2022

California Earthquake Early Warning Business Plan Update

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Cal OES
GOVERNOR'S OFFICE
OF EMERGENCY SERVICES

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1. Introduction

This is the annual update to the California Earthquake Early Warning (EEW) Business Plan.

California's state-wide EEW Program began in 2013 with SB 135 (Chapter 342, Statutes of 2013), which requires the California Governor's Office of Emergency Services (Cal OES) to implement a comprehensive EEW system in California in collaboration with other stakeholders. Since that time, Cal OES has built 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 build out a network of seismic stations, which is now 100% funded and nearly 80% completed; researched and built multiple pathways to distribute EEW alerts, including the MyShake alerting app that has been downloaded over 1.7 million times; and conducted outreach and education campaigns to recruit system users and train them in how to react to an EEW alert. Further work remains in continuing to adopt innovations in technology, increase and diversify alert delivery methods, reduce alert latencies, provide robust and continuous public education, and increase the uptake of automated protective actions in a variety of settings. Major upcoming initiatives include increasing focus on system maintenance, conducting outreach to socially vulnerable populations in partnership with community-based organizations, supporting research on new methods of detecting earthquakes, and investigating alerting pathways beyond the current internet- and cellphone-based pathways.

Senate Bill (SB) 438 (Hill, Chapter 803, Statutes of 2016) establishes the California Earthquake Early Warning Advisory Board within Cal OES and requires Cal OES, in consultation with the board, to produce a Business Plan Update by February 1, annually. This update includes the statutory report elements, which cover:

- 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.

2. Progress of Earthquake Early Warning in California

Much progress has already been made in developing and implementing a California EEW System. The California EEW System now delivers EEW alerts statewide to the public through three cell-phone-based pathways: the Cal OES-sponsored MyShake app, Wireless Emergency Alerts (WEA), and to Android-enabled devices. The network of seismic stations that powers EEW alerts in California is nearing completion—all 1,115 stations are either built or funded—so the California EEW Program is now placing greater focus on maintaining the system and seeking adoption of the EEW technology by state and local agencies, businesses, and owners of critical infrastructure throughout the state. Additionally, Cal OES is supporting research to develop additional alerting pathways, including the use of television and radio broadcast signals, to provide widespread and redundant alerting coverage for a variety of public and private-sector use cases. While continuous improvements are ongoing, the system now has a proven track record of providing critical, lifesaving services to the public.

Public Alerting for EEW

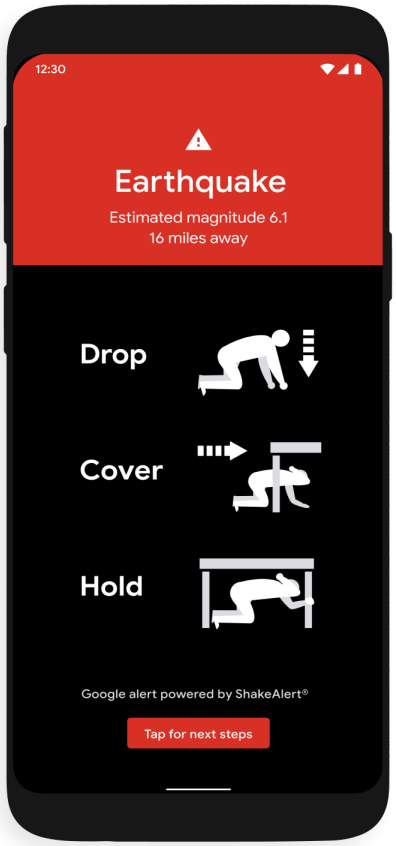
Three cellphone-based alerting pathways now enable millions of Californians to receive EEW alerts.

Public alerting for EEW in California includes the nation's first statewide cell phone application for EEW, MyShake, as well as use of the Wireless Emergency Alert (WEA) system, and direct delivery to phones on the Android system. Cal OES funded UC Berkeley to develop the MyShake app to be available statewide. Since its release in 2019, MyShake has successfully issued 51 alerts, which reflects alerts for 100 percent of earthquakes that met prescribed app alerting protocols. Ongoing funding allows support of existing users, expanding the user base, and additional enhancements, such as the "HomeBase" feature that was released in January 2022. The "HomeBase" feature allows users to set their location in the app to receive alerts without enabling location services on their phone, a feature intended to encourage participation of additional users. The MyShake app has always put privacy first for all users regardless of whether they use location services or the new HomeBase feature—no personally identifiable information is ever stored, and all locations are anonymized to a 10 km-by-10 km grid.

The app also incorporates training on the use of earthquake alerts, provides earthquake preparedness information, and allows users to report what they experience during an earthquake and see the reports of others. Ongoing work includes continuing to reduce latency times for alert delivery, improving the

performance of the app as the user base increases, leveraging current social science research to optimize user response to the warning, and adding additional features to enable users to prepare for and recover from earthquakes.

In total, since December 2019, MyShake has sent 51 alerts to 185,246 devices. Of those MyShake alerts, 22 alerts were sent to 79,754 devices in 2021 alone. WEA has sent over 11 alerts, a lower number than MyShake alerts because the WEA system sends alerts only for larger earthquakes.



In August 2020, a partnership with Google resulted in an update of the Android operating system that provides earthquake warnings to Android devices before shaking starts. Google modeled this feature using the same shaking and magnitude thresholds already established by the State of California for earthquake early warnings.

Within the Android Earthquake Alerts System, users will receive two types of notifications for earthquakes of magnitude 4.5 or greater:

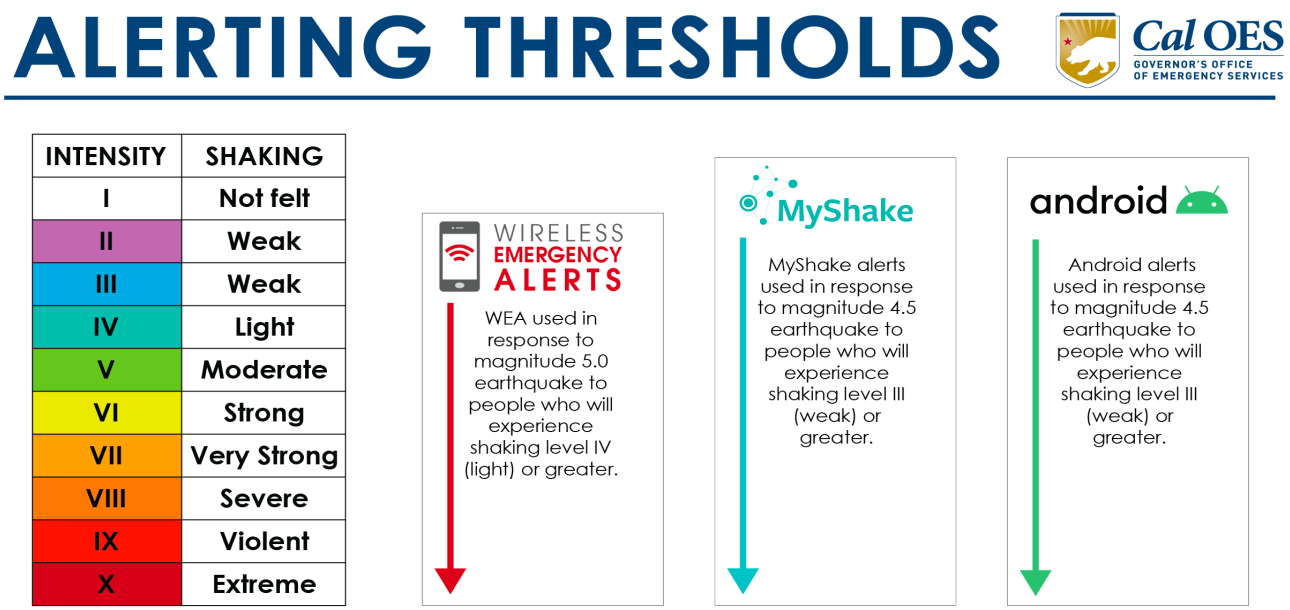
- Be Aware Alert
- Take Action Alert

When an earthquake occurs with weak and/or light shaking (MMI 3 and 4), the Be Aware Alert will notify the user and provide additional information but will respect user settings such as Do Not Disturb and Notification settings on the device.

When an earthquake occurs with moderate to extreme shaking (MMI 5+) the Take Action Alert will break through these user settings and notify the user by initiating the Drop, Cover, Hold screen and play a loud sound.

When either of the notification alerts are selected, Android will direct the user to additional information such as earthquake safety information and a detailed map of an early estimate of the earthquake location and magnitude. The Android Earthquake Alerts System is available to Android users at no cost and is integrated into the operating system, which means that it does not have to be downloaded.

Cal OES continues close coordination with Apple for development of emergency alerts for earthquakes in North America on iOS devices such as iPhone, iPad, and Apple Watch. In Japan, users are already benefitting from an integrated Earthquake Alert system within iOS and are able to receive earthquake alerts, tsunami alerts, and other disaster information.



System Operations

All 1,115 planned seismic stations are now funded and nearly 80 percent are built; future work will increase focus on operations and maintenance.

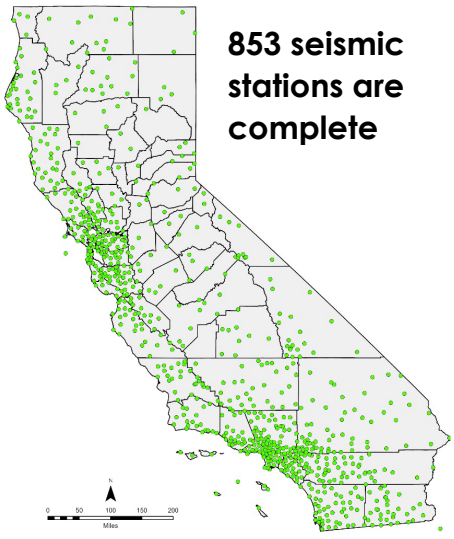
The California EEW Program continues to work with California Integrated Seismic Network (CISN) partner organizations and the Cal OES Public Safety Communications (PSC) Division to install, update, and connect seismic stations to the EEW network. The seismic stations and communications equipment that make up the California EEW System represent the California portion of ShakeAlert, which is the national EEW network administered by USGS.

The California EEW Program and PSC successfully completed pilot projects, which connected seismic stations to the California Public Safety Network (CAPSNET) microwave for telemetry transport to CISN data processing centers. This began with a targeted investment in 2018 to create the California EEW Microwave Telemetry Plan to connect twenty five percent of the seismic stations to the CAPSNET state microwave system, including funding acceleration of upgrades to CAPSNET equipment. In 2020, the plan and funding allocation were adjusted to increase the number of stations to be connected. The current number of stations targeted for microwave connection is 328, just under thirty percent of the total number of EEW stations at final build out. This project is ongoing. As of January 2022, there are 52 EEW stations connected to the state microwave network. Use of CAPSNET not only provides redundancy for data collection and transfer, but also capitalizes upon one of the fastest delivery methods using existing state public safety infrastructure.

California is approaching completion of the build-out phase outlined in the initial technical implementation plan. As a result, there is an ongoing assessment by system operation partners to better identify:

1. Current number of stations contributing to the system.
2. Remaining station placement and resolution of any siting issues (permitting, leases, accessibility).

This assessment shows that as of February 2022, there were 853 EEW stations completed of the 1,115 required to reach acceptable sensor density according to CISN partners. The remaining 262 stations have been funded as of the state fiscal year 2021-22 budget, but installation is not yet complete, or the stations are waiting for telemetry. Many factors have affected the installation of stations including land-use and environmental permits, weather, travel, and access to the sites. Most recently, physical distancing restrictions required due to COVID-19, as well as interruptions in the supply chain to acquire equipment and materials, have delayed installations.



As the California EEW System nears full buildout, Cal OES and its partners are increasing their focus on ongoing operations and maintenance, seeking adoption of the EEW technology among industry partners, and development of additional public alerting pathways. Ongoing allocations will be needed to fund equipment and staff to perform preventative and routine maintenance on sensors and associated equipment in order to keep stations operating effectively. Seismic stations, especially free field ground stations, are susceptible to damage and decay due to weather, vermin, natural disasters such as fires, and vandalism. On average, thirty percent of stations require monthly maintenance of some sort. Monthly maintenance ranges from minor fixes such as software updates and telemetry checks to more extensive repairs such as replacement of severed cables or solar panels. In addition to routine maintenance, components need to be updated as technology advances, and outdated or inoperable equipment and parts need to be replaced.

Engaging Industry for Automatic 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.

Automating protective actions such as slowing or stopping trains has been a key goal of the EEW program since its inception. 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 similar to the 1989 Loma Prieta Earthquake. Among other things, the researchers estimated that EEW could prevent half of all injuries, abate millions of dollars in losses to the technology industry, avert train derailments, and prevent many of the deadly fires that commonly follow earthquakes. California is already capable of using the EEW system to slow trains, alert hospital personnel, slow and stop elevators, alert classrooms over public announcement systems, open fire station doors automatically, shut off kitchen gas lines, and notify personnel through Voice over Internet Protocol phones. Ongoing and future work will increase the uptake of these existing technologies and encourage the development of new capabilities.

Some of the first groups to implement EEW for automatic protective actions were transportation organizations. Notable is Bay Area Rapid Transit (BART), who has used EEW notifications to slow and stop trains since 2012. The Los Angeles Metropolitan Transit Authority (LA Metro) launched automatic alerts to their Rail Operations Center in Watts and 25 additional Metro buildings, rail yards, and maintenance facilities. Southern California Regional Rail Authority (Metrolink) developed an interface that integrates EEW notifications with Metrolink's Positive Train Control system, which automatically slows or stops trains.

Other sectors that have already begun implementing automatic actions triggered by EEW notifications include the healthcare sector, where alerts are delivered via public announcement at Cedars Sinai Hospital in Los Angeles. The education sector has also launched automatic notifications to Drop, Cover, and Hold on at Santa Monica College, Biola University, Polytechnic School in Pasadena, 23 schools in the Porterville School District, two schools in the Lindsay Unified School District, Eagle Rock High School, San Pascual Elementary School, and the Santa Monica Public Library. Public safety organizations such as Menlo Park Fire District and Los Angeles Fire Station 51 at Universal Studios have implemented systems that automatically notify firefighters, roll up firehouse doors, and turn off gas appliances. Los Angeles City Hall has also implemented a system to send notifications by PA system.

Cal OES is using a sector-based approach to leverage these successful implementations to expand the uptake of automated protective actions within the state of California. Existing implementations will be highlighted as part of a targeted outreach campaign in order to expand implementations from the same sectors, and also to gain new implementations within remaining sectors. The sectors of focus include K-12 Education, Higher Education, Business, Medical, Transportation, Utilities, First Responder, and Telecommunications. As a major effort in 2022, Cal OES will leverage its existing connections in these sectors across the state, including the EEW Advisory Board, to recruit new users and implement automated actions. As new

potential users are recruited, Cal OES will simultaneously work with USGS to rapidly move potential users through the licensing process to exponentially increase the pace and scale of end-user adoption.

Research and Development

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

Cal OES is exploring more pilot projects to leverage television and radio broadcast signals as low-latency, redundant pathways for information dissemination that does not rely on the Internet, cell phone towers, or the electrical grid. These systems also already have part of their respective broadcast bandwidths dedicated to emergency use. Cal OES pilot projects will test the feasibility of delivering time-sensitive EEW notifications in real-world applications, such as schools, government buildings, and hospitals. Alert receivers would be deployed and evaluated for purposes of automatic hazard mitigation and early notification of earthquakes.

Currently, there are private companies leveraging the television and radio broadcast spectrums to deliver mass Common Alerting Protocol (CAP) notifications in times of crisis. These technologies fetch federal, state, local, and tribal emergency alerts and transmit the data to alert-enabled television and radio stations that notify television and radio alert enabled devices up to 150 miles away.

Television and radio broadcast systems are wireless alternatives to cellphone technology and provide valuable options for stakeholders in rural regions where cellphone and internet are not readily available. Backup generators also enable television and radio stations to continue their respective broadcasts when the Internet, cell phone networks, and the electrical grid are down. In the 2011 Tohoku, Japan earthquake, resilient television infrastructure withstood shaking and continued to broadcast critical information to residents when the Internet and cell phone towers failed.

Cal OES is also supporting the California Geologic Survey (CGS), the University of California, Los Angeles (UCLA), and the California Institute of Technology (Caltech), to explore the nexus of EEW and strong motion sensors, which assess the structural health of monitored buildings during and after an earthquake.

Distributed Acoustic Sensing (DAS) is another area of high-potential research and development. DAS is emerging as a unique and powerful geophysical method that utilizes fiber optic cables to measure seismic activity at high resolution. This unique capability can turn an existing optical fiber into a seismic array with very high density (meter-scale) compared to traditional approaches involving the deployment of seismic sensors. This could lead to significantly improved coverage in offshore regions where the performance of the EEW system is sometimes limited due to lack of seismic

stations. Additionally, submarine communication cables have the potential to capture near-field rupture processes of megathrust earthquakes, contributing to building an improved earthquake and tsunami warning system. Cal OES is supporting partners at UC Berkeley and Caltech to conduct additional research to potentially prepare DAS technology for inclusion into the California EEW System.

Part of the funding to UC Berkeley for MyShake has included research on using phone accelerometers to enhance speed and accuracy of EEW alert generation. Current data indicates that incorporation of MyShake-based phone triggers could reduce EEW alert latency by 0.5 seconds and thereby increase the area where the alert is delivered before damaging shaking arrives. Phone sensors can also contribute to confirming the validity of alerts, reducing probability of false alerts. In 2021, Google began leveraging the MyShake phone-based accelerometer technology to issue alerts without relying on a traditional seismic network. The MyShake-based Google alerts are now available in numerous countries worldwide.

Public Education

An ongoing public media campaign remains successful, and a new effort reaching socially vulnerable population via community-based organizations is showing promise in its early stages.

In October 2020, Cal OES launched a comprehensive public awareness campaign to educate all California residents about the state's EEW system: Earthquake Warning California. The campaign directs Californians to no-cost tools, resources, and information, including how to access the smartphone MyShake App, Android Earthquake Alerts, Wireless Emergency Alerts (WEAs). The campaign also highlights and drives users to the www.earthquake.ca.gov website. Campaign elements include an updated earthquake.ca.gov website, original creative television and digital ads, earned media, and public relations. As part of the public relations aspect of the campaign, there are ongoing, strategic efforts to educate key user groups such as local governments, first responders, businesses, the education sector, critical infrastructure providers, and non-profit organizations about the benefits of EEW. The campaign incorporates a main theme that many things can "Catch You Off Guard", but earthquakes don't have to, now that earthquake warnings are possible. Ads reflect a combination of tones ranging from informative to light-hearted, which were tested for effectiveness through focus groups. Since its launch in

October 2020, the campaign has had almost 399 million impressions (an estimation of how many people viewed a product) through television and digital media.

In June 2021, Cal OES partnered with the United Way Bay Area (UWBA) and the Inland Southern California United Way (ISCUW) to implement community outreach in vulnerable earthquake areas that have access limitations and functional needs. ISCUW has already completed 34 in-person and virtual activities, resulting in approximately 4,303 public engagements. In 2022 and 2023, UWBA will conduct a 2-1-1 keyword text message campaign. When the user texts the word "earthquake" the system will connect the user with interactive education tools and resources. The system will feature the MyShake App and users will be encouraged to download the app. UWBA will also have peer-to-peer engagements with homeowners/renters who are unable to afford retrofitting. Most members of this target population live in older buildings either as renters unable to modify the residence, or as homeowners unable to afford retrofits. Other members of the target population are unhoused or reside in abandoned buildings, under freeways, and other locations where earthquakes pose infrastructure risks as well as residents being isolated or unlocatable in emergency. In addition, Cal OES will continue to connect and engage with disaster vulnerable and underserved communities working with the newly established Cal OES Office of Diversity, Equity, and Inclusion to ensure earthquake early warning is accessible to under-served and under-resourced communities that may be disproportionately impacted by earthquakes. This partnership will continue to conduct targeted outreach and education that will build community resiliency and strengthen earthquake preparedness.

As of January 2022, Pulsar Advertising Inc., in partnership with Cal OES, continues a campaign that has established a network of more than 400 California partners who share information through social media, email blasts, newsletters and the Cal OES website. The 400 partners include more than 250 California counties and cities plus associations, employers, transportation agencies, non-profits, faith-based institutions, schools, and chambers of commerce. The campaign has generated more than 2,400 media stories in local and statewide media from large markets including Los Angeles, San Francisco, and Sacramento and those serving hard to reach audiences.

Across all public-awareness efforts, a core goal is to increase the number of Californians who opt in to receiving an EEW alert. A key metric for this goal is the number of users that have installed the Cal OES-sponsored MyShake app; thanks to the combined public-awareness efforts, over 1.7 million phones now have the MyShake app. Another 5,000 phones currently download it each week, with higher download rates during increased media pushes and after earthquakes.

Collaborative efforts between Cal OES and USGS continue to solidify roles and responsibilities now that the program is maturing and identifying strategies to expand

the use of EEW alerts in California and beyond. The general public, education, medical, business, transportation, public safety, utilities, and telecommunications sectors and workforce protection will continue to be the focus of implementation and expansion efforts.

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 operation and maintenance, actual costs to maintain the system continue to be assessed. A current breakdown is as follows:

Table 1: Updated 2022 plan for operations and maintenance

EEW Stations (Including but not limited to, equipment and labor to maintain seismic stations, system GPS stations, network infrastructure and data processing)	$ 6,100,000
Telemetry	$ 4,000,000
Outreach and Education	$ 3,100,000
Research and Development (Develop new technology and expand uses; continue supporting MyShake alert app)	$ 1,200,000
Program Management (Permanent and temporary support)	$ 1,486,000
Contingency	$ 1,200,000
Total	**$ 17,086,000**

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.

2017-18 Funding

Cal OES did not receive any additional funding to build out the system in 2017-18, and operation and maintenance funding was not yet needed.

2018-19 Funding

Cal OES received $15 million one-time General Fund and allocated it 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 is 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. As of the publishing of this plan, Cal OES is entering into a number of contracts and agreements with system partners to encumber the funding.

2022-23 Funding

Cal OES received $17.1 million ongoing General Fund to support education and outreach, operations, and research and development of the California EEW System. This funding will allow the state to increase its earthquake sensor density in the rural parts of Northern California and the Sierra Nevada Microwave Telemetry project, and offer grants to community-based organizations to educate socially isolated groups and other under-served communities.

4. Contracts and Requests for Proposals

In the 2021-22 state fiscal year, Cal OES will enter 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.

Cal OES will also offer support for research and development through Inter-Agency Agreements and contracts to continue the support behind the MyShake App, to investigate the feasibility of Distributing Acoustic Sensing technology in EEW, and to develop EEW network-health diagnostics.

Cal OES will request proposals to continue education and outreach efforts that launched in October 2020. Objectives will continue to increase user participation and educate Californians that earthquake warnings are available, how to receive them and how to use them, and will continue targeting socially vulnerable communities. Education and outreach will also 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 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 nonvoting 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 initial meeting on June 22, 2017, and has held subsequent meetings on the following dates:

- November 30, 2017
- April 30, 2018
- September 27, 2018
- March 7, 2019
- September 26, 2019
- August 5, 2020
- October 27, 2021

The next Advisory Board meeting is tentatively scheduled for June 2022.

Advisory Board members have made several recommendations about the development of the program during the meetings. Key Advisory Board policy focus areas in 2021 included:

Leveraging Relationships with State Agencies: Members of the Advisory Board recommended that Cal OES reach out to other cabinet-level state agencies and encourage them to notify their respective staff about the MyShake App and life-saving actions to take during earthquake emergencies.

> **Response:** Cal OES drafted a letter and distributed it to these agencies in December 2021. As a result, the California Department of Corrections and Rehabilitation added the included information to their website.

Launch of Education and Outreach Campaign: Members of the Advisory Board provided feedback about the program name, general outreach campaign and strategy.

> **Response:** The Advisory Board provided feedback on the campaign and new proposed program names. That feedback was incorporated along with focus group responses in the final campaign construction.

Algorithms: The Advisory Board expressed concern about algorithm performance at detecting earthquakes during the Antelope Valley earthquake in July 2021.

> **Response:** Cal OES scientific partners indicate that sparse sensor density contributed to the issue, so it has now been resolved through station completion and slight adjustments to the algorithms. The system performed as expected during more recent events in the same area, indicating the issue is resolved.

6. Long Term Funding

As reflected in the 2022 Budget Act, years of experience and maturity of the system have demonstrated that, like other emergency warning systems, EEW is a core public safety function. Government funding of the program provides consistency and reliability in system operations and maintenance, as well as to public education.

The private sector also has a key financial responsibility; it will develop and employ alert-delivery pathways that are tailored to sector-specific use cases; private entities have and will continue to contribute their share to the system via many types of investment. For example, a public-private partnership with Google equipped all Android mobile devices with EEW technology at no cost to the state, significantly increasing the number of phones able to receive EEW alerts. Several companies are funding their own pilot projects to build and test automated actions based on EEW alerts, including installations at Northridge Hospital and Eagle Rock High School that demonstrate the capability to automatically notify everyone on campus in an earthquake. Cal OES has established annual goals to significantly grow the number of end users in key sectors in order to protect infrastructure, workers, and the public and to mitigate impacts on the economy. This is a significant focus area for 2022.

As more private businesses, utilities, and services become users of the EEW System, they will invest in infrastructure improvement, equipment, staffing, and ongoing service costs with private funds, further amplifying this important public/private partnership.

Cal OES will continue to explore funding partnerships with businesses, utilities, and local, state, and federal programs.

7. Conclusion

Since the envisioning of the California EEW Program in 2013, California has realized a statewide system that provides critical seconds of warning prior to an earthquake. The seismometer network is now 100 percent funded, and public alerts have been consistently issued since 2019. The California-funded MyShake app has millions of downloads and has delivered alerts to nearly 200,000 devices. Future focus is to improve and advance the system by adopting innovations in technology, increasing and diversifying alert delivery methods, reducing alert latencies, providing robust and continuous public education, and increasing the uptake of automated protective actions in a variety of settings.

The next year is critical for the California EEW Program. A key focus will be to increase uptake of the EEW alerts by target industry sectors. Another key focus will be network completion and a transition to network operation and maintenance. Research and development will continue to improve the EEW system, including new technologies that will speed and diversify EEW delivery.

As we expand and broaden sector adoption to other industries, local governments, and other stakeholders, contributions from those sectors will increase exponentially, thereby exponentially increasing the benefits of EEW to Californians where they live, work, and visit.

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 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 datacenter 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, and EEW datacenter 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 relation 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**