

2023/2024

California Earthquake Early Warning Business Plan Update

Governor Gavin Newsom

Director Nancy Ward
California Governor's Office of Emergency Services



Cal OES
GOVERNOR'S OFFICE
OF EMERGENCY SERVICES



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1. Introduction

This is an update to the California Earthquake Early Warning (EEW) Business Plan. This update includes the following statutory report elements:

- The overall progress of the implementation of the system.
- An update on funding acquired and expended.
- An update on contracts and requests for proposals.
- A summary of recommendations made by the California Earthquake Early Warning Advisory Board to Cal OES.

California's statewide Earthquake Early Warning Program began in 2013 with Senate Bill 135 (Chapter 342, Statutes of 2013), which requires the Governor's Office of Emergency Services (Cal OES) to implement a comprehensive system within California in collaboration with other stakeholders. Since that time, Cal OES has formed numerous partnerships, including with the California Institute of Technology (Caltech), the California Geological Survey (CGS), the University of California (UC), the United States Geological Survey (USGS), and the Alfred E. Alquist Seismic Safety Commission.

Cal OES has worked with these and other partners to create a robust program to educate and prepare Californians for an earthquake and provide alerts of incoming shakes. Cal OES and its partners have funded a network of 1,115 seismic stations, which are 89 percent complete as of the date of this report. There has been advancement in multiple pathways to distribute Earthquake Early Warning (EEW) alerts, including the free MyShake app, downloaded over 3 million times, and industry specific implementation. Major upcoming initiatives include research to explore offshore detection capability, expand delivery through public television, and continue uptake and use of EEW in critical infrastructure sectors.

The current program's success in providing critical seconds to perform lifesaving actions was clearly demonstrated during three (3) substantial earthquakes at the end of 2022 and three (3) earthquakes in 2023 that led to over 13 million devices being alerted. With these real-world experiences, there is growing awareness among the public that the California Earthquake Early Warning System (CEEWS)¹ is a viable life-safety tool.

Cal OES aims to increase the opportunity for California businesses and service entities to implement automated protective actions using EEW technology. Through targeted pilot programs, Cal OES will seek to encourage the addition of

¹ CEEWS is the California portion of the national ShakeAlert system currently operating in California, Oregon, and Washington.

new ShakeAlert Pilot License Agreements (PLA) and License to Operate (LTO) vendors. This is a vital step toward making EEW ubiquitous in California society.

2. Progress of Earthquake Early Warning in California

California has made significant progress in the development and implementation of CEEWS. This system delivers EEW alerts statewide to the public through three cellphone-based pathways: the Cal OES-sponsored MyShake app, Wireless Emergency Alerts (WEA), and Android-enabled devices. Cal OES is currently working with California Public Television stations and USGS to outfit all 11 public television stations with the ability to broadcast EEW, which will be a new public notification pathway.

Engaging Industry for Implementation and Automated Protective Actions

Cal OES continues to encourage multiple sectors to implement automated protective actions that are demonstrated to save lives and property in an earthquake.

The potential for automated protective actions is a core component of the success of the California EEW Program. The ability to prevent train derailment, and signal hospitals and schools that an earthquake is about to strike is vital for the protection of California against earthquakes. Several studies have demonstrated the high benefit-cost ratio for EEW automated actions. In "Benefits and Costs of Earthquake Early Warning" (Strauss and Allen, 2016), researchers at the Berkeley Seismological Laboratory concluded that EEW could prevent \$1-1.5 billion in damage and other costs in earthquakes like the 1989 Loma Prieta Earthquake. The researchers estimated that EEW technology and automated actions could prevent half of all injuries, abate millions of dollars in losses to the technology industry, avert train derailments, and prevent many deadly fires that commonly follow earthquakes.

A critical step in the advancement of the California EEW Program is utilizing pilot projects to advance the implementation of the technology across various sectors. Current expansion efforts include partnering with the California State Transportation Agency (CalSTA), is studying the potential to integrate earthquake early warning technology and automated actions within California airports. Capabilities being assessed include alerting individuals to take action to protect themselves with *Drop, Cover, and Hold On* and activating or ceasing critical processes before shaking starts such as alerting air traffic control to ground planes and keep them from landing, shutting off valves, de-energizing control panels, and starting backup generators. Additionally, the California EEW Program is working with Cal OES Fire & Rescue to implement EEW systems and automated actions within local fire stations, such as opening bay doors—to

promote injury avoidance, reduce response impediments, and quicken overall response time—and enhancing situational awareness for firefighters. These partnerships will be crucial in the development of further projects to expand the usage of EEW throughout California.

As a major effort in 2023, Cal OES leveraged its existing connections in a sector-based approach across the state, including the California EEW Advisory Board, to recruit new users and implement automated actions. As new potential users are recruited, Cal OES has worked with USGS to rapidly move potential users through the licensing process to increase the pace and scale of end-user adoption. Additionally, the CEEW Program will continue to work with Cal OES's Hazard Mitigation Assistance program to support outreach, review, and approval of EEW projects that are eligible for Hazard Mitigation Grant Program (HMGP) and Building Resilient Infrastructure and Communities (BRIC) grants offered by the Federal Emergency Management Agency (FEMA).

Further, in partnership with UC Berkeley, Cal OES will explore the potential to bring EEW technology into schools through the integration of the MyShake app into Chromebooks that are commonly issued to the 5.8 million students in California. Desktop computers remain the primary type of work device and there are many work and school environments that disallow the use of smartphones. This pilot project plans to target critical sectors with a desktop app that will allow for MyShake to be available where they might not have access to smartphones. The MyShake app for the Chromebook would not only allow for students to have access to life saving alerts in school, but they can also take the technology home and introduce MyShake to their families.

System Operations

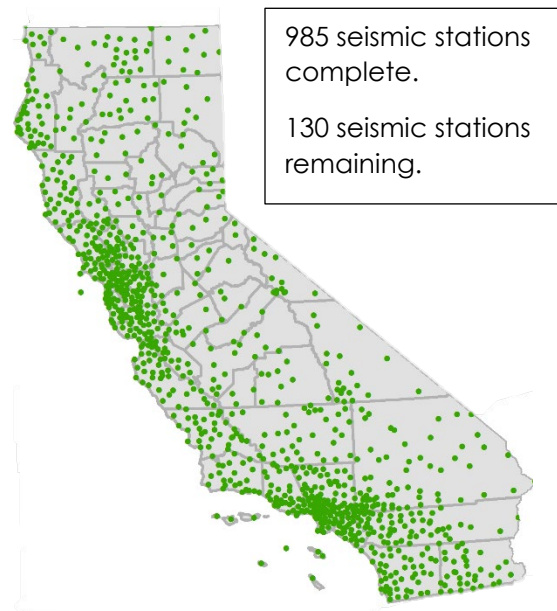
All 1,115 planned seismic stations are now funded, and 89 percent are built; future work will increase the focus on operations and maintenance.

CEEWS, comprised of seismic stations, communication equipment, and processing centers, is part of the national ShakeAlert network administered by USGS. The California EEW Program works with the California Integrated Seismic Network (CISN)² and Cal OES Public Safety Communications to maintain the equipment and the network to ensure the functionality of the system for the constant monitoring and distribution of earthquake data. With the near completion of the required sensors to reach optimal sensor density, Cal OES has transitioned focus from the build-out phase to regular maintenance and the refurbishment of legacy stations and software.

² The California Integrated Seismic Network (CISN) is a collaboration between Cal OES and the system operations partners, monitors earthquakes and collects data to support improvements to earthquake resilience. www.cisn.org.

Ongoing funding will sustain equipment and staff to perform preventative and routine maintenance to keep stations operating effectively. Seismic stations, especially free-standing field ground stations, are susceptible to damage and decay due to weather, vermin, natural disasters (e.g., fires), and vandalism. On average, thirty percent of stations per month require maintenance ranging from minor fixes, such as software updates and telemetry checks, to more extensive repairs, such as the replacement of severed cables or solar panels. Further, logistical challenges exist to deliver, install, and maintain equipment in difficult-to-reach areas throughout California.

Cal OES continues to explore the adoption of new technologies that diversify telemetry pathways. With an aim to create redundancy and promote resiliency, Cal OES is working with its partners to connect many of its stations to the California Public Safety Network (CAPSNET) for the use of its integrated microwave signal. This signal can be used for telemetry transport to CISEN data processing centers. The use of this network creates redundancy in data collection and transfer but also utilizes one of the fastest signals already available in California.



Research and Development

Research continues into creating new pathways for delivering alerts beyond the internet and cellular networks and new methods of detecting earthquakes.

Similar to the above, the development of alternative alerting pathways for CEEWS will create redundancy. Datacasting through television provides dedicated bandwidth for emergency use that can send low latency signals to datacasting enabled devices in hospitals, schools, homes, businesses, government buildings, and other critical service facilities. These low latency signals can provide resiliency during natural disasters and have the capability to contribute to automated actions. The signal can reach televisions up to 150 miles away, providing critical alerts to rural areas where cellphone and internet signals are not available. Additionally, television stations can also be supported by diesel generators, giving 3-4 days of functional usage after losing power from the electrical grid. While alert receivers can be deployed almost anywhere for public notifications, they are still being evaluated for use in automated protective actions.

In 2017, Cal OES partnered with America's Public Television Stations (APTS) and California Public Television (CPT) to leverage existing survivable broadcast infrastructure that is hardened to strict federal standards and implemented Phase I of the datacasting pilot project. Five (5) public television stations reaching 32.5 million Californians (81 percent) in Sacramento, San Francisco, Fresno, Southern California (Los Angeles and Orange County), and San Diego were included in the project. CPT was able to test the ability to broadcast alerts received from CEEWS and proved the latency of datacasting is 1-2 seconds from the time an alert is generated. Phase I saw the real-time successful test of this technology with the December 2022 Ferndale Earthquake.

With proof of concept in hand, Cal OES is granting funds to APTS and CPT to support Phase II of the pilot project which will bring datacasting capabilities to five (5) additional California Public Television stations in Eureka, Redding, Rohnert Park, Los Angeles, and one station in Reno, Nevada that supports hard-to-reach areas of eastern California. With the completion of Phase II, all areas of California serviced by public television stations will be able to receive datacast alerts. These 11 stations will reach 88 percent of California's population. Phase II also includes funding to support the development of commercial and consumer receivers that are integral to allowing end users to receive the datacast signal.

There is currently no alerting capability for earthquakes that originate on faults offshore where there are no CEEWS stations. Seventy percent of false and missed alerts are related to events that occur in the Mendocino Triple Junction, the main seismically active offshore area in northern California. The Palos Verdes fault zone in southern California is also a very active seismic area offshore. Cal OES and its partners are researching ways to reduce latency and address the lack of reliable monitoring offshore through the continued support of Distributed Acoustic Sensing (DAS). Submarine sensors are extremely expensive; however, submarine communication cables have the potential to capture near-field rupture processes of megathrust earthquakes. These fiber optic cables can transport data at near the speed of light. They can be utilized with DAS to send large amounts of data related to seismic activity.

UC Berkeley is testing this technology in Monterey Bay by using Monterey Accelerated Research System (MARS), a 52-km long submarine cable in a dense seismic array. This cable runs over the San Gregoria and San Andreas faults. The success of DAS could lead to significant advancements in the coverage of offshore areas.

Caltech has also made progress on DAS onshore, gaining access to a cable near Ridgecrest that can provide data in real-time. Continued aftershocks in Ridgecrest offer an ideal opportunity to test research and development projects related to DAS, including the conversion of DAS strain measurements into

acceleration that is measured by typical strong motion instruments used for EEW. Additionally, Caltech is exploring the possibility of using fiber optic cables to Catalina Island.

The advancement of this technology aims to improve real-time earthquake location and magnitude estimates using DAS data by focusing on:

- Fine-tuning DAS configuration parameters to optimize the signal-to-noise ratio.
- Calibrating all the cable measurement points.
- De-noising signals through time-space filtering.
- Optimizing the P-wave picking algorithms.
- Adjusting EEW algorithm filters to DAS data.

In collaboration with Caltech and UCLA, CGS has leveraged research and development investment on the Community Seismic Network, which utilizes an accelerometer and computer to detect and process motion. This sensor can track time using Network Time Protocol (NTP) instead of Global Positioning System (GPS), allowing it to function indoors and provide widespread use. This technology is being tested at the NASA-Jet Propulsion Lab (JPL) test site and throughout the Los Angeles Unified School District. In the Los Angeles Unified School District, there are currently 400 campuses utilizing this technology to test a distributed network and the sensors' capacity to help direct first responders based on peak shaking felt at each campus. This technology also has the advantage of providing a local early warning alert and potentially initiating automated actions.

Public Education & Outreach

The ongoing Earthquake Early Warning public education and outreach campaign expanded efforts include reaching socially vulnerable populations via community-based organizations.

Cal OES continues its comprehensive public awareness campaign to educate all California residents about the state's EEW system. As part of the campaign, there are ongoing, strategic efforts to educate key user groups such as local governments, first responders, medical and health care providers, businesses, the education sector,



telecommunications, critical infrastructure providers, and non-profit organizations.

Leveraging local events has produced positive results, including news coverage, partner engagement, and website traffic. In 2022 and 2023, Cal OES traveled to several cities to raise awareness of earthquake preparedness. These tours leveraged the Great California ShakeOut and other local preparedness events, reaching an audience of over 2.4 billion people and led to over 1,500 shake simulator experiences. The shared efforts encouraged residents, businesses, and critical infrastructure industries to take the necessary steps to be prepared for an earthquake, learn more about EEW and the state's EEW resources, and download the MyShake app.

Outreach efforts yielded extensive media attention during the 2022 Spring Break tour and the October 2022 and 2023 Great California ShakeOut tours. CEEWS was featured in over 140 media stories and received over \$4 million ad equivalency. A M5.1 earthquake struck San Jose a week after the October 2022 tour's conclusion. More than two million Californians received an alert through the MyShake app before the shaking reached them. During the 2023 tour, the Isleton earthquake, felt throughout the Bay Area, struck one day before the Great California ShakeOut, contributing to the overall 53,171 MyShake downloads, 507 media mentions, and \$2.4 million of total ad equivalency. The table below details notable earthquakes from 2022 and 2023 and related CEEWS statistics.

2022 Earthquakes					
Date	Location	Magnitude	MyShake Downloads*	MyShake Alerts	Android Alerts**
September 13	Santa Rosa	M4.4	30,000	21,352	400,000
October 25	San Jose	M5.1	165,000	95,272	2,100,000
December 23	Ferndale	M6.4	108,400	271,277	3,000,000
2023 Earthquakes					
May 11	Almanor	M5.5	9,000	3,938	100,000
August 20	Ojai	M5.1	43,000	194,168	5,600,000
October 18	Isleton	M4.2	19,000	389,394	1,300,000

*approximate number of downloads to the MyShake app within 48 hours of the shaking.

**approximate number of devices alerted.

Cal OES continues to conduct outreach through strategic partnerships. In 2022 Cal OES partnered with Inland SoCal and Bay Area United Way to reach low-income, difficult-to-reach, and non-English speaking communities through food banks, donated backpacks and school supplies, and health information in

various languages. These connections with the community provided opportunities to present information regarding the MyShake app and the resources available to prepare for an earthquake. Bay Area United Way also worked with the San Jose Earthquakes Soccer Club to provide outreach, displaying advertisements across the stadium. In 2023, Cal OES continued the partnership with the San Jose Earthquakes with 7.2 million social media impressions and outreach to 139,000 fans who attended their home games.

Cal OES will continue to connect and engage with disaster-vulnerable and underserved communities by working with the newly established Cal OES Office of Diversity, Equity, and Inclusion to ensure EEW is fully accessible to communities.

Across all public-awareness efforts, a core goal is to increase the number of Californians who opt-in to receiving an EEW alert. Thanks to the combined public-awareness efforts, the MyShake app has been downloaded over 3 million times. Cal OES will focus on increasing engagement with industry groups to educate them about EEW and EEW automated actions. Updated toolkits and outreach materials haven been distributed to individuals and businesses, starting with the transportation sector. Transit agencies have been early adopters of the EEW technology and can serve as roadmaps for other sectors. EEW aims to publicize these success stories to other sectors as an incentive to invest in the technology.

Public Alerting for EEW

Three cellphone-based alerting pathways now enable millions of Californians to receive EEW alerts.

Each second that can be removed from the EEW signaling process is vital time to *Drop, Cover, Hold On*. A focus for improvement is to decrease the latency by reduced time to detect an earthquake. The initial shaking, the P-wave, comes before the substantial shaking, the S-wave. Sensors collect the data from the initial shaking and send the information to processing centers. Processing centers send the signals out in shards to prevent overload of the system. Current research is focusing on

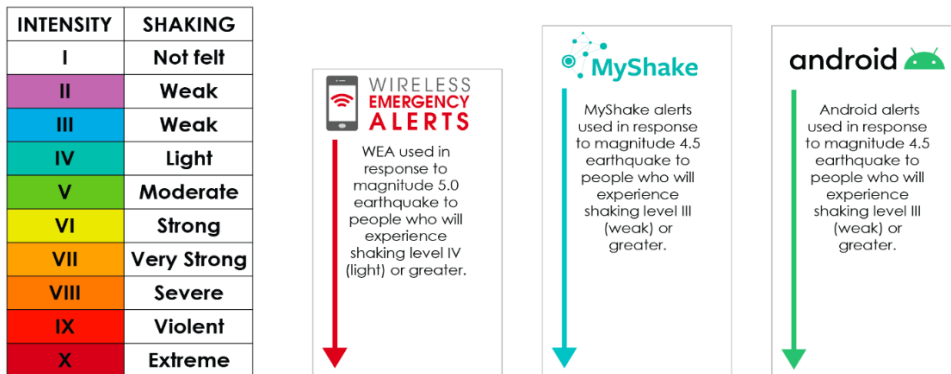


decreasing the latency of this transition to provide extra life-saving seconds by exploring how multiple algorithms can aggregate alerts using ground-motion data.

MyShake delivers alerts within a second or two after processing the earthquake. The location of the earthquake, the density of sensors, and the complexities of the geology where the earthquake strikes all affect latency. For example, when an earthquake occurs off-shore, there will be a delay in detection by the seismic station network until the P-wave reaches land. All enabled Android cellphones have EEW built into the operating system and automatically alert users with information to prepare them for what is to come.

Alerts are delivered for earthquakes M4.5 or greater to users in the areas of weak to severe shaking. Alerts will not be generated for all felt events, only those that are estimated to potentially cause injury or damage. The chart below shows the threshold at which an alert is triggered for each alerting pathway.

ALERTING THRESHOLDS



The current information sent to each phone has been available in English and Spanish and has recently become available in Korean, Vietnamese, Chinese, and Tagalog. The MyShake alert adapts to the settings on the smartphone to provide the alert in the selected language of the phone. This is a useful tool in Cal OES's outreach with partners, such as United Way, to achieve the shared goal of reaching as many users as possible, providing them with the information to protect themselves and their families.

Update on Ongoing Funding Needs

Current funding needs are slightly increased since the first Business Plan in 2018, but spending remains similarly allocated between categories.

Since 2018, and during the transition from build-out to system operation and maintenance, actual costs to maintain the system continue to be assessed. A current breakdown is as follows:

Table 1: Updated 2023 Spending Plan

EEW Stations (Including but not limited to, equipment and labor to maintain seismic and GPS stations, network infrastructure, and data processing) and MyShake app	\$ 9,945,000
Telemetry	\$ 4,060,619
Outreach and Education	\$ 650,000
Research and Development	\$ 2,000,000
Program Management	\$ 430,381
Total	\$ 17,086,000

Table 2: Updated 2024 Spending Plan

EEW Stations (Including but not limited to, equipment and labor to maintain seismic and GPS stations, network infrastructure, and data processing) and MyShake app	\$ 9,890,000
Telemetry	\$ 2,547,763
Outreach and Education	\$ 2,867,856
Research and Development	\$ 1,850,000
Program Management	\$ 430,381
Total	\$ 17,586,000

Cal OES will continually evaluate requirements as this program matures and make necessary adjustments and realize efficiencies where possible.

3. Funding

2016-17 Funding

Cal OES received the initial \$10 million one-time General Fund to contract for sensor installation, social science research, education and outreach efforts, research to improve telemetry and mass alert distribution, and consultation on the original Business Plan. The details about funding and contracts are included in Appendix A.

2018-19 Funding

Cal OES received \$15 million one-time General Fund, allocated for seismic station build-out. The details about funding and contracts are included in Appendix B. Cal OES also received \$750,000 ongoing General Fund for

California EEW Program staffing.

2019-20 Funding

Cal OES received \$16.3 million one-time General Fund for seismic station installations, continued telemetry improvements, and launching a statewide education and outreach campaign. The details about funding and contracts are included in Appendix C.

2020-21 Funding

Cal OES received a loan of \$17.3 million to the California Earthquake Safety Fund from the California School Land Bank Fund to support the California EEW System until a continuous funding stream could be established. The details about funding and contracts are included in Appendix D.

2021-22 Funding

Cal OES received \$17.3 million one-time General Fund in 2021-22 for seismic station installations to complete the build-out and to support the continuation of operations and maintenance. Cal OES entered into several contracts and agreements with system partners to encumber the funding. The details of these contracts are included in Appendix E.

2022-23 Funding

Cal OES received \$17.1 million in ongoing General Fund to support education and outreach, system operations, and research and development of CEEWS. This funding allowed the state to increase its earthquake sensor density in the rural parts of northern California and the Sierra Nevada Microwave Telemetry project. It supported operations and maintenance of the seismic network stations, enabled grants to community-based organizations to educate hard-to-reach and other underserved communities, developed strategic partnerships for the implementation of EEW technologies in critical sectors, and made progress on the installation of EEW infrastructure in the remaining public television stations. The details of these contracts are included in Appendix F.

2023-24 Funding

Cal OES will continue to receive \$17.1 million in ongoing General Fund for the operation and maintenance of the seismic network, an outreach campaign that continues to target underserved and hard-to-reach communities, research and development projects, and an implementation pilot project that will integrate EEW technology into approximately 20 fire stations throughout the state. In addition to the ongoing General Fund, Assembly Bill 102, Budget Act of 2023, provided a one-time allocation of

\$500,000 for the purpose of purchasing and distributing datacasting receivers.

4. Contracts and Requests for Proposals

In 2022-23, as in past state fiscal years, Cal OES entered into Inter-Agency Agreements and Non-Competitive Bids with system operations partners for the continued development, operation, and maintenance of the statewide seismic network infrastructure and processing centers. With the build-out of the seismic stations nearly complete, in state fiscal year 2023-24 Cal OES will focus on maintenance and operations to keep the stations, processing centers, and cloud storage devices functional. Additionally, Cal OES will continue to support updates and increased capacity for the MyShake app, while also exploring an Application Programming Interface (API) for Chromebook and Mac computers.

Implementation of the EEW system in critical infrastructure remains a priority. Cal OES is driving a strategic sector-based approach to expand the usage of the system through select pilot projects. In fiscal year 2022-23, Cal OES entered into an Inter-Agency Agreement with UC Berkeley's Resilient and Innovative Mobility Initiative (RIMI) team to study EEW implementation considerations and costs in California airports. In fiscal year 2023-24, Cal OES will select five (5) fire departments to fund the installation of EEW technology and automated actions. The departments will be selected based on their location in a community with a CDC Social Vulnerability Index (SVI) of 0.6 and above, housing a Cal OES fire apparatus, and a history of catastrophic seismic events.

Cal OES supports research and development through Inter-Agency Agreements and contracts to expand EEW technologies. Current efforts include:

- Studying the feasibility of DAS technology in EEW with additional funding allocated to Caltech and UC Berkeley. Cal OES is supporting research on the use of existing fiber optic infrastructure for earthquake monitoring to increase sensor density.
- Developing the Community Seismic Network (CSN) for structural health monitoring of EEW alerting and emergency response with additional funding allocated to CGS. CGS is working with Caltech and UC Los Angeles to collect and provide required strong motion data to evaluate the CSN performance for EEW, ShakeMap, and engineering applications.
- Continuing the datacasting pilot project, with Cal OES granting funds to APTS to fully outfit the remaining California Public Television stations with datacasting capabilities. For fiscal year 2023-24, AB 102 allowed Cal OES

to develop a grant specific to the purchase and installation of datacasting receivers in critical industry sectors.

Cal OES will continue the education and outreach efforts to increase user participation and educate Californians about earthquake warnings and how to receive them. Cal OES will combine this effort with Listos California to leverage connections to educate vulnerable communities. Education and outreach will continue targeting potential partners in industry and local government to implement automated actions from EEW alerts.

5. California Earthquake Early Warning Advisory Board

The California Earthquake Early Warning Advisory Board advises the director of Cal OES on all aspects of the program, including, system operations, research and development, and finance and investment. The Board membership consists of industry experts and leaders as follows:

- The Secretary of the Natural Resources Agency, or designee.
- The Secretary of California Health and Human Services, or designee.
- The Secretary of Transportation, or designee.
- The Secretary of Business, Consumer Services, and Housing, or designee.
- One member who is appointed by, and serves at the pleasure of, the Speaker of the Assembly and represents the interests of private businesses.
- One member who is appointed by, and serves at the pleasure of, the Governor and represents the utilities industry.
- One member who is appointed by, and serves at the pleasure of, the Senate Committee on Rules and represents county government.
- The Chancellor of the California State University, or designee, serves as a non-voting member of the board.
- The President of the University of California, or designee, may serve as a nonvoting member of the board.

The Advisory Board held its 2022 and 2023 meetings on the following dates:

- June 29, 2022
- November 3, 2022
- May 10, 2023
- December 6, 2023

The next Advisory Board meeting is scheduled for late spring 2024.

Advisory Board members have made several recommendations about the development of the program during the meetings. Key Advisory Board policy focus areas included:

Outreach Materials: Members of the Advisory Board recommend developing a toolkit specifically for educational institutions, such as UCs and CSUs, that could allow some types of EEW applications and mitigation strategies to be written and funded into grants.

Response: Toolkits were developed with feedback from board members representing the education sector and are now available.

Outreach Efforts: Members of the Advisory Board recommend that low cost preparedness items, such as earthquake putty, are draw for the public and increase education.

Response: Outreach booths have informational flyers and other educational preparedness materials.

Diversity in Outreach: Members of the Advisory Board recommend ensuring outreach targets both English and Spanish news media outlets to reach a wider audience and help increase awareness of earthquake safety and use of the MyShake app.

Response: Outreach materials are available in both English, Spanish, and Chinese. Cal OES partnered with United Way to ensure awareness of earthquake safety and preparedness reaches a wider audience across California. Outreach tours target all ethnic media outlets for interviews and includes English and Spanish speaking spokespersons. Ethnic media includes but is not limited to Chinese, Vietnamese, Korean, and Tagalog.

Outreach Events: Members of the Advisory Board recommend conducting more outreach more throughout the year. There is a lot of focus on EEW during the Great California ShakeOut in October. However, more focus needs to be brought to the program year around.

Response: In 2022 and 2023, the earthquake simulator traveled to 30 events in 18 cities. Cal OES also conducted an Earthquake Safe Spring Break Tour.

Device Technology: Members of the Advisory Board recommend an analysis on the different distribution systems (MyShake and Android) to determine success rates, accuracy, etc. Further, work needs to continue with Apple to incorporate EEW on the iPhone.

Response: Cal OES is exploring a comparative analysis of the different systems. Cal OES continues to discuss iOS integration of EEW technology with Apple.

Other Ways of Implementing EEW: Members of the Advisory Board recommend exploring other pathways for implementing EEW outside of electronic devices. For example, datacasting or partnering with automakers or vehicle fleets.

Response: Cal OES is in Phase II of a datacasting pilot project by American Public Television Stations (APTS) and California Public Television (CPT) which will add the remaining six (6) public television stations to the current datacasting network.

Streamlining Processes: Members of the Advisory Board recommend working with partners on streamlining processes, such as permitting and procurement. PG&E and Board Member Pepper offered to collaborate on this effort.

Response: Cal OES created a working group to resolve issues surrounding permitting delays.

Government Facilities: Members of the Advisory Board recommend implementing EEW in high profile buildings.

Response: Cal OES is exploring EEW implementation at buildings on a risk-informed methodology.

Visuals: Members of the Advisory Board recommend providing success stories and visuals that show what EEW implementation looks like.

Response: Cal OES is developing video success stories and working with partners on toolkits and visuals to illustrate implementation of EEW in new sectors.

Testing: Members of the Advisory Board recommend testing EEW with other systems currently in place, such as fire systems.

Response: Cal OES has had initial discussions with the Office of the State Fire Marshal to explore considerations related to EEW and existing building safety systems and regulations.

6. Long-Term Funding

The focus of EEW will be to provide reliability in system operations and strategic technological advances. Educating Californians on earthquake safety and CEEWS remains a priority as well.

The private sector is a key contributor to the implementation of EEW by expanding use of the system to protect critical infrastructure sectors and the public. Several companies are funding their own pilot projects to build and test automated actions based on EEW alerts. With a focus to expand users and increase automated actions, Cal OES aims to recruit more private partners to contribute to EEW implementation.

7. Conclusion

Now in its fifth year, EEW has proven to be a vital system that provides critical seconds for Californians to act upon an alert of an earthquake. The seismic stations built through this program have now sent alerts to millions of devices through the MyShake app, Android, and Wireless Emergency Alert pathways. As build-out nears completion, the focus has shifted to other ways of increasing and diversifying alert delivery methods, reducing alert latency, and expanding public awareness.

With the work that has been done and the advancements planned for the near future, EEW will continue to ensure the safety of all those who live, work, and visit California.

Appendix A. 2016-17 Spending Allocations

Contractor	Description	Funding Allocation
Seismic Station Installation and Maintenance		Total: \$6,484,000
California Geological Survey	70 strong motion station upgrades	\$250,000
California Institute of Technology	10 new broadband stations	\$527,000
United States Geological Survey	70 new strong motion stations	\$3,145,000
University of California, Berkeley	33 new broadband stations	\$2,562,000
Education and Training		Total: \$2,261,000
National Broadcasters Association	Public awareness campaign	\$2,138,000
California Geological Survey	Outreach to science teachers to assist in warning development	\$40,000
Cal OES Office of Public Information	Communication equipment	\$45,000
California State University, Fullerton	Research by Dr. Michele Wood to identify research gaps	\$38,000
Research and Development		Total: \$670,000
American Public Television Stations	Purchase and install equipment to attach to PBS stations to test datacasting capabilities with EEW	\$170,000
Cal OES Public Safety Communications	Demonstration project to connect stations to seismic laboratories over the state microwave network in northern and southern California	\$500,000
Finance / Business Plan		Total: \$250,000
Blue Sky Consulting	Research and production of the original Business Plan	\$250,000
Administration (6 months)		Total: \$335,000
2016-17 State General Fund Budget Allocation		Total: \$10,000,000

Appendix B. 2018-19 Spending Allocations

Contractor	Description	Funding Allocation
Seismic Station Installation and Maintenance		Total: \$7,895,000
California Geological Survey	8 new strong motion seismic stations and 24 upgraded strong motion seismic stations	\$1,380,000
California Department of Water Resources	11 new or upgraded strong motion seismic stations and 13 new or upgraded combination strong motion and broadband stations	\$1,000,000
University of California, Berkeley	55 new combination broadband and strong motion seismic stations and 5 upgraded combination broadband and strong motion seismic stations	\$5,500,000
Department of General Services Permitting Fee	Fund additional workload capacity to review land use permit applications	\$15,000
Statewide Telemetry Plan		Total: \$5,895,000
Cal OES Public Safety Communications Division	Connect up to 25% (280) of EEWS seismic stations to the state microwave network	\$5,895,000
Research and Development		Total: \$1,210,000
University of California, Berkeley	Expand the use of the MyShake app to deliver EEW alerts to the public. Cell phones will also be used to use to crowd-source seismic event data. This data can potentially help reduce alert latency	\$1,210,000
2018-19 State General Fund Budget Allocation		Total: \$15,000,000

Appendix C. 2019-20 Spending Allocations

Contractor	Description	Funding Allocation
Seismic Station Installation and Maintenance		Total: \$7,900,000
California Geological Survey	Establish Real-Time Data System at CGS and an interactive map of seismic activity for emergency response, upgrade 40 or more strong motions seismic stations, and install and conduct training on Earthworm algorithm software training to create redundant EEW data processing capability within the state	\$1,600,000
University of California, Berkeley	EEW State Microwave Project – Install microwave link to Warren Hall and connect 50 EEW remote seismic sites to microwave telemetry, 18 New and Upgraded Broadband/Geodetic stations, and EEW datacenter upgrades including 7 servers, microwave connection equipment, and VPN routers	\$3,200,000
California Institute of Technology	EEW State Microwave Project – Connect 100 EEW remote seismic sites to the State Microwave, 20 New or Upgraded Stations Broadband or Geodetic Stations, and EEW data center upgrades including 4 servers and routers.	\$3,100,000
Education and Training		Total: \$6,900,000
Pulsar Advertising	Statewide public awareness and education campaign	\$6,900,000
Research and Development		Total: \$1,500,000
University of California, Berkeley	Continue to support and enhance MyShake for statewide mobile earthquake notification	\$800,000
California Geological Survey	Update the existing CISN display (maintaining priority for emergency responders and creating a new public web application that will utilize ShakeAlert products	\$400,000
University of California, Berkeley	Conduct research to enhance alerting abilities by reducing latency, alerting during aftershock sequences, and reducing no-warning zones	\$300,000
2019-20 State General Fund Budget Allocation		Total: \$16,300,000

Appendix D. 2020-21 Spending Allocations

Contractor	Description	Funding Allocation
Seismic Station Installation and Maintenance		Total: \$9,232,210
California Geological Survey	Continue with the establishment of a real-time data system at CGS for emergency response, upgrade 50 strong motions seismic stations	\$1,200,000
United States Geological Survey	Purchase updated equipment for 41 strong motion and broadband stations, construct three new telemetry interconnects, and communication costs	\$1,832,210
University of California, Berkeley	Install 30 new and upgraded broadband/geodetic stations, EEW data center upgrades, microwave EEW connections, and machine learning research and development	\$3,700,000
California Institute of Technology	Install 11 new broadband stations, upgraded 60 dataloggers, EEW datacenter upgrades, and machine learning research and development	\$2,500,000
Statewide Telemetry Plan		Total: \$2,300,790
Public Safety Communications	Connect 70 more EEW stations and annual reoccurring microwave leases and circuit cost	\$2,300,790
Education and Training		Total: \$3,500,000
United Way	Public awareness and education campaign	\$2,500,000
Imprenta	Graphic design and public relations services	\$1,000,000
Research and Development		Total: \$2,030,000
University of California, Berkeley	Continue to support and enhance MyShake for statewide mobile earthquake notification	\$1,400,000
California Geological Survey	Update the existing CISN display (maintaining priority for emergency responders and creating a new public web application, both will be mobile friendly	\$130,000
University of California, Berkeley, and California Institute of Technology	Conduct research to enhance alerting abilities by incorporating machine learning to reducing latency, alerting during aftershock sequences, and making EEW alerting more accurate	\$500,000
Administration		Total: \$220,000
2020-21 California Earthquake Safety Fund Loan Allocation		Total: \$17,283,000

Appendix E. 2021-22 Spending Allocations

Contractor	Description	Funding Allocation
Seismic Station Installation and Maintenance		Total: \$10,205,000
California Geological Survey	Enhance real-time data center for structural monitoring, update 40 existing seismic stations to provide real-time data	\$2,010,000
United States Geological Survey	Purchase equipment to instrument 41 new or updated EEW seismic stations with dataloggers and sensors, equipment to update 6 EEW seismic stations, and continue FirstNet pilot project	\$850,000
University of California, Berkeley	Support operation and maintenance through equipment purchases and ongoing network improvement, increase staff, add 12 new and update 3 broadband stations, and modernize software for improved network data monitoring, alerting, and maintenance prioritization	\$4,645,000
California Institute of Technology	Rebuild and instrument 12 existing EEW seismic stations, update 20 stations with new dataloggers and sensors, update telemetry equipment, and continue support of operation and maintenance with upgrades for enhanced data quality and network monitoring	\$2,700,000
Statewide Telemetry Plan		Total: \$2,192,000
Public Safety Communications	Microwave leases and circuit costs for up to 350 stations and high-altitude antennas	\$2,192,000
Education and Training		Total: \$2,618,000
CEEWS Campaign	Public relations services for statewide education and outreach	\$2,618,000
Research and Development		Total: \$2,050,000
University of California, Berkeley	Continue support of MyShake app platform development and the development of metrics and tools to improve operation and maintenance decision-making process	\$1,600,000
University of California, Berkeley, and California Institute of Technology	Conduct research utilizing distributed acoustic sensing (DAS) and already existing fiber optic infrastructure for earthquake monitoring to increase sensor density particularly offshore	\$450,000
Administration		Total: \$218,000
2021-22 State General Fund Budget Allocation		Total: \$17,283,000

Appendix F. 2022-23 Spending Allocations

Contractor	Description	Funding Allocation
Seismic Station Installation and Maintenance		Total: \$9,945,000
California Geological Survey	Support EEW and Real-time Data Center operations and maintenance through equipment purchases and ongoing network improvement	\$1,490,000
United States Geological Survey	Support operations and maintenance through equipment purchases, upgrades of aging infrastructure, and ongoing network and telemetry improvement. Continue FirstNet pilot project and ongoing communication costs	\$455,000
University of California, Berkeley	Support operations and maintenance through equipment purchases and ongoing network improvement. Fund expanded field team staff, engineering, and IT positions	\$3,500,000
California Institute of Technology	Support operation and maintenance through positions, equipment purchases, and upgrades of aging infrastructure for enhanced data quality, and network monitoring	\$2,500,000
University of California, Berkeley	Support MyShake app, including updates and additional storage to increase capacity	\$2,000,000
Statewide Telemetry Plan		Total: \$4,060,619
Public Safety Communications	One-time equipment and personnel costs to complete the PSC EEW Telemetry Project and PSC EEW annual maintenance	\$4,060,619
Education and Training		Total: \$650,000
Community Outreach Grants	Fund community-based outreach through Inland SoCal United Way and United Way Bay Area	\$350,000
EEW Benefit Cost Analysis	Utilize an Interagency Agreement to select a contractor to develop a Benefit Cost Analysis of the EEW program	\$300,000
Research and Development		Total: \$2,000,000
University of California, Berkeley, and California Institute of Technology	Conduct research utilizing distributed acoustic sensing (DAS) and already existing fiber optic infrastructure for earthquake monitoring to increase sensor density particularly offshore where the network is sparse and prone to errors	\$800,000

University of California, Berkeley	Conduct a feasibility study to understand EEW implementation costs and considerations for scale in airports.	\$400,000
America's Public Television Stations	Support the implementation of datacasting technology within remaining public broadcasting stations for statewide coverage	\$500,000
California Geological Survey	Continue the Community Seismic Network (CSN) pilot project for structure health monitoring for EEW alerting and emergency response.	\$300,000
Administration		Total: \$430,381
2022-23 State General Fund Budget Allocation		Total: \$17,086,000