.9.5.3.1 The structural stability and stress analyses of a concrete gravity dam for both non-overflow and spillway sections shall be performed using the gravity method of stress and stability analysis, as described in the aforementioned publications. The trial-load twist method of analysis may be used for the stability analysis when keyed or grouted transverse contraction joints are provided. The finite element method may be used to supplement the gravity method and to investigate specific features where areas of maximum stresses may occur within the dam and foundation.

5.9.5.3.2 Loads to be considered as a minimum in the stability and stress analyses are as follows: dead weight of the dam and appurtenant structures, headwater and tailwater pressures, uplift pressures in the dam and foundation, earth and silt pressures, ice pressure, seismic forces, and temperature, if appropriate. Ice pressure shall be equivalent to a force of 10,000 pounds per linear foot applied at one foot below the normal water surface elevation.

5.9.5.3.3 Concrete gravity dams shall be designed for full hydrostatic uplift pressures along appropriate planes within the dam and foundation. The uplift pressure shall vary linearly from full hydrostatic pressure at the upstream face of the dam to the tailwater pressure at the downstream dam face or zero if no tailwater conditions exist. Reduction in the uplift pressures will be allowed when dam and foundation drains are provided. The effectiveness of the drains will be required to be verified and monitored through the installation of piezometers.

5.9.5.3.4 The following loading conditions shall be investigated in the design of a concrete gravity dam, as a minimum. Other loading condition could be required depending on site conditions:

5.9.5.3.4.1 Usual Loading Condition - Reservoir at the normal water surface with minimum tailwater pressure, uplift pressures, and earth, silt and ice pressures, if applicable.

5.9.5.3.4.2 Unusual Loading Condition - Usual loading condition with no ice pressure and with hydrostatic pressures as a result of the

flooding condition produced by the appropriate inflow design flood.

5.9.5.3.4.3 Extreme Loading Condition - Usual loading condition with no ice pressure and with seismic forces in the downstream direction.

5.9.5.3.5 The minimum factors of safety and allowable stresses as a result of the loading condition shall be as provided in Table 5.6:

TABLE 5.6 Minimum Factors of Safety and Allowable Stresses for Concrete Gravity Dams

Loading Condition	Resultant Location within Base	Min. Sliding Factor of Safety	Concrete Compressive Stress	Concrete Tensile Stress
Usual	Middle 1/3	3.0	0.3 f'c	0
Unusual	Middle 1/2	2.0	0.5 f'c	0.5 ft
Extreme	Within Base	1.0	0.9 f'c	1.0 ft

5.9.5.4 Roller Compacted Concrete Design Requirements - Design of new RCC dams shall meet all requirements for concrete dams regarding field investigations, testing, foundation treatment, stability and stresses. RCC dam design shall also meet the following additional requirements:

5.9.5.4.1 An RCC mix design study shall be submitted with the design report, containing proposed aggregate data, source of aggregate, strength test results, and proposed cementitious contents.

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

5.9.5.4.3 Design dimensions shall be constructable with conventional earthwork equipment, particularly between the upstream face of the dam and the drainage gallery, and the "chimney section" width.

5.9.5.4.4 Adequate cold joint treatment shall be provided in the specifications to prevent formation of unbonded lift joints that are potential paths of seepage.

5.9.5.4.5 RCC dams with a structural height of 100 feet or higher shall be designed with a drainage gallery, when dam and foundation drains are provided.

5.9.5.4.6 Specifications shall include provisions for placing RCC under cold weather, hot weather, and rain.

5.9.5.4.7 RCC spillway chute steps shall be protected with conventional facing concrete, or equivalent protection, unless the State Engineer approves a

lesser standard for good cause shown. 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.

5.9.5.4.8 Outlet works gate and spillway towers shall be designed as temporary free-standing tower, if structures are proposed to be completed before any RCC placement.

5.9.5.5 Roller Compacted Concrete Dam Construction Requirements - The construction of RCC dams shall meet the following additional requirements.

5.9.5.5.1 An RCC test section shall be constructed outside the dam footprint at least 21 days before production placement of the RCC. The final design mix and the method of construction shall be approved by the SEO prior to production placement.

5.9.5.5.2 The Owner shall provide full-time qualified field observation during RCC production placement.

5.9.5.5.3 Locations of all cold joints shall be documented.

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.

5.9.5.5.5 Because a RCC dam can be completed within a short period of time, the dam shall be allowed to gain adequate strength before initial filling of the reservoir.

5.9.5.6 Concrete Slope and Overtopping Protection - The design of RCC and soil-cement dam rehabilitation shall meet the following additional requirements.

5.9.5.6.1 Soil-cement mix design shall meet guidelines of Portland Cement Association or the U.S. Bureau of Reclamation.

5.9.5.6.2 Soil-cement slope protection shall be designed for a minimum 56-day strength of 750 psi for durability considerations.

5.9.5.6.3 Soil-cement shall not be used for emergency spillway or embankment overtopping protection, unless it can be demonstrated that the soil-cement can withstand the anticipated flow rates and velocities.

5.9.5.6.4 RCC emergency spillway or RCC embankment overtopping protection shall not operate for floods more frequent than the 100-year storm.

5.9.5.6.5 Normal thickness of soil-cement or RCC shall be a minimum of 2 feet.

5.9.6 **Spillway and Outlet Works Design Requirements**

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.

5.9.6.1.1 The spillway flows must be safely routed back to the natural channel or drainage way that would exist if the dam were not built. Where the

spillway channel discharges into an adjacent basin, apart from the drainage on which the dam is located, the owner shall possess title to the property, a right-of-way, or easement for the flood channel downstream to the location where the maximum discharge would no longer cause damage beyond what naturally would occur on the adjacent drainage.

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.

5.9.6.1.3 Pipe emergency spillways are not acceptable.

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 table.

5.9.6.1.5 For floodwater detention and flood control dams, the required principal spillway and outlet conduit discharge rate shall be coordinated with the Division Engineer for the Water Division in which the dam is located.

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:

5.9.6.2.1 The outlets for High Hazard dams shall be capable of releasing the top five feet of the reservoir capacity in five days, and for all other classes of dams as required by the State Engineer. 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. For all other Hazard dams, the outlets should be sized to draw down the reservoir under emergency conditions in a reasonable period of time, as determined by the State Engineer.

5.9.6.2.2 All principal outlets connected to a pipeline shall have a by-pass valve that will meet the capacity criteria as defined in Rule 5.9.6.2.1.

5.9.6.2.3 Outlet conduits for all dams, except for dams with un-gated outlets, shall have a guard gate installed at the upstream end of the conduit

5.9.6.2.4 Intake structures for outlet works shall have trash racks unless exempted by the State Engineer for good cause shown.

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.

5.10 **Reservoir and Water Diversion Requirements**

5.10.1 **Reservoir and Site Requirements**

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

5.10.1.2 Borrow areas shall be located at least 200 feet from either toe of the dam. The dimension of this limit may be reduced using engineering analyses indicating that the reduced dimension will not negatively impact dam stability and/or foundation seepage.

5.10.1.3 The dam crest and appurtenant structures shall be accessible by equipment and vehicles for emergency operations and maintenance.

5.10.1.4 The dam owner shall possess title to the property, or a permanent easement, including permanent access, for a minimum distance of fifty feet or the height of the dam, whichever is greater, downstream from the downstream toe of the dam for the purpose of maintenance and the removal of trees and large vegetation along the downstream toe of the dam.

5.10.1.5 Pipelines, utility lines or any other construction that penetrate 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. To be considered for approval, such penetrations must be designed to protect against seepage and piping through trench backfill materials and avoid temporary or permanent impacts to dam stability, and must be documented with as-constructed survey data and installation details submitted to the State Engineer.

5.10.1.6 The design of a new reservoir or enlargement of an existing dam and reservoir shall not result in the inundation of properties (except marina-type structures) during the Inflow Design Flood (IDF) unless the dam owner owns or obtains flood right-of-ways for all areas which may be inundated by the reservoir surcharge. The owner shall submit a written statement certifying they own the properties, or own the right-of-way on all affected properties, or possess a right-of-way easement for the reservoir inundation zone.

5.10.1.7 Flood easements for spillway discharges shall meet the requirements of Rule 5.9.6.1.1.

5.10.2 **River Diversion During Construction Requirements**

5.10.2.1 A water diversion plan to control surface water during construction meeting the requirements of Rule 9 may be developed by the construction contractor based on information and requirements provided by the Engineer, or the Engineer may prepare these plans.

5.10.2.2 In developing the requirements of the plan during the project design, the design storm for the construction period, including the estimated volume or flow rate that must be managed during construction should be clearly specified in the Design Report.

5.10.2.3 The contractor may be allowed flexibility to develop the methods and means to divert the water in coordination with other aspects of the construction.

5.10.2.4 Regardless of who prepares the detailed water diversion plan, the plan must be prepared and submitted to the State Engineer for review in advance of construction of the diversion facilities in accordance with Rule 9. The plan must

be prepared under the direction of a qualified Professional Engineer registered in the State of Colorado.

5.10.2.5 The water diversion plan meeting the intent of Rule 9 should include the following items.

5.10.2.5.1 Design drawings and specifications depicting the constriction of cofferdams, spillways, conduits, gates, or other temporary features that may be required to control the water.

5.10.2.5.2 Stability analysis of the cofferdam, under both normal and design flood loading condition.

5.10.2.5.3 Hydraulic calculations showing the capacity of spillways or conduits used for diversion.

5.10.2.5.4 The plan for the removal or abandonment of cofferdams, spillways, conduits, or other temporary features after construction is complete.

Rule 6. Requirements for Alteration, Modification, or Repair of an Existing Dam:

6.1 An owner proposing to alter, modify, or repair an existing dam shall submit an application package in a form acceptable to the State Engineer and receive approval of the construction plans and specifications from the State Engineer prior to construction. The provisions of Rule 6 shall apply to such application only to the extent directly related to work for which approval is being sought.

6.1.1 **Design Requirements -** The requirements of Rule 5 shall apply except as modified by Rules 6.1.2 and 6.1.3. A Hydrology Report, Geotechnical Report, Design Report, and Instrumentation Plan are required as a minimum to support the scope of the work described on the application.

6.1.2 **Application and Approval Requirements for High Hazard, Significant Hazard, and Large, Low Hazard Dams -** Plans for repair of an existing dam, or alteration of existing High Hazard, Significant Hazard, and Large, Low Hazard dams to non-jurisdictional size may be approved by the State Engineer by letter without meeting requirements set forth in Rules 5.2 and 5.3, subject to the following conditions:

6.1.2.1 A completed application form provided by the State Engineer shall accompany appropriate specifications and necessary drawings depicting minimum details for the repair or alteration. Plans and specifications must be prepared by an engineer. The provisions of Rules 5.6, 5.7, and 11 shall apply.

6.1.2.2 The plans and specifications shall contain sufficient detail to enable a contractor to prepare a bid and construct the repair, or alter the dam to non-jurisdictional size. The provisions of Rule 9 shall apply. The engineer shall give the State Engineer not less than 7 days notice of the start of construction.

6.1.2.3 Upon completion of repair or alteration, the engineer shall file as-constructed plans in conformance with Rule 5 and Rule 10.

6.1.2.4 The requirement for submitting as-constructed plans for altering an existing jurisdictional size dam to non-jurisdictional size dam will be determined by the State Engineer.

6.1.3 **Application and Approval Requirements for Small and Minor, Low Hazard and NPH Dams -** Plans for repair of Small and Minor, Low Hazard dams, or NPH dams; and plans for the alteration of all Low Hazard or NPH dams to non-jurisdictional size are exempt from the provisions of Rules 5, 6, 9, and 10, except as specified in Rule 6.1.3.1 through Rule 6.1.3.3.

6.1.3.1 Notice - The dam owner must provide at least thirty days advanced written notice to the State Engineer. The written notice must contain the name of the dam, the location of the dam, the name of the owner, and a clear description of the work to be performed.

6.1.3.2 Determination - If the State Engineer determines that plans and specifications prepared by an engineer are necessary for the repair, the owner will be notified within five working days from the date the owner's notice was received. A cost estimate and filing fee will also be required. The owner cannot begin construction until the plans and specifications are approved by the State Engineer. If plans and specifications are not required, the State Engineer will inform the dam owner of engineering and construction requirements, if any, and will perform construction inspections as determined necessary.

6.1.3.3 Project Completion - The dam owner must keep the State Engineer informed of the project status and provide the State Engineer with as-constructed drawings and specifications within sixty days following completion of the work. The as-constructed drawings must be drawn on good quality mylar with permanent ink (or equivalent), and the drawings shall be reproducible, and suitable for a long lasting permanent record.

6.1.4 **Inflow Design Flood Requirements -** The inflow design flood (IDF) requirements for all existing dams shall be determined in accordance with Rule 5. Structures with spillways designed and approved prior to 1988 and in accordance with the methods published in the U.S. Department of the Interior, Bureau of Reclamation, "Design of Small Dams," Second Edition 1973, (later amendments, editions or subsequent publications not included) shall be considered adequate for the original hazard classification. If the classification has changed, then the provisions of these Rules and specifically Rule 5 apply.

6.1.4.1 The methods of Rule 5 apply, but may be reduced for good cause shown. Spillways designed in accordance with these Rules will not be required to be enlarged due to subsequent revisions in ESP or PMP estimates, unless, in the opinion of the State Engineer, a substantial increased threat to public safety exists.

6.1.4.2 The minimum size spillway for all existing High Hazard dams and Large and Small Significant Hazard dams, for which an incremental damage analysis shows a smaller spillway is justifiable under Rule 5.9.1.7, is the spillway size required to safely accommodate the flood generated by a 24-hour, 100-year rainstorm event.

6.1.5 **Freeboard -** The minimum freeboard requirements for an existing dam shall be the maximum required to either prevent overtopping by wave action or to pass the IDF without overtopping, but not less than three feet.

6.2 **Approval Limitation -** If construction, alteration, or repair of a reservoir dam is not commenced within five years of approval of the application, the State Engineer's approval shall be void. The owner must resubmit the application and receive approval before commencing construction, and shall meet the requirements of the current Rules and Regulations.

6.3 **Design Review Limitation -** The design review performed by the State Engineer shall be limited to three years from the date of the review. Re-submittal of the design package shall be required if resolution of the design review comments does not occur within three years.

Rule 7. Requirements for Removing or Breaching an Existing Dam:

7.1 **Breach Plan and Application -** An owner proposing to permanently remove or breach a dam shall submit an application package in a form acceptable to the State Engineer prior to commencing work. Plans for Removal or Breach of a dam shall meet the following requirements:

7.1.1 **Application -** A completed application shall be submitted on a form provided by the State Engineer.

7.1.2 **High and Significant Hazard Dams -** For High and Significant Hazard dams, a breach plan shall be prepared by an engineer.

7.1.2.1 The dam shall be excavated down to the level of the natural ground, or as necessary in accordance with Rule 7.1.2.3, at the maximum section; and shall be of sufficient width to pass the 24-hour, 100-year flood with a maximum increase in reservoir depth of five feet. However, the maximum breach width shall not exceed the width of the original natural channel before the dam was constructed, regardless of the 100-year flood magnitude unless approved by the State Engineer for improved public safety.

7.1.2.2 The sides of the breach shall be excavated to a slope that is stable, but not steeper than 2:1 (two horizontal to one vertical). Slope stability analysis that provides an adequate factor of safety for steeper slopes may be accepted by the State Engineer, but in no case shall the slopes be steeper than 1:1.

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.

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.

7.1.2.5 The drawing(s) of the plan for the breach of a dam shall include the location, dimensions and lowest elevation of the breach.

7.1.2.6 The removal or breaching of the dam shall be performed under the purview of an engineer.

7.1.2.7 The engineer shall submit written notice of the completion of the removal or breaching of the dam along with as-constructed plans in conformance with Rule 10.

7.1.3 **Low Hazard and NPH Dams -** For Low Hazard and NPH dams the owner shall submit a written notice of intent to breach the dam to the State Engineer. The State Engineer shall determine the size of the breach in accordance with the following:

7.1.3.1 The bottom width of the breach shall be one-half the height of the dam but not less than ten feet;

7.1.3.2 The side slopes of the breach shall not be steeper than one horizontal to one vertical;

7.1.3.3 The breach shall be to original ground at the low point in the foundation of the dam; and

7.1.3.4 The excavated material shall not be placed in the stream channel.

Rule 8. Fees:

The owner shall submit with the application for construction, enlargement, alteration, modification, or repair an amount equal to three dollars for each one thousand dollars or fraction thereof of the estimated cost of construction including engineering costs, but the maximum fee shall not exceed three thousand dollars, nor shall the minimum fee be less than one hundred dollars. When an owner resubmits an application that was previously received and disapproved by the State Engineer, the owner shall submit a new filing fee in accordance with the above. Checks shall be made payable to the Colorado Division of Water Resources.

Rule 9. Construction of Jurisdictional Size Dams:

9.1 **High and Significant Hazard Dams -** For all High and Significant Hazard dams, the owner shall provide an engineer experienced in dam design and construction, who shall be responsible for the following:

9.1.1 **Plan for Construction Observation -** Not less than 30 days prior to construction, the engineer must submit to the State Engineer a general plan for construction observation. The construction observation plan shall include:

9.1.1.1 The date of the start of construction;

9.1.1.2 Names and qualifications of the engineer and staff to be used on the project;

9.1.1.3 A construction observation schedule for the engineer and staff;

9.1.1.4 For dams on rock foundations, a schedule for observations of the foundation by a geologist, or engineering geologist;

9.1.1.5 A schedule for inspection of the gate installation by the gate manufacturer or its representative unless waived by the State Engineer;

9.1.1.6 Identification of the firm that will conduct the construction material tests in the field and in the laboratory; and

9.1.1.7 A schedule of the construction material tests.

9.1.2 **Approval -** Within ten working 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.

9.1.3 **Pre-Construction Meeting -** Subsequent to submitting the construction observation plan, but no later than two weeks prior to commencement of construction, a meeting shall be held between the engineer, dam owner, State Engineer and the general contractor. The general contractor shall develop and thoroughly explain its construction control plan along with any anticipated construction difficulties. During this meeting, the means used to divert and care for the stream during construction will be identified by the contractor; and if reasonable, the plan will be approved by the State Engineer. The name of the contractors and any principals in charge 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.

9.1.4 **Engineer's Observation -** The engineer shall observe the construction of the dam. It is the engineer's responsibility to observe the progress and quality of the construction to determine whether the construction is proceeding in accordance with the approved plans and specifications. 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. To assure independent review and proper quality assurance, in cases where the engineer has a contractual relationship with the general construction contractor to provide engineering services, the owner shall provide an independent, third-party engineer to perform the engineering quality assurance observations.

9.1.5 **Construction Records -** The engineer shall maintain a record of construction that, as a minimum, shall include: daily activity and progress reports; all test results pertaining to construction; photographs sufficient to provide a record of foundation conditions and various stages of the construction through completion; all geologic information obtained; and construction problems and remedies.

9.1.6 **Progress Report -** A construction progress report summarizing the contents of Rule 9.1.5 shall be submitted to the State Engineer every 30 days or more frequently if directed by the State Engineer. A summary report of all the items in Rule 9.1.5 shall be submitted at the end of construction in accordance with Rule 10.

9.1.7 **Notice for Inspection -** The engineer shall give the State Engineer at least five days advance notice of initial materials placement on the dam's foundation, in the cutoff trench, outlet backfill, outlet foundation and any appurtenance requested by the State Engineer in the approval of the plan for construction observation, to allow for observation by the State Engineer.

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, must be provided by the engineer to the State Engineer. No change shall be executed until approved by the State Engineer. Major changes must be submitted in writing with supporting documentation, and approved in writing by the State Engineer. Minor changes may be transmitted verbally by the engineer and approved by the State Engineer verbally.

9.1.9 **Final Inspection -** The engineer shall give the State Engineer at least 10 days advance written notice prior to the projects final construction inspection.

9.1.10 **Completion of Construction -** The engineer shall notify the State Engineer of the completion of the construction in accordance with Rule 10.

9.2 **Low Hazard and NPH Dams -** Low Hazard and NPH dams require the owner to provide an engineer experienced in dam design and construction, who shall be responsible for the following:

9.2.1 **Construction Plan -** Not less than 30 days prior to construction or as soon as possible for dams whose construction season is affected by freezing weather, the engineer shall notify the State Engineer in writing of the date construction will begin, the name of the engineer in charge of the project, and the name of the contractor.

9.2.2 **Engineer Observation -** The engineer shall observe, or provide for the observation by a qualified technician directly responsible to the engineer, the construction work on the

dam, the cutoff trench, and outlet works foundation to see that they are in substantial accordance with the approved plans. The engineer shall endeavor to guard against defects and deficiencies in the construction of the dam, and shall disapprove or reject work failing to conform to the approved plans and specifications.

9.2.3 **Inspection, Testing and Reporting -** Tests of construction materials shall be taken and inspections of the construction made to verify that the work is completed in accordance with the approved plans and specifications. Periodic progress reports shall be submitted as requested by the State Engineer. The engineer shall compile a record of all tests conducted, and any problems and remedies, for submittal to the State Engineer at the end of construction.

9.2.4 **Change Orders -** Change orders shall be submitted in accordance with Rule 9.1.8.

9.2.5 **Final Inspection -** The engineer shall give the State Engineer at least 10 days advance written notice prior to the projects final construction inspection.

9.2.6 **Completion of Construction -** The engineer shall notify the State Engineer of the completion of construction in accordance with Rule 10.

Rule 10. Acceptance of Construction of Jurisdictional Size Dams:

10.1 **Acceptance of Construction -** Construction for which application has been made pursuant to Rule 5 or Rule 6 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, unless temporary approval of storage is granted by the State Engineer. The acceptance shall specify the vertical height, freeboard, length of the dam, the capacity of the reservoir in acre-feet, and any limitation upon, or requirements for the use of the dam. The State Engineer shall furnish the acceptance or denial within 60 days of receipt of a complete notification of completion.

10.2 **Construction Completion Documents -** The engineer shall provide the following construction documentation within 60 days of the final construction inspection in order for the project to be deemed complete:

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

10.2.2 As-constructed drawings that meet the format requirements of Rule 5;

10.2.3 A final construction report containing the following information, if applicable, in accordance with the requirements of Rule 9; a summary of construction, problems encountered, and solutions implemented to resolve the problems; a summary of construction material tests and geologic observations; photographs of construction from exposure of the foundation to completion of construction;

10.2.4 A record of the location of permanent monuments and instrumentation as well as installation details and initial surveys and readings shall be submitted, if applicable;

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. No filling schedule is required for minor dams rated Low Hazard and all NPH dams or if waived by the State Engineer for good cause shown. The dam owner, however, shall monitor the dam frequently during the first filling; and

10.2.6 A long-term instrumentation monitoring plan for new dams and enlargements (except for minor Low Hazard and all NPH dams) that shall include: the frequency of monitoring; the data recording format; graphical presentation of data; and, the parties who will perform the work.

10.3 The engineer shall provide periodic review of the data included in the long-term monitoring plan on at least an annual basis for the first five years, whereupon the monitoring shall continue in accordance with Rule 15. The engineer shall submit the data and a written assessment of the dam's performance to the State Engineer annually.

10.4 Upon written request by the owner and for good cause shown, the State Engineer may temporarily approve storage of water prior to full compliance with Rule 10. The written request shall include a schedule for compliance with Rule 10, a certification letter signed and sealed by the engineer in accordance with Rule 10.2.1, a schedule for the first filling of reservoir in accordance Rule 10.2.5, and a monitoring plan for observing the behavior of the dam and appurtenances during the initial filling or refilling of the reservoir. For High and Significant Hazard dams, an Emergency Action Plan prepared in accordance with Rule 16 shall be developed by the owner and approved by the State Engineer prior to placing any water in the reservoir. 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 10 have been satisfactorily completed.

10.5 The engineer and/or owner shall submit an Emergency Action Plan that conforms to Rule 16 within 60 days after the final construction inspection.

Rule 11. Construction, Modification, Alteration, Repair, and Breach of Non-jurisdictional Size Dams:

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, must submit notice of the intent to construct the dam on forms provided by the State Engineer not less than 45 calendar 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 determine if the submittal of plans and specifications and approval of the plans and specifications by the State Engineer 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 45 days after receipt of the complete notice of intent to construct form. All dam owners shall be required to comply with the applicable dam safety and water administration requirements.

11.2 **Modification or alteration to Non-jurisdictional Size Dam -** Jurisdictional size dams proposed to be modified or altered to non-jurisdictional size shall comply with the following requirements:

11.2.1 For High or Significant Hazard dams, the owner shall submit plans for approval in accordance with Rule 6.1.2.

11.2.2 For Low Hazard or NPH dams, the owner shall submit written notice of the intent to alter the dam to the State Engineer in accordance with Rule 6.1.3.

11.2.3 The engineer shall submit written notice of the completion of the project and file as-constructed plans in conformance with Rule 10.

11.3 **Repair and Breaching of Non-jurisdictional Dams -** Repair and breaching of existing non-jurisdictional size dams shall meet the following requirements:

11.3.1 Owners who intend to repair, modify, breach or entirely remove a non-jurisdictional dam shall submit written notice to the State Engineer prior to construction.

11.3.2 High or Significant Hazard non-jurisdictional size dams shall have the plans for repair or breaching prepared by an engineer and submitted to the State Engineer for approval before construction. The plans shall be of sufficient detail to allow review and provide for the quality control of the work and must meet the requirements of Rule 7.1.2, if the dam is being breached.

11.4 **Spillway Requirements -** Spillway sizing requirements shall meet the criteria for the appropriate hazard classification of the dam for a Minor size dam as specified in the appropriate Table of Inflow Design Flood Requirements in Rule 5.9.1.

11.5 **Construction of Non-Jurisdictional Size Dams under Rule 11 -** The construction of non-jurisdictional size dams under these provisions with freeboard in excess of five feet with the intent to convert the dam to a jurisdictional size structure with only minor modifications to the spillway will not be approved. The modification of a non-jurisdictional size dam to a jurisdictional size dam will not be permitted within 10 years of the construction of the original structure and/or without meeting the requirements of Rule 5.

Rule 12. General Maintenance, Ordinary Repairs, and Emergency Actions:

12.1 **General Maintenance -** General maintenance and ordinary repairs that do not require prior approval of the State Engineer for the purpose of this Rule shall be those activities that do not impair the safety of the dam. These maintenance and repair activities include:

12.1.1 Removal of brush or tall weeds.

12.1.2 Cutting of trees and removal of slash from the embankment or spillway. Removal of small stumps is acceptable provided no excavation of more than 3 feet into the embankment occurs. An engineer must oversee removal of trees and stumps larger than 12" diameter.

12.1.3 Rodent control, removal or extermination. Repair of minor rodent damage is acceptable provided it does not involve excavation of more than 3 feet into the embankment.

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

12.1.5 Surface grading of the embankment crest or spillway to eliminate potholes and provide proper drainage provided that the freeboard is not reduced. Material placed on the dam crest to restore the design freeboard must be compacted to specifications outlined in Rule 5. The State Engineer must be provided notice prior to placement of material on the dam crest of greater than 1 foot in depth for approval. Placement of material in excess of 1 foot in depth to provide freeboard is not considered general maintenance.

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 where the damage has not yet resulted in weakening of the dam. An engineer must oversee restoration of the embankment.

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

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

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

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

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

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

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.

12.2 **Excavation and Determination of General Maintenance -** General maintenance and ordinary repair which may impair safety such as excavation into or near the dam, construction of new appurtenant structures for the dam, and repair of damage which has already significantly weakened the dam must be done in accordance with Rule 6. When questions arise concerning this Rule, the determination of general maintenance and ordinary repair will be made by the State Engineer.

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 being addressed. Additional remedial actions may be required after the emergency passes. Emergency actions may include:

12.3.1 Stockpiling materials such as riprap, earthfill, sand, sandbags and plastic sheeting;

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;

12.3.3 Armoring eroding areas by placing sandbags, riprap, plastic sheeting, or other available material;

12.3.4 Plugging leakage entrances on the upstream slope;

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

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

12.3.7 Constructing training berms to control flood waters;

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

12.3.9 Removing obstructions from outlet or spillway flow areas.

12.4 **Emergency Excavation -** Lowering the water level by excavating the spillway or embankment is prohibited unless failure is imminent.

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.

12.6 **Emergency Action Plan -** For all High and Significant Hazard dams, the Emergency Action Plan must be implemented in conjunction with any emergency actions taken in accordance with Rule 12.

Rule 13. Determination of Safe Storage Level:

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. The reservoir owner shall not store water in excess of the amount so determined by the State Engineer to be safe.

13.2 **Restriction of Storage -** If the dam safety inspection or information from other reliable sources reveals problems affecting the safe storage level of the reservoir, the State Engineer will issue an order restricting reservoir operations until the problems have been resolved. The dam owner shall comply with the restriction order at all times. The restriction order will be removed or modified by the State Engineer only after receipt and approval of engineering evaluations which indicate that the problems have been adequately remediated and after completion of required repairs.

13.3 **Review of Potential Hazard Classification -** As part of the determination of safe storage level, the State Engineer will periodically review the classification of existing dams by evaluating the consequences of failure applying the definitions of Rule 4. If the State Engineer's review indicates the consequences of failure have increased or decreased due to changes in development within the dam failure inundation area, the State Engineer will assign an appropriate new classification and will require that, the dam meet the requirements of these Rules as they apply to the new classification, within a reasonable period of time.

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

14.1 **Owner Safety Inspection -** An owner may provide a safety inspection report to the State Engineer regarding 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 report if said report is written by a qualified engineer, as defined below. The owner's engineer must notify the State Engineer and submit a written summary of qualifications at least 14 days prior to the scheduled safety inspection.

14.2 **Engineer Qualifications -** An engineer shall be considered qualified to provide information to the State Engineer regarding the safe storage level of a reservoir if the engineer meets the following minimum qualifications:

14.2.1 Registration as a professional engineer in Colorado;

14.2.2 Three years of experience in the field of dam safety; and

14.2.3 Experience in conducting safety inspections of dams.

14.3 **Scope of Inspection -** Dam safety inspections by the owner's engineer shall include, but are not limited to: review of previous inspections, reports and drawings; site inspection of the dam, spillways, outlet facilities, seepage control and measurement system; and evaluation of data from permanent monument or monitoring installations, if any. The inspection shall include an assessment of all parts of the dam which are related to the dam's safety. (See Rule 15.1 for outlet inspection requirements.) The engineer shall prepare an inspection report that describes the findings, and lists actions the dam owner must take to improve the safety of the dam to an acceptable level. The report shall include the engineer's recommendation of the safe storage level.

14.4 **Retaining an Engineer -** If the owner elects to retain an engineer to conduct safety inspections, such inspections shall be conducted in accordance with current policies and Rules of the State Engineer.

Rule 15. Dam Owner's Responsibilities:

15.1 **Outlet Inspection -** It is the dam owner's responsibility to provide for inspection of outlet facilities associated with the dam. The frequency of outlet inspections and the requirements of those inspections are as follows:

15.1.1 High and Significant Hazard dams shall receive a Type A outlet inspection in conjunction with safety inspections, and Type B inspections at least once every ten years unless the condition indicates more frequent inspections are necessary. A Type B inspection of the entire outlet conduit shall only be required on dams without upstream gates if ordered by the State Engineer in conformity with Rule 15.1.4. Type B inspections may be waived where the condition of the outlet conduit would not be considered detrimental to the safety of the dam.

15.1.2 Low Hazard and NPH dams shall receive a Type A outlet inspection in conjunction with routine periodic safety inspections of the dam. A Type B inspection may be required by the State Engineer to determine the safe storage level.

15.1.3 Type A outlet inspections shall consist of observation of exposed surfaces of the inlet and discharge structures, control valves or gates and vaults; a test of the outlet valve(s) for proper operation, observation of the downstream end of the conduit and adjacent embankment for leakage; and observation of the dam (upstream slope, crest, downstream slope or natural ground) in the vicinity of the outlet alignment for signs of distress which would indicate failure of the outlet system.

15.1.4 Type B outlet inspections shall consist of a complete Type A inspection, a close inspection of the interior of the conduits, outlet wells, and access ways, and operation of the outlet valve(s) or gates through the full operating range. In cases where the conduits are too small for a person to safely enter, the owner shall provide for an inspection using video or other remote sensing equipment capable of detecting flaws or imperfections within the conduit. A written report of inspection findings, including the opinion of the owner's engineer, must be submitted to the State Engineer unless waived by the State Engineer for good cause. A Type B inspection of the normally inundated outlet conduit of a dam without upstream guard gates shall be required only when existing baseline data available to the State Engineer is inadequate to permit an evaluation of the condition of the outlet conduit. Thereafter, such inspections shall only be required if the criteria set forth in ACER Technical Memorandum No. 6, U.S. Department of the Interior, Bureau of Reclamation, 1985, (later amendments, editions or subsequent publications not included) indicates the need for an inspection. In ordering such inspections, the State Engineer shall coordinate with the dam owner and make all reasonable efforts to prevent expense and waste of water consistent with ensuring dam safety.

15.1.5 At 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, the dam owner shall inform the State Engineer in writing. The dam owner is responsible to provide for inspection of outlet facilities associated with the dam and may take advantage of the low water level conditions to perform the necessary outlet inspection. The State Engineer may require an inspection of the conduit when conditions warrant and/or based on the period of time since the last outlet inspection.

15.2 **Owner Observations -** The owner is responsible for ensuring frequent observation of the dam, unless prohibited by weather or difficulty of access to the dam, especially at times when the reservoir is full, during heavy rains or flooding, and following an earthquake. When the reservoir water level is greater than half the full storage capacity, High and Significant Hazard dams shall be observed at least twice a month, and a Low Hazard dam shall be observed at least every three months. The observations shall be conducted in accordance with methods acceptable to the State Engineer. Conditions which threaten the safety of the dam must be reported to the State Engineer in accordance with the Emergency Action Plan for High and Significant Hazard dams as soon as reasonably possible, after discovery of the conditions. If dam failure appears imminent, the county sheriff (or local emergency manager) must be immediately notified. The owner is responsible for the safety of the dam and shall take action to lower the reservoir if it appears that the dam has weakened or is in danger of failing.

15.3 **Monitoring Instrumentation -** The owner of a dam is responsible for installing, maintaining, and monitoring the required instrumentation. All instrumentation plans shall be submitted to the State Engineer for review and approval prior to installation of instrumentation, survey monuments, weirs, flumes or other measuring devices.

15.3.1 The following minimum instrumentation is required on existing dams; however, the State Engineer may require additional instrumentation when he deems it necessary.

15.3.1.1 High Hazard dams shall have survey monuments to monitor horizontal and vertical movement of the dam and appurtenant structures, and weirs, flumes or other structures that are acceptable to the State Engineer to monitor seepage. Installation of piezometers to measure the internal water surface of the embankment or adjacent abutments and foundation of the dam may be required by the State Engineer for determination of the safe storage level in the reservoir.

15.3.1.2 Significant and Low Hazard dams shall have weirs, flumes or other structures that are acceptable to the State Engineer to monitor seepage. Significant Hazard dams may require piezometers be installed as described in Rule 15.3.1.1.

15.3.1.3 All dams shall have gage rods pursuant to Rule 5.

15.3.2 The dam owner shall measure seepage during each routine observation of the dam. Owners of High Hazard dams shall also be responsible for providing first order surveys of horizontal and vertical movement monuments. These surveys 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. 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.

15.3.3 The dam 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 by the State Engineer.

15.3.4 The dam owner shall promptly notify the State Engineer of any abnormal changes in the dam based on the results of evaluation of instrumentation data, as compared to historical patterns and trends.

15.4 **Responsibility for Maintenance -** The owner is responsible for adequate and timely maintenance of the dam. The owner shall establish an annual maintenance plan to ensure that the maintenance, as identified in Rule 12, is accomplished.

15.5 **Trash Racks -** The owner shall ensure that trash racks are installed on all outlet structures unless waived in writing by the State Engineer.

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

Rule 16. Emergency Action Plans (EAP):

16.1 **Emergency Action Plans (EAP) -** Owners of High and Significant Hazard dams shall prepare and maintain an Emergency Action Plan. An EAP is a formal document that identifies potential emergency conditions at a dam and specifies preplanned immediate actions to prevent failure of the dam, reduce the potential for loss of life, and minimize property damage downstream. An EAP shall contain, as a minimum, the following key elements:

16.1.1 **Emergency Condition Detection -** The conditions, incident, events, or measures for detection of an existing or potential emergency shall be described.

16.1.2 **Emergency Level Determination -** Guidance shall be provided for classifying the emergency level following incident detection using the system of:

16.1.2.1 Emergency Level 1 - A non-emergency incident, unusual event, or slowly developing situation, which not mitigated endanger the structural integrity of the dam or result in uncontrolled release of water causing flooding downstream;

16.1.2.2 Emergency Level 2 - Potential dam failure situation, rapidly developing, and;

16.1.2.3 Emergency Level 3 - Urgent, dam failure is imminent or in progress.

16.1.3 **Notification and Communication -** Prioritized notification lists and flowcharts applicable to each of the emergency levels shall be provided to enable communication and notification of the emergency level and with applicable Local, State and Federal emergency agencies, engineering and construction support personnel, the State Engineer's office, and other affected parties as appropriate.

16.1.4 **Expected Actions -** Description of actions necessary to prevent a dam failure incident or to help reduce the effects of a dam failure and facilitate response to an emergency, including, but not limited to, identification of equipment, manpower, and material available for implementation of the plan.

16.1.5 **Inundation Mapping -** A dam failure inundation map for High and Significant Hazard dams showing the stream which will be flooded, including urban and rural impacts. Inundation mapping for High and Significant Hazard dams shall contain the following minimum information:

16.1.5.1 - Inundation mapping for High Hazard dams shall show the calculated extents of the dam breach flood wave. Include cross sections at critical locations showing lateral and vertical flood extents, flood wave velocity and flood wave arrival time. Inundation mapping shall be extended downstream to a location where no potential for loss of life and no significant property damage exist.

16.1.5.2 - Inundation mapping for Significant Hazard dams shall show the route of the dam breach flood wave, the estimated time of arrival of the flood wave at critical sections, and the estimated lateral extent of inundation. The inundation mapping shall be extended downstream to a location where no significant property damage exists. The inundation mapping requirements for Significant Hazard dams may be modified for good cause, with the approval of the State Engineer.

16.1.6 **Termination -** A description of the roles and responsibilities for declaring that the emergency or incident at the dam is terminated, and a discussion of the requirements for follow up evaluation including, but not limited to, documenting the event in a summary report.

16.2 **EAP Guidelines -** The State Engineer's guidelines are available to aid in the preparation and/or revision of EAPs for all High and Significant Hazard dams.

16.3 **EAP Distribution -** The owner shall submit a copy of the EAP to the Colorado Division of Emergency Management (CDEM), all emergency response coordinators involved in the plan, and other affected parties, as necessary. A distribution list that includes the names and contact information for all parties who have been provided with a copy of the EAP shall be included in the EAP. The owner shall incorporate reasonable recommendations from the CDEM, the State Engineer, emergency coordinators, and other parties affected by the plan.

16.4 **EAP Updates -** The owner shall review the EAP annually and update as necessary and appropriate. The updates shall be distributed to all parties shown on the distribution list.

16.5 **EAP Testing -** The owner shall test the EAP as necessary to ensure the effectiveness of the EAP, that the EAP is up to date, and to obtain information for revisions or corrections, as deemed necessary. All Revisions and corrections shall be distributed to all parties on the distribution list.

Rule 17. Exempt Structures:

17.1 **Exempt Structures -** Existing or proposed structures not designed or operated for the purpose of impounding water above the natural surface of the ground other than flood detention are exempt from these Rules. Exempt structures include:

17.1.1 Highways, road-fills, and railroad embankments with an ungated outlet conduit;

17.1.2 Diversion dams if less than jurisdictional size, and all diversion dams of any size if Low Hazard or NPH;

17.1.3 Refuse embankments (e.g., solid waste disposal facilities); and,

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

17.2 **Mine Tailing Impoundments -** Mill tailing impoundments which are permitted under the Colorado Mined Land Reclamation Act, sections 34-32-101 through 125, C.R.S. or the Colorado Surface Coal Mining Reclamation Act, sections 34-33-101 through 137, C.R.S. are exempt from these Rules. Any solution process impoundment permitted under the Colorado Mined Land Reclamation Act, or the Colorado Surface Coal Mining Reclamation Act, are exempt from these Rules and Regulations. Siltation structures which are permitted under the Colorado Surface Coal Mining Reclamation Act, sections 34-33-101 through 137, C.R.S. are exempt from these Rules.

17.3 **Uranium Mill Tailing Dams -** Uranium mill tailing and liquid impoundment dams permitted under the authority of the Colorado Department of Public Health and Environment are exempt from

these Rules. Raw and potable water dams, sewage effluent dams, and water treatment sludge dams associated with the uranium mill are not exempt.

17.4 **Livestock Water Tanks -** Livestock Water Tanks as defined in the Livestock Water Tank Act of Colorado, Sections 35-49-101 through 116, C.R.S., are exempt from these Rules.

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

Rule 18. Restriction of Recreational Facilities within Reservoirs:

18.1 **Restriction on Construction -** 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 bottom of the spillway unless:

18.1.1 The facility is constructed to withstand partial or complete inundation without significant damage; or

18.1.2 The facility is necessary to the operation of the reservoir; and

18.1.3 The facility is capable of being restored with a minimum amount of cleaning or expense. Boat ramps, docks, and marinas are exempt from these Rules.

18.2 **Existing Facilities -** This Rule does not apply to facilities completed prior to July 1, 1984, but shall apply to any subsequent enlargements or modifications to such facilities.

18.3 **Construction Requirements -** Any person planning on constructing, enlarging, or modifying any facility coming under this Rule shall notify the State Engineer in writing 180 days in advance of construction. The notice shall include the following information:

18.3.1 The name and location of the reservoir and/or dam;

18.3.2 Whether the recreational facility is new, or an enlargement or modification to a facility completed prior to July 1, 1984;

18.3.3 A description of the facility, its intended purpose, and its location within the reservoir including depth below the high water line; and

18.3.4 A description of how the facility will be able to withstand the damage from the inundation without a significant amount of cleaning or expense to restore it.

18.4 **Approval Prior to Construction -** No person shall be allowed to construct, enlarge, or modify any facility coming under this Rule until approved by the State Engineer.

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 dam owners under the foregoing Rules in particular cases if, in the State Engineer's judgment, dam safety will not be reasonably impaired and the circumstances of the individual case so warrants. Such circumstances may include, but are not limited to, 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 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 section 1.1.4(2)(vi) of the Division of Water Resources' Procedural Regulations, 2 CCR 402-5. Such request must be made within thirty (30) days of the date of the State Engineer's determination and must identify the person(s) requesting the hearing and the basis upon which they believe error was committed in the determination. 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 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 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 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 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 1.1.3.B.2.

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 25. Effective Date:

These Rules shall become effective on January 1, 2007.

Editor's Notes

History