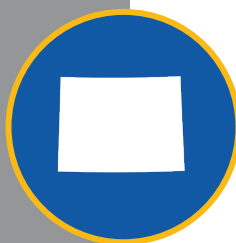


COLORADO DEPARTMENT OF
NATURAL RESOURCES

DAM SAFETY DESIGN

State of Colorado

PREPARING FOR **EXTREME RAINFALL**



CLIMATE CHANGE **CHALLENGES**



CLIMATE-READY **DESIGN**



Probable Maximum Precipitation (PMP) is the greatest accumulation of precipitation for a given duration that is meteorologically possible for a given area at a particular time of year. PMP is a key variable used to determine how to design high hazard dams to withstand flooding. Federal guidelines for PMP estimation have not been updated since 1988, and many storms used in that analysis were from the 1970's. Between 2016 to 2018 the Colorado Dam Safety Program decided to use the best available science to update PMP estimates and rules and regulations for dams in Colorado. A Colorado – New Mexico Regional Extreme Precipitation Study (CO-NM REPS) studied the potential impacts of climate change on extreme rainfall estimates. Dam Safety officials from Colorado and New Mexico worked with federal and state agencies, climate experts and meteorological consultants to develop 21st century PMP methodologies for their states.

Clusters of dam failures have already been observed during recent extreme storms. Warming temperatures are expected to increase the magnitude of extreme precipitation events and increase the risk of future extreme storms and flooding. The CO-NM REPS study projected increases in both temperature and moisture availability in the region. The report provided recommendations for the states to account for these likely climate change influences on extreme precipitation.

After evaluating the CO-NM REPS study, Dam Safety officials decided to increase PMP estimates by 7%. This Atmospheric Moisture Factor was recently approved by the State Engineer to be implemented in dam safety rules and regulations across the state. The Colorado State Climatologist, and representatives of NOAA's ESRL/PSD, both supported the Rule making and use of the "best available science". The new Rules will add a 7% increase to all rainfall estimates used for Colorado dam design, effective on January 1, 2020. This work cost \$1.65 million USD and was funded by the Colorado Water Conservation Board and the State of New Mexico.

COLORADO DAM SAFETY



SPOTLIGHT ON THE SCIENCE

The REPS project supported an in-depth climate change analysis and literature review with partners from the Western Water Assessment (WWA), University of Colorado, Boulder and CIRES, and NOAA. The study used Climate Model Intercomparison Project 5 Global Climate Model (CMIP5 GCM) output of projected 10-year maximum precipitable water for moderate and high greenhouse gas emissions scenarios out to the year 2070. The projections indicated a 2°F of warming and corresponding 7% increase in water vapor. Colorado Dam Safety officials considered multiple options to incorporate climate change projections

1. **Qualitative considerations** of climate risk such as the use of residual "freeboard" in design to create a buffer for flood routing. No specific methods or approaches for adding an additional buffers were provided.
2. **Devise a probabilistic framework** and range of PMP adjustments for engineers to choose from based on different risk tolerances for each design or upgrade.
3. **Incorporate a consistent PMP adjustment** based on climate model data.

Dam Safety officials ultimately chose option 3, a consistent 7% adjustment that is simple yet scientifically robust. Dam Safety Rules are typically updated every decade, and officials can use the update processes to take stock of climate impacts and adjust the PMP if needed at the time.

THE ROLE OF STAKEHOLDERS

Colorado Dam Safety led the PMP updating process, and engaged stakeholders and a Project Review Board comprised of subject matter experts from partner agencies including; U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, NOAA ESRL/PSD, NOAA National Weather Service, Federal Energy Regulatory Commission, Federal Emergency Management Agency, United States Geological Survey, and the Nuclear Regulatory Commission. Multiple dam owners from Colorado and New Mexico also participated in workshops and provided their perspectives on the study. Dam owner participation was considered a key factor in the success of Colorado Dam Safety rule and regulation updates.



KEY TAKE-AWAYS

The outcomes of the study have led to improved decisions and reduced uncertainty for dam owners and dam regulators in Colorado and New Mexico. Standards based on the new tools have been developed and adopted, and these will inform the design, evaluation, approval, and construction of spillways for new dams, enlargements, and rehabilitation projects. In addition, this project will see benefits that extend far beyond Colorado and New Mexico. The study, and its extensive review board of national experts, was designed with a larger vision: to ultimately serve as a national model for other states to follow. Presently, no national standards or guidance exist for the consistent development and application of extreme precipitation estimates for state dam safety programs. The Standards of Practice developed in this study outline steps that other states and regions can follow to produce scientifically valid results in a consistent manner.

LEARN MORE

For more information about CO DNR and its other climate change work contact:

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