STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY **GAVIN NEWSOM**, *Governor*

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Alfred E. Alquist SEISMIC SAFETY COMMISSION
2945 Ramco Street, Suite 195
West Sacramento, CA 95691

Subject: Department of Water Resources (DWR) – Seismic Safety Summary Report

Dear Salina Valencia:

Enclosed please find the Department of Water Resources (DWR) Seismic Safety Summary Report.

Assembly Bill No. 100, Section 8589.75 requires numerous agencies at various levels of government to annually report substantial responsibilities and efforts undertaken in the fields of earthquake preparedness and seismic safety. Accordingly, This report summarizes DWR's multiple seismic safety risk reduction and recovery programs, conducted through its Division of Operations and Maintenance, Division of Engineering, Division of Safety of Dams, and Division of Flood Management. This report intends to highlight DWR's role within the State's overall earthquake risk reduction and post disaster economic recovery goals, while fulfilling DWR's mission to sustainably manage the water resources of California, in cooperation with other agencies, to benefit the state's people and protect, restore, and enhance the natural and human environments.

If you have any questions, please contact Taylor Kanaan at Taylor.Kanaan@water.ca.gov or (916) 882-2369.

Sincerely,

John Paasch
Deputy Director, Security and Emergency Management Program
Executive Division

Enclosures

State of California
California Natural Resources Agency
Department of Water Resources

Seismic Safety Summary Report

November 25, 2022

EXECUTIVE SUMMARY

The Department of Water Resources (DWR) is committed to public safety and performs numerous planning and management activities for seismic safety throughout California. DWR remains vigilant and constantly monitors seismic activity with a network of state-of-the-art equipment in more than 100 locations. These instruments provide timely information about the intensity of earthquakes which can be used to estimate the potential for damage to critical infrastructure. This information is used to help prioritize post-earthquake inspections, evaluate how infrastructure respond to earthquake shaking, and guide design decisions for future seismic retrofit projects.

DWR is currently conducting a thorough evaluation to prioritize upgrades for all State Water Project (SWP) facilities, including 26 dams and 36 water storage facilities. Making the necessary seismic retrofit investments to protect California's water system are a top priority for DWR.

Due to California's unique geology and seismic activity, the seismic resiliency of non-federal state jurisdictional sized dams across the state are paramount. DWR's Division of Safety of Dams (DSOD) is entrusted with regulating approximately 1,240 dams across California to safeguard life and property from dam failures. Evaluating dams for seismic stability has been a part of DWR's mission for decades, and DWR regularly works with dam owners to mitigate seismic deficiencies. More than $4 billion has been spent on dam construction, enlargement, alterations, and repairs at over 150 dams over the last decade.

DWR also works closely with local and federal agencies to monitor and improve the state's aging flood control infrastructure. DWR finalized the Delta Flood Emergency Management Plan (DFEMP), which details preparedness, response, and recovery activities in the event of earthquake-induced flooding in the low-lying, heavily leveed region of the Sacramento-San Joaquin Delta.

To prepare to respond to a major earthquake, DWR integrates planning, engineering, and operations activities to build resiliency. DWR evaluates flexibility in operations, performs recurring assessments, and continually expands emergency response capabilities.

1.0 INTRODUCTION

DWR's mission is to sustainably manage the water resources of California, in cooperation with other agencies, to benefit the state's people and protect, restore, and enhance the natural and human environments. Under this mission, DWR performs numerous planning and management activities for seismic safety throughout California, some of which include:

- The development, operation, and maintenance of the California State Water Project (SWP).
- The implementation of a comprehensive and system-wide approach to dam safety, flood protection, and emergency management.

This report summarizes DWR's multiple seismic safety risk reduction and recovery programs and meets the requirements of Assembly Bill No. 100, Section 8589.75.

2.0 STATE WATER PROJECT

Since the 1960s and 1970s the SWP has been supplying water to almost 27 million Californians and 750,000 acres of farmland through California Water Code authorities. It spans more than 705 miles from Northern California to Southern California and includes 36 storage facilities, 30 pumping and generating plants, and approximately 700 miles of canals, tunnels, and pipelines. Figure 1 below shows the locations of primary SWP storage and water delivery facilities. Planned, built, operated, and maintained by DWR, the SWP is the nation's largest state- owned water and power generator and user-financed water system.

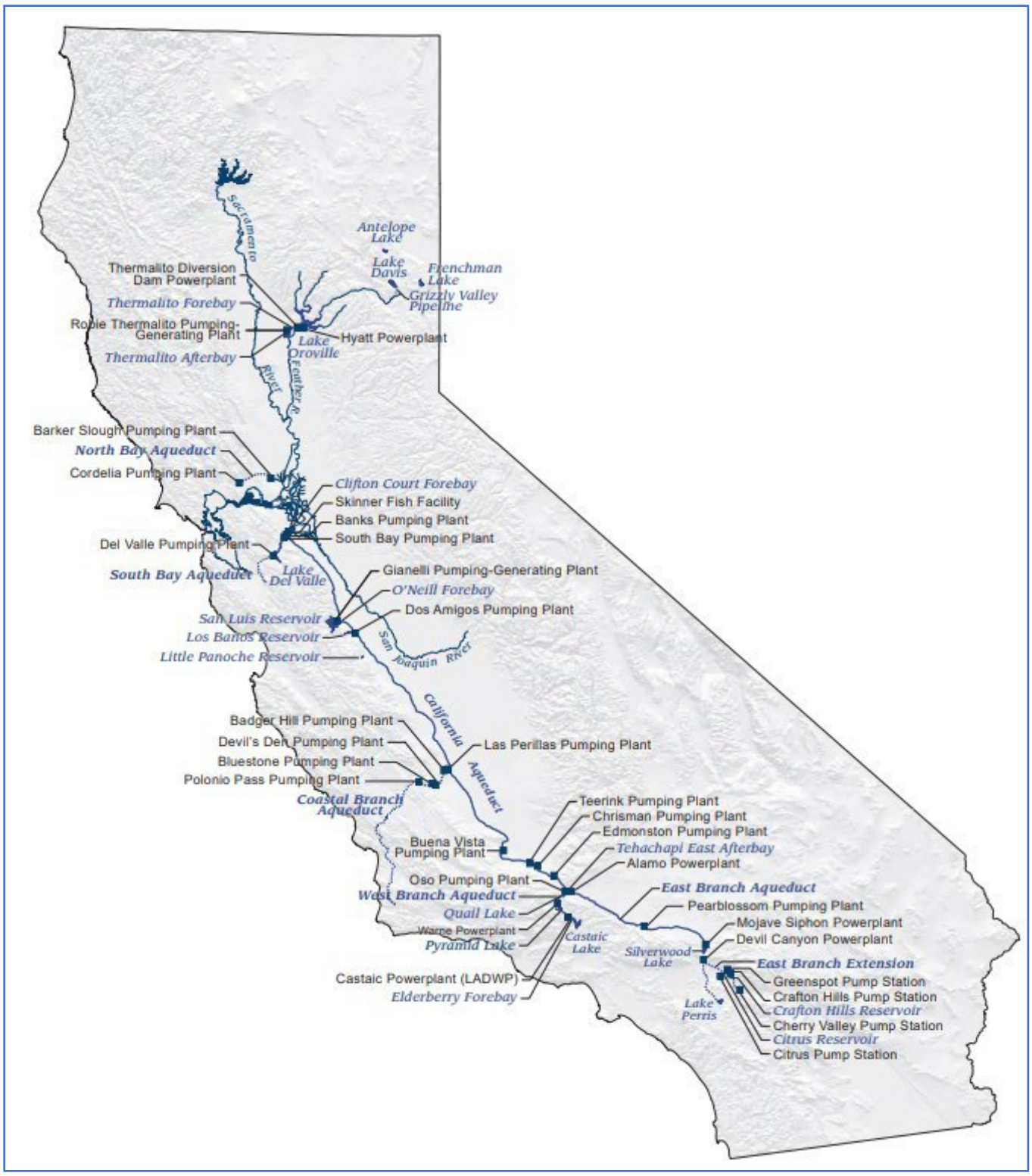

Figure 1: Map of California showing the names and locations of primary SWP storage and water delivery facilities.

Public safety is the highest priority for DWR in its management and operation of the SWP. To ensure public safety, as well as reliable water deliveries and power generation, DWR continually monitors and evaluates seismic activities that could affect the SWP. Major portions of the California Aqueduct are located parallel to and near the San Andreas Fault and other active faults. The SWP's conveyance facilities cross seismically active faults at multiple locations. Figure 2 shows faults in California in relation to the SWP conveyance facilities. SWP pipelines that cross active faults are typically located above ground or at shallow depths to make repairs easier if they are damaged by fault movement.

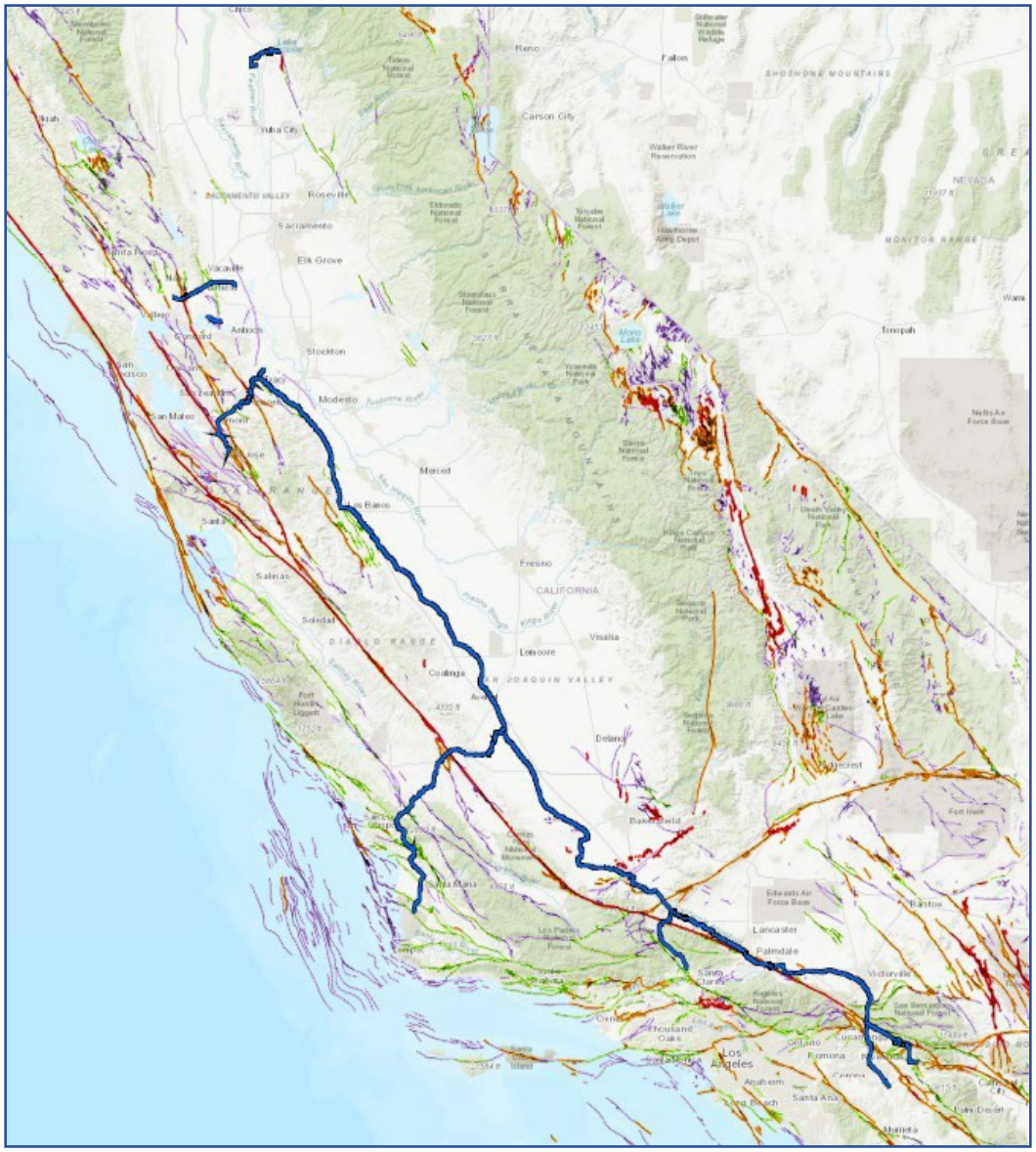

Figure 2: Shows faults in California in relation to the SWP conveyance facilities.

2.1 DIVISION OF OPERATIONS AND MAINTENANCE

The Division of Operations and Maintenance (O&M) manages the SWP to ensure adequate water supplies are available under various hydrologic and legal conditions while maintaining operational flexibility. O&M also develops, plans and operates the SWP to meet environmental and regulatory requirements, which also apply to the seismic safety programs and projects.

2.2 DIVISION OF ENGINEERING

The Division of Engineering (DOE) provides timely, cost-effective, and quality engineering, geology, construction, geodetic, and administrative services to the public, state water contractors, State, and federal agencies, and other DWR organizations. As such, DOE has historically maintained responsibility for many seismic components required by DWR's programs. These responsibilities vary and are typically dependent on the needs of the programs, such as the Delta Seismic Program and the SWP Seismic Criteria. Some seismic studies, analyses, and investigations are funded by other divisions such as O&M's Dam Safety Program. The SWP Seismic Program is intended to fill the gaps between all the DWR's programs that involve seismic investigations to ensure that a comprehensive approach is being executed. DOE has a $2 million budget over the next five years for the SWP Seismic Program.

2.3 SWP SEISMIC PROGRAM AND PROJECTS

DWR is updating its monitoring systems, performing studies, updating design guidelines, and modernizing SWP facilities across the state.

2.3.1 MONITORING

DWR owns, operates, and maintains seismic monitoring instruments to record ground and structure movement at or near SWP facilities. DWR monitors earthquake activity within the state as well as in nearby states. O&M uses the ShakeCast system developed by the U.S. Geological Survey to send out automatic notifications to staff when post-earthquake inspections are necessary (see section 3.2 for more information). DWR is about three years into a 10-year, $2.5 million effort to modernize its seismic monitoring network.

DWR's Emergency Preparedness Program has created post-earthquake inspection procedures and forms to document seismic-related damage to SWP facilities. DWR inspects SWP facilities following earthquake activity based on estimated shaking intensities at critical facilities. If necessary and based on the earthquake damage, DWR will implement its SWP Emergency Action Plans.

DWR recognizes that seismic monitoring in California continues to be a shared effort between numerous State, federal, research, and other private agencies. To support this effort and maximize the value of seismic data collected, DWR shares its seismic data with members of the California Integrated Seismic Network to assist their efforts to report on significant earthquake activities. DWR also shares seismic data to support the California Earthquake Early Warning System.

2.3.2 STUDIES AND DESIGN GUIDELINES

Delta Seismic Study

The Delta Seismic Study includes geotechnical and seismic assessments, studies, and evaluations of conditions of the levees in the Sacramento-San Joaquin Delta region to gain a better understanding of Delta geology and seismicity. These studies inform DWR's approach for seismic design and analysis of SWP facilities located in and around the Sacramento and San Joaquin Delta. DWR is installing strong motion monitoring system and accelerometers and conducting dynamic response studies of Delta soils including liquefaction analyses, fault sources, ground motions and site response.

SWP Seismic Loading Criteria - Review and Update

The Seismic Loading Criteria Report provides design engineers with guidelines for selecting appropriate seismic loading criteria for a wide variety of SWP facilities, including dams, canals, pipelines, tunnels, check structures, bridges, buildings, utility overcrossings, and pumping and power plants. The seismic design load should be selected based on the criticality of a facility and consequences of its failure.

Because the state of practice in earthquake engineering and seismology continually changes, this document is periodically reviewed and updated to ensure that SWP facilities are always in step with current practice. DOE conducts a review of the Seismic Loading Criteria Report roughly every five years and updates it as needed.

SWP Seismic Studies Program - Statewide

This program evaluates faulting and seismicity in California and the related risks posed by earthquake events affecting SWP facilities. The studies in this program cover statewide initiatives and include development of current state-of-practice for seismic sources, fault rupture, ground motions, and the seismic evaluations and analysis of impacts and risk to existing facilities. Future studies will focus on defining seismic risk for specific study areas, which include the State Water Project facilities in Northern California, Southern California, the Sacramento-San Joaquin River Delta, the Central Valley, and other areas as necessary. These future studies will also include planning- and conceptual-level earthquake design studies and analysis for new SWP facilities located in and around seismic risk areas.

2.3.3 SWP MODERNIZATION PROGRAMS & PROJECTS

DWR is moving forward with the modernization of SWP facilities to reduce seismic and hydrologic risks. DWR will assess the SWP dams and associated appurtenant structures and undertake construction activities to ensure those function safely. Work on most of the projects described below began in 2019.

Perris Dam Remediation Project

The Perris Dam Modernization Project addresses seismic risks that could impact water deliveries and the safety of surrounding communities. In 2005, DWR began the Perris Dam Modernization Project with the seismic retrofit to the dam embankment. The retrofit included several upgrades, such as strengthening the dam's foundation with over 320,000 cubic yards of cement deep soil mixing (CDSM) and adding 1.4 million-cubic-yards of embankment material to buttress the downstream of the 130-foot tall, earthen Perris Dam. When the remaining project components are completed in 2026, DWR will achieve its goal of upgrading its infrastructure to protect water system and enhance public safety. The estimated project cost is $265 million dollars, with roughly $52 million of the funding coming from the Proposition 84 bond.

Sisk Dam Remediation Project

The Sisk Dam Remediation is a joint project between U.S. Bureau of Reclamation and DWR that will add stability berms and other physical features to the existing 3.5-mile-long earthen B.F. Sisk Dam to reduce risks associated with a large seismic event.

Construction on the multi-year project began in the summer of 2022 and is anticipated to be complete in 2028. The estimated cost is $1.1 billion.

Pyramid Dam Modernization Program

In 2019, DWR began assessing the condition of the facility and possible improvements to the emergency and gated spillways. The gated spillway is used approximately once per year and the emergency spillway has never been used. DWR wants to continue safe operations of the gated spillway and emergency spillway if used. DWR conducted seismic evaluations of the gated spillway to determine if any retrofits are necessary to ensure it will work appropriately in the event of an earthquake. Currently, DWR is performing a safety assessment, which will inform DWR's prioritization of projects that will reduce risks associated with the facility.

Castaic Dam Modernization Program

The Castaic Dam Modernization Program began in 2018 and involves reducing seismic risk to the intake tower and access bridge, evaluating the spillway to identify and implement necessary modifications, and improving dam safety monitoring capabilities on various dam components. DWR anticipates the modernization efforts of the program will take about 10 years to complete. To date DWR has:

- Conducted a stability analysis, which indicated the dam structure will continue to perform safely, even in the event of a major earthquake.
- Successfully completed a three-year refurbishment effort of the isolation valves to the State Water Contractor at the Castaic Outlet.
- Completed seismic retrofits of the access bridge to the outlet structures to ensure that personnel can access the outlet structures during a major earthquake.
- Completed a conceptual design report for the Tower Debris Mitigation Project.

Currently, DWR is performing a safety assessment, which will inform DWR's prioritization of projects that will reduce risks associated with the facility. The safety assessment is anticipated to be complete in 2023.

3.0 DIVISION OF SAFETY OF DAMS

Since August 14, 1929, the State of California has regulated dams to prevent failure, safeguard life, and protect property. The California Water Code entrusts dam safety regulatory power to DWR, which delegates that authority to the Division of Safety of Dams (DSOD). DSOD provides oversight to the design, construction, and maintenance of approximately 1,240 non-federal jurisdictional-sized dams in California.

3.1 INSPECTION AND REEVALUATION

Since the 1970s, DSOD has been conducting seismic reevaluations of dams and continues these efforts as the state-of-the-practice advances with respect to earthquake engineering. Dams included in these reevaluations are generally located near high-slip rate faults and could be susceptible to large deformations during a major earthquake event. As a result of these reevaluations, numerous dams have had major seismic retrofits completed over the last decades. DSOD has also conducted reevaluation programs focused on seismic-induced failure modes due to instability of dam structures, radial gate assessments associated with seismic and operational failure modes and, more recently, spillway assessments associated with hydraulic failure modes.

On February 26, 2018, Assembly Bill 1270 added section 6103 to the CA Water Code, which requires DSOD, in consultation with national dam safety and dam safety risk management organizations, to propose amendments to its inspection and reevaluation protocols to ensure public safety. DSOD convened a 14-member multi-disciplinary Technical Advisory Panel to review DSOD's dam safety program. Based on the Panel's recommendations, DSOD has recently begun incorporating risk informed decision making into its dam safety program. Risk analysis methodologies provide a tool to further comprehend the interactions of performance observations, loading probabilities, and engineering analyses to better understand the risk of failure. Risk analysis methodologies are also used to evaluate the potential for a sequence of unusual events and decisions that can lead to a system failure.

3.2 SHAKECAST AT DSOD

DSOD uses USGS's open-source ShakeCast application to provide near-real-time estimates of the severity of earthquake shaking at each dam under its jurisdiction to identify those dams potentially warranting a post-earthquake response.

The ShakeCast application continuously monitors a USGS database for new ShakeMaps, which are mapped representations of ground shaking produced after earthquakes. The application automatically downloads data when it becomes available – typically within a few minutes after the earthquake occurred. ShakeCast produces an email message detailing the time the earthquake occurred, its magnitude, and its location. It compares the intensity of ground shaking at dam locations to a pre-defined threshold set for each dam. If the shaking intensity threshold is met or exceeded, the dam is placed onto a list for potential post-earthquake response. ShakeCast emails the list of dams to DSOD engineers and engineering geologists emergency responders for assessment and possible action.

For all earthquakes that may warrant a post-earthquake response from DSOD, the list of dams from ShakeCast is ranked to address dams of high concern and highest ground shaking first. The emails also note those dams located near the earthquake epicenter that do not require a post-earthquake response.

3.3 INUNDATION MAPPING

As required by California Water Code section 6161, DSOD reviews and approves inundation maps prepared by licensed civil engineers and submitted by dam owners for extremely high, high, and significant hazard dams and their critical appurtenant structures. Inundation maps approved by DSOD are a tool used to develop emergency action plans; they are intended to provide general information for emergency planning under different dam failure scenarios, including the scenario of a Sunny Day instantaneous dam failure due to seismicity. DWR assumes no legal responsibility resulting from the use of this information. Actual evacuation zones and timing will be determined by local emergency managers who are responsible for specific evacuation procedures in an emergency event.

3.4 FUNDING

DSOD's funding comes from a Special Fund that collects fees paid by dam owners. Senate Bill 92 (Chapter 26, Statues of 2017) required DWR to adopt, by regulation, a schedule of fees to cover reasonable regulatory costs in carrying out the supervision of dam safety. These fees support a wide variety of activities, including the annual inspections of state jurisdictional dams; application review and construction inspection work; engineering studies that include hydrologic, structural, and seismic stability re-evaluations; emergency response; and review and approval of mandated flood inundation maps of dams and critical appurtenant structures for emergency preparedness. More than $4 billion has been spent on dam construction, enlargement, alterations, and repairs at over 150 dams over the last decade. Additional funding information is available on DWR's website.

4.0 DIVISION OF FLOOD MANAGEMENT

DWR's Division of Flood Management (DFM) prevents loss of life and reduces property damage caused by floods by monitoring weather and river conditions, issuing forecasts, coordinating flood response, managing emergency information, and participating in flood control projects. In 2018, DFM released the Delta Flood Emergency Management Plan (DFEMP) that provides strategies for response to Delta levee failures, up to and including earthquake-induced multiple island failures. DFEMP provides a concise, but flexible, blueprint for guiding Delta flood emergency management, and focuses primarily on the concept of operations for Delta flood emergency preparedness, response, and recovery. The plan includes the prepositioning of emergency construction materials at existing and new stockpile and warehouse sites in the Delta and developing tactical modeling tools (Delta Emergency Response Tool) to predict flood response logistics, timelines, and sequences of response actions and to restore water quality.

DFEMP has extensively coordinated with state, federal, and local emergency response agencies. In conjunction with local agencies, USACE and Cal OES, DWR conducts tabletop and field exercises to test and revise the plan under real-time conditions.

DWR and USACE provide vital Delta region response to flood and earthquake emergencies that complement Cal OES operations. The Delta Emergency Operations Integration Plan (DWR and USACE, 2019) integrates federal personnel and resources during flood emergency operations.

A 5-year update of DFEMP is currently underway. The 2018 DFEMP was funded by Proposition 1E, and the update is being funded by Proposition 1.

5.0 CONCLUSION

Assembly Bill No. 100, Section 8589.75 requires numerous agencies at various levels of government to annually report substantial responsibilities and efforts undertaken in the fields of earthquake preparedness and seismic safety. Accordingly, this report summarizes DWR's multiple seismic safety risk reduction and recovery programs, conducted through four divisions: O&M, DOE, DSOD, and DFM. This report intends to highlight DWR's role within the State's overall earthquake risk reduction and post-disaster economic recovery goals, while fulfilling DWR's mission to sustainably manage the water resources of California, in cooperation with other agencies, to benefit the state's people and to protect, restore, and enhance the natural and human environments.