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THE ROLE OF THE U.S. GEOLOGICAL SURVEY AND THE U.S. FOREST SERVICE IN PREPARING FOR AND RESPONDING TO NATURAL HAZARD EVENTS, AS WELL AS THE CURRENT STATUS OF MAPPING AND MONITORING SYSTEMS

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED FIFTEENTH CONGRESS

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CONTENTS

OPENING STATEMENTS

	Page
Murkowski, Hon. Lisa, Chairman and a U.S. Senator from Alaska	1
Cantwell, Hon. Maria, Ranking Member and a U.S. Senator from Washington	3

WITNESSES

Applegate, Dr. David, Associate Director for Natural Hazards, U.S. Geological Survey	5
Casamassa, Glenn, Associate Deputy Chief, National Forest System, U.S. Forest Service, U.S. Department of Agriculture	11
Branson, Hon. Pat, Mayor, City of Kodiak, Alaska	23
Norman, David K., State Geologist, Washington Geological Survey, Department of Natural Resources	39
West, Dr. Michael, Alaska State Seismologist, Alaska Earthquake Center, and Research Associate Professor, Geophysical Institute, University of Alaska Fairbanks	44
Berry, Karen, State Geologist and Director, Colorado Geological Survey at the Colorado School of Mines, and President-Elect, Association of American State Geologists	55

ALPHABETICAL LISTING AND APPENDIX MATERIAL SUBMITTED

Applegate, Dr. David:	
Opening Statement	5
Written Testimony	7
Responses to Questions for the Record	82
Berry, Karen:	
Opening Statement	55
Written Testimony	57
Branson, Hon. Pat:	
Opening Statement	23
Written Testimony	25
Map entitled "Maximum Estimated Tsunami Inundation, Kodiak Area, Alaska"	38
Cantwell, Hon. Maria:	
Opening Statement	3
Casamassa, Glenn:	
Opening Statement	11
Written Testimony	13
Slides	18
Responses to Questions for the Record	89
CoreLogic:	
Letter for the Record	94
Murkowski, Hon. Lisa:	
Opening Statement	1
Norman, David K.:	
Opening Statement	39
Written Testimony	41
West, Dr. Michael:	
Opening Statement	44
Written Testimony	46

THE ROLE OF THE U.S. GEOLOGICAL SURVEY AND THE U.S. FOREST SERVICE IN PREPARING FOR AND RESPONDING TO NATURAL HAZARD EVENTS, AS WELL AS THE CURRENT STATUS OF MAPPING AND MONITORING SYSTEMS

TUESDAY, JANUARY 30, 2018

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The Committee met, pursuant to notice, at 10:09 a.m. in Room SD–366, Dirksen Senate Office Building, Hon. Lisa Murkowski, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

The CHAIRMAN. Good morning. The Committee will come to order.

We are here for two purposes this morning. Our first task is a business meeting to report four nominations and ratify Subcommittee assignments for our new members, Senator Capito and Senator Smith. We are awaiting a quorum. We need two more or, maybe, three more now. So what I intend to do is go ahead and begin our full Committee hearing on natural hazards and then if we are able to find a quorum this morning we will take a quick break, conduct that business and then get back to you.

Our focus this morning is on volcanoes, earthquakes, landslides, tsunamis, and avalanches—natural hazards that many Americans experience on a somewhat regular basis and the measures being taken to minimize risks from those hazards.

We had an opportunity just yesterday, in speaking with the Mayor of Kodiak who is here as one of our witnesses today, but we had a very timely event just last week. We had a magnitude 7.9 earthquake that struck off the coast of Alaska, about 175 miles southeast of Kodiak, in the Gulf of Alaska. And it was just a little bit after midnight that the earthquake struck, about 12:30. A lot of folks were already in bed. That was the Monday of the government shutdown, Monday evening.

But thanks to the good work from the Alaska and National Earthquake Centers and the National Tsunami Warning Center, a tsunami alert was issued and communities from Chignik to Cordova to Kodiak evacuated to higher ground. It is reassuring to

know that the Earthquake and Tsunami Centers, who provide critical information for life-saving purposes, were not impacted by the shutdown.

We worked real quickly to make sure—is everybody up? Is everybody doing what they were supposed to be doing, even in the midst of a shutdown? So thank you for that.

We do understand that the earthquake caused some damage, including in Kodiak, but the tsunami associated with it was quite small and that means that, basically, we just got lucky and the people of, not only Kodiak, but many of our coastal communities just felt like they just got lucky.

And as many Alaskans know, that is not always the case. In 2015, we had 53 landslides that came down in Sitka, Alaska, including one that tragically claimed three lives. Earlier this winter, Alaska lost a member of the skiing community to an avalanche in Hatcher's Pass, right in Anchorage's backyard.

I am frequently reminded of the magnitude 9.2 earthquake that struck Alaska on Good Friday back in 1964. It is the largest earthquake to ever hit North America and coupled with tsunamis, it claimed 131 lives and caused significant, widespread damage. We had an opportunity to look at some of those pictures from that massive earthquake and tsunami.

Of course, Alaska is not the only state to face these hazards. Last month, mudslides in southern California claimed the lives of 21 people and caused millions of dollars of damage. I know that Senator Cantwell will speak on the landslide that occurred in Oso a few years ago. We have had discussions about that horrible tragedy and the fact that it took 43 lives. But also an imminent disaster, if you will, one that is about to give way at Rattlesnake Ridge in Washington State that everyone is watching very, very closely.

The good news is that our federal, state, and local partners are developing the tools and maps needed to better understand these natural hazards, in an effort to give more advanced warning to communities in danger. Those include seismic monitors for earthquakes, elevation mapping to mark out slopes vulnerable to landslides, cameras on volcanoes, sensors along rivers and coasts, and tidal monitors to help detect tsunamis.

Some operations are, of course, more advanced than others. The U.S. Geological Survey's (USGS's) National Earthquake Information Center is staffed 24 hours a day, 7 days a week. It maintains hundreds of seismic monitors across the country.

But out at the Bogoslof Volcano on the Aleutian Chain, which erupted for about eight months last year—so eight months it just kept going and spewing—we watched the activity, but we effectively had to rely on satellite data to alert pilots of the ash clouds because there is no monitor on that particular volcano.

I am one of several members who have introduced legislation to address those gaps. We have two bills, the National Volcano Early Warning and Monitoring System Act and the National Landslide Preparedness Act. These are already included in our Energy and Natural Resources Act, which is awaiting consideration on the Senate floor.

This morning, we will learn about the need for better monitoring and mapping to provide as much of a warning of natural hazards events as possible and to reduce impacts to life and property.

Now, before I turn to Senator Cantwell for her opening remarks, I would like to acknowledge the President's intent to nominate James Reilly, a geologist and an astronaut, to be the Director of the USGS. I look forward to receiving his paperwork and considering him before the Committee.

Finally, I would like to acknowledge Chairman Thune of the Commerce Committee. He worked with us to ensure that tsunamis could be included as part of our hearing. NOAA, which falls under Commerce's jurisdiction, is the lead federal agency on tsunamis, but we are glad to be discussing that issue this morning, particularly given the issue in Alaska last week.

With that, I will turn to you, Senator Cantwell, for your comments.

STATEMENT OF HON. MARIA CANTWELL,
U.S. SENATOR FROM WASHINGTON

Senator CANTWELL. Thank you, Madam Chair, and thank you for holding this hearing of great importance to both of our states and to the nation. Earthquakes, volcanoes, landslides, avalanches, and tsunamis are a potential impact to millions of Americans each year.

I would also like to thank one of our witnesses for being here, Mr. Dave Norman, from the State of Washington. He is our state geologist, and I look forward to hearing your testimony.

Washington, like Alaska, has its share of natural hazards. Washington has five high- to very-high-threat volcanoes, that includes Mount Rainier which is considered the nation's most dangerous. USGS estimates that within a person's lifetime there is a one in seven chance that Mount Rainier will erupt.

Volcano monitoring at these sites is almost non-existent. That is why at Glacier Peak and Mount Baker, which only has one seismometer, we need to have at least five, to ensure the proper early warning systems in case of eruption.

The Cascadia Subduction Zone also poses a serious earthquake and tsunami risk to Washington State. I know many people around the country were shocked to read the New Yorker article on "The Big One" and see the level of devastation that it might cause. I guarantee you, the State of Washington is working very hard on a preparation plan, but we need help and support at all levels.

I have worked very closely with the Chairwoman here, and my colleagues also on Commerce, to secure the best technology to help identify the risk associated with the Cascadia fault. We still have a long way to go with our communities to prepare for these very unique hazards.

In addition, the Chair mentioned Rattlesnake Ridge, a landslide outside Yakima, Washington, that is moving 2.5 inches every day. It is not a question of whether there will be a major landslide there, but a question of when.

The Chair also mentioned Oso, the devastating mudslide that happened in Washington State, killing many Washingtonians. Just today, the National Weather Service announced that recent rains have increased the chance of landslides in Western Washington.

So these changes in weather events, where we have more intense rain, where you can have double of what people have seen in the past on any given day, means that we have to think differently about our warning system as it relates to landslides.

Natural hazards are unpreventable, but the more we know about the science and the causes of hazards, the better we can prepare for these events and build more resilient and safer communities. Our states play a leadership role in this, but the USGS is absolutely a critical partner in monitoring and responding to these hazards.

Last week, with Alaska's experience of an 8.0 magnitude earthquake followed by a tsunami warning/watch that extended all across the Pacific, NOAA and USGS transmitted alerts after the earthquake, but there is more that we can do to ensure timely and effective warning communication so that it reaches all people within the tsunami zones, especially those in rural areas.

I am proud of the work we were able to do on the Tsunami Warning Education and Research Act, S. 533, last Congress in addition to ensuring investments in DART buoy systems and network science. It also increases preparedness funding to states and calls for more coordination between USGS, NOAA and their tsunami programs.

This DART system is what gives us the information after an earthquake about what the wave size might actually be and that way we can translate that information into our citizens on what they need to do to prepare. Obviously, we have had a couple incidents that show us that we need to continue to build out on that.

Looking to the array of natural disasters facing Washington and Alaska and the U.S., I am working to secure passage of the National Landslide Preparedness Act. I am also pleased to be a co-sponsor of Senator Murkowski's National Volcano and Early Warning Monitoring System and a co-sponsor of Senator Feinstein's National Earthquake Hazard Reduction Program Reauthorization Act.

So, as the Chair said, there are many issues. We all look forward to hearing your testimony but also just helping our communities better prepare for these natural disasters in the future.

Thank you.

The CHAIRMAN. Thank you, Senator Cantwell.

We will now go to our witnesses. Again, if we do have additional members come that establishes a quorum, I hope you will not take offense that you might be interrupted, but I appreciate your flexibility here.

The Committee is joined this morning by a very distinguished panel.

We have Dr. David Applegate, who is the Associate Director for Natural Hazards at the U.S. Geological Survey. We welcome you to the Committee.

Mr. Glenn Casamassa has been before us in prior hearings. He is the Associate Deputy Chief for the National Forest System at the U.S. Forest Service with the Department of Agriculture.

I mentioned in my opening statement that we are joined today by the Mayor of Kodiak, the City of Kodiak, the Honorable Pat Branson. Thank you for traveling the distance that you have and

for joining us to share the comments from a community that was just recently impacted.

Mr. Dave Norman was introduced by Senator Cantwell. He is the State Geologist at the Department of Natural Resources in the Washington Geological Survey. Welcome to the Committee.

Dr. Mike West is the State Seismologist at the Alaska Earthquake Center. We anticipate that you do not have very good sleep many nights.

[Laughter.]

But we appreciate the good job that you do.

And Ms. Karen Berry, who is the State Geologist and Director at the Colorado Geological Survey at the Colorado School of Mines. She is also the President-Elect for the Association of American State Geologists. We appreciate your leadership in these areas.

With that, Mr. Applegate, if you would like to begin. We ask you to keep your comments to about five minutes. Your full statements will be incorporated as part of the record.

Welcome.

STATEMENT OF DR. DAVID APPLEGATE, ASSOCIATE DIRECTOR FOR NATURAL HAZARDS, U.S. GEOLOGICAL SURVEY

Dr. APPLEGATE. Great, thank you.

Thank you, Chairman Murkowski, Ranking Member Cantwell and the members of the Committee for holding this hearing.

My name is Dave Applegate, and I'm the Associate Director for Natural Hazards at the U.S. Geological Survey.

Every day, people and communities across the nation face risks associated with natural hazards that threaten lives, livelihoods and the infrastructure that underpins our economy and our way of life.

The strength of the USGS is in the range of scientific capabilities and partnerships that we bring to bear to deliver information to first responders, decision-makers, and the public across a wide range of natural hazards.

USGS and our partner-run monitoring networks enable rapid situational awareness tools for effective response, while our hazard and risk assessments and scenarios help communities understand and mitigate their exposure before the disaster happens. These products are underpinned by targeted research to improve our understanding and to maintain world-class expertise.

A variety of USGS capabilities that serve multiple missions also contribute. For example, improved elevation data through 3DEP and geologic mapping enable new discoveries of faults, landslides, and deposits from volcanic eruptions.

For our science to make a difference to society, it is essential that we engage directly with users to shape how we collect and deliver information so that people, businesses, and all levels of government are more effectively able to assess their risks and build more resilient communities. And we can't do that without our state and university partners, several of whom are here today.

For earthquakes, we're testing the bounds of how fast we can deliver actionable information. We're working with states, university partners and private foundations to develop an earthquake early warning system, called ShakeAlert, for the West Coast and we're working with private firms and public agencies to integrate those

warnings into automated systems and emergency announcements. Through new funding directed by Congress in recent years, the system is now about half completed and we expect to begin limited public alerting by the end of the year. When completed, this technology is expandable to other regional networks of the USGS Advanced National Seismic System, such as Alaska, Nevada, and Utah.

Last week's Alaska earthquake was a reminder of the threat posed by subduction zones, those areas where two tectonic plates collide and one is driven beneath the other generating the largest earthquakes and many of the world's volcanoes.

The Pacific Ocean's Ring of Fire includes zones off Alaska and the Pacific Northwest's Cascadia. Also, Puerto Rico and the U.S. Virgin Islands are atop a subduction zone in the Caribbean.

This past June, the USGS released a science plan that lays out an achievable vision for addressing the hazards associated with subduction zones. The plan defines science priorities and identifies potential partnerships to advance observations and modeling, quantify hazards and risks and provide forecasts.

From Northern California to the Aleutians, volcanic hazards pose immediate threats to nearby communities and also produce ash clouds that disrupt international air traffic. Fast-moving debris flows of volcanic material, known as lahars, threaten communities downslope.

In Washington State, the USGS and Pierce County are working together to establish a lahar detection and warning system for all major drainages of Mt. Rainier. When completed, it will serve as a model for protecting populations at risk of lahars from other volcanoes. The USGS is currently finalizing a Congressionally-mandated report that specifies the implementation plan for a National Volcano Early Warning System that will ensure that all volcanoes in the U.S. are monitored at levels commensurate with their threat.

In Alaska, USGS science and hazard monitoring operations focus on threats from a wide range of hazards. Congress directed the USGS to provide an implementation plan including cost estimates for the adoption of future seismic stations—the relevant ones being those of the National Science Foundation's transportable array currently deployed across Alaska for a period of two years. The USGS plan provides a detailed strategy and costs, prioritizing the retention of the TA equipment, upgrades at permanent stations of the Alaska Seismic Network and Alaska Volcano Observatory Network, plus other high-value stations for monitoring the most threatening volcanoes in the state.

USGS is also prioritizing the update of the Alaska Seismic Hazard Model, which is the basis for earthquake-safe construction statewide, and its results will be applicable to other subduction zone environments including Cascadia and Puerto Rico.

With that, I thank you for the opportunity to share some of current USGS activities that are helping make communities and the nation safer and more resilient. Happy to answer questions.

[The prepared statement of Dr. Applegate follows:]

Statement of David Applegate
Associate Director for Natural Hazards
U.S. Geological Survey
Before the
Committee on Energy and Natural Resources
U.S. Senate

January 30, 2018

Thank you Chairman Murkowski, Ranking Member Cantwell, and members of the committee. My name is Dave Applegate, and I am the Associate Director for Natural Hazards at the U.S. Geological Survey (USGS). I am also currently exercising the authority of the Deputy Director. I appreciate the opportunity to testify here today about natural hazards and to share with the committee current USGS activities that are helping make communities and the Nation safer and more resilient. Every day, people and communities across the Nation face risks associated with geologic hazards. These hazards include: earthquakes, volcanoes, landslides and subsidence, coastal erosion, tsunamis, and even naturally occurring contaminants. While these hazards threaten lives, they also threaten homes, buildings, wildlife, the environment, and the infrastructure that underpins our economy and our way of life.

In carrying out our natural hazards mission, the strength of the USGS is the range of capabilities and partnerships we can bring to bear to deliver useful, actionable hazards information to first-responders, emergency managers and other local, state and federal decision makers.

USGS monitoring networks enable rapid situational awareness tools for effective response, while our hazard and risk assessments and scenarios help communities understand and mitigate their exposure. And all these real-time and long-term products are underpinned by targeted research to improve our understanding of hazard processes and maintain world-class expertise. Other USGS capabilities that serve multiple purposes also contribute. Improved elevation data collected through the 3D Elevation Program, or 3DEP, lead to better flood inundation maps as well as new discoveries of faults, landslides, and deposits from past volcanic eruptions that inform us of the frequency of eruptions and the reach of volcanic hazards on the landscape. Geologic mapping improves our understanding of energy and mineral resources as well as geologic hazards.

Even the most thorough geologic research does not automatically lead to better designed buildings or residents who know how to properly evacuate. For science to make a difference in the outcomes that matter most to society, it is essential that we integrate our geoscience research with engineering and social science and then engage directly with users to shape the collection, investigation, and delivery of our information. This integration empowers the public, policymakers at all levels, businesses, governments, and individuals, to effectively assess their

risks from hazards and to build communities that are more resilient. This is what we at the USGS and our many partners are focused on. It is a responsibility that we carry with us to work every day.

Getting our information into the hands of those who can use it when they need it is of paramount importance. After the Thomas Fire in southern California this past month, the USGS produced maps of debris-flow hazards for the area that supported the NOAA National Weather Service issuance of public warnings. These maps were used by CALFIRE and the California Geological Survey Watershed Emergency Response Teams to identify property and infrastructure, including oil and gas infrastructure, at risk from post-fire debris flows and flash flooding. Those assessments in turn formed the basis for emergency response and evacuation planning by Santa Barbara and Ventura Counties. Our ability to serve the public in anticipation of, during, and subsequent to natural hazard events is exemplified by USGS delivery of coastal inundation and erosion hazard forecasts for the series of major hurricanes (Harvey, Irma, Jose, Maria and Nate) and nor'easters that impacted our Gulf and Atlantic coastal communities this past year. The ability to do so is a result of persistent mapping, monitoring and research programs that inform effective planning, response, and recovery by our federal, State, and local partners.

In accordance with congressional funding, we are working with the States, university partners, and private foundations to develop an earthquake early warning system called *ShakeAlert* for the West Coast, and we are working with private firms and public agencies to integrate those warnings into automated systems and emergency announcements. With new funding directed by Congress in recent years for this purpose, the system is now about half-completed and we expect to begin limited public alerting by the end of this year. There are many technical and other challenges remaining, including determining the appropriate federal, state and local cost share, before full, border-to-border public alerting will achieved. However, an earthquake early warning system would be able to provide an additional layer of safety from inevitable large earthquakes. If completed, this technology is expandable to other regional seismic networks of the USGS Advanced National Seismic System, such as Alaska, Nevada, and Utah, providing a significant boost in the capabilities of those seismic networks, which have declined in recent years due to constrained state and federal funding.

In the U.S. and around the globe, large-scale natural hazard events shape our landscapes and our lives. Nowhere is that more evident than it is for the landscapes that sit astride subduction zones, where two tectonic plates collide and one subducts, or is driven beneath, the other. The margins of the Pacific Ocean consist of a series of subduction zones, known as the Ring of Fire, linked by transform faults such as the San Andreas Fault. The Pacific subduction zones most relevant to the U.S. border the Pacific Northwest (Cascadia), Southern Alaska and the Aleutian Islands, the Marianas Trench, and the Tonga zone near American Samoa. The U.S. Territories of Puerto Rico and the Virgin Islands, are also atop a subduction zone in the Caribbean.

This past June, the USGS released Circular 1428, a subduction zone science plan that defines USGS science priorities and identifies potential partnerships with other organizations involved in related scientific research, emergency management, policy making, and planning. The plan highlights knowledge gaps and opportunities for improvement in three crucial areas—(1) advancing observations and modeling of subduction zone processes, (2) quantifying subduction zone natural hazards and risk, and (3) providing forecasts and rapidly delivered updates during and after subduction zone events. The plan lays out an achievable vision for addressing the hazards associated with subduction zones, which include some of the most catastrophic natural disasters in history.

Off-shore earthquakes and landslides may trigger tsunamis, some so large that they traverse the entire Pacific Ocean, while others are localized but still deadly. A megathrust earthquake off the Aleutians or Cascadia could cause tsunamis as far away as Hawaii or southern California. Monitoring for these tsunamis requires integrated warning systems and close cooperation between the USGS and NOAA. The magnitude-9.2 Great Alaskan Earthquake of 1964 occurred when part of the Pacific Plate snapped while subducting beneath the North American Plate causing tsunamis, 129 deaths in 3 states, and an estimated $2.4 billion in property losses (in 2017 dollars).

Subduction zones also generate strings of active volcanoes. From Northern California to the Aleutians, to the Mariana Islands and beyond, these volcanic hazards pose immediate threats to nearby communities and also produce ash clouds that disrupt international air traffic. The 1991 eruption of Mount Pinatubo in the Philippines was the largest eruption of the 20th century. There, forecasts by the USGS and Philippine authorities led to the evacuation of 75,000 people, including 18,000 U.S. military personnel, and averted an estimated $250 million in property losses. Fast-moving debris flows of volcanic material known as lahars threaten communities downslope from volcanoes. The USGS and Pierce County, Washington, are working together to establish a lahar detection and warning system for all major drainages of Mt. Rainier. When completed, it will serve as a model for protecting populations at risk of lahars from other volcanoes. The USGS is currently finalizing a congressionally mandated report that specifies the implementation plan for a National Volcano Early Warning System that will ensure that all volcanoes in the U.S. are monitored at levels commensurate with their threat that makes use of the latest national threat level assessment to be published by the USGS in 2018.

In Alaska, USGS science and hazard monitoring operations focus on threats from earthquakes, tsunami, volcanic eruptions, landslides, coastal change and geomagnetic storms. Regarding earthquakes, the report language accompanying the *Consolidated Appropriations Act, 2017,* directed the USGS to report back to the House and Senate Appropriations Committees with "an implementation plan, including cost estimates, for the adoption of future seismic stations." The

relevant seismic stations are those of the National Science Foundation's EarthScope Transportable Array (TA), currently deployed across Alaska for a period of two years. The USGS implementation plan will provide a detailed strategy and costs for the adoption of 60 of 270 TA seismic stations, the retention of the TA equipment upgrades at 30 permanent stations, upgrades to 28 of 140 geodetic stations that are part of NSF's Plate Boundary Observatory project, and construction and operation of an earthquake early warning system for the Anchorage region. Of these investment options, the USGS prioritizes the retention of the TA equipment upgrades at 30 permanent stations of the Alaska Seismic Network and Alaska Volcano Observatory network, plus two other high-value stations for monitoring high-threat volcanoes in the state. USGS has begun discussion with the National Science Foundation about potential adoption of these stations.

USGS is also prioritizing the update of the Alaska Seismic Hazard Model, which is the basis for earthquake-safe construction state-wide. Because Alaska hosts significant elements of the national critical infrastructure, such as the Trans-Alaska Pipeline, major ports and military bases, earthquake-resistant construction is especially important, not only for the state but for the nation. The current USGS map is significantly outdated and does not accurately account for new scientific information on large earthquake occurrence and related earthquake ground shaking data. In 2016, this need was recognized as a priority by the Alaska Seismic Hazards Safety Commission. Completing—and subsequently maintaining and improving—this major update is part-in-parcel with the USGS priority for expanding subduction zone science. Its activities and results will be applicable to other subduction zone environments, including Cascadia and Puerto Rico.

All of our efforts—to understand hazards, to build monitoring and warning systems that produce actionable products and inform the public, and to integrate USGS information into official and private-sector responses—depend ultimately on equipment and personnel. In this regard, I would emphasize another example of critical infrastructure, namely our country's scientific capabilities. When our science infrastructure is robust and efficient, it improves our ability to protect other infrastructure, to repair damage quickly, and to restore it to an even more resilient state.

On behalf of the 8,000 employees of the USGS, thank you for inviting us to testify and for the attention you are giving to this important topic. I am happy to answer any questions you may have.

The CHAIRMAN. Thank you, Dr. Applegate.

Mr. Casamassa, welcome.

STATEMENT OF GLENN CASAMASSA, ASSOCIATE DEPUTY CHIEF, NATIONAL FOREST SYSTEM, U.S. FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

Mr. CASAMASSA. Madam Chairman, Ranking Member Cantwell, members of the Committee, thank you for the opportunity to present the views of the U.S. Department of Agriculture regarding natural hazards on National Forest System lands, specifically around our efforts to monitor, mitigate, and forecast avalanches along with our use of mapping and monitoring systems.

I'm not going to spend much time on issues that relate to areas that USGS has covered, but I will say that the Forest Service actively manages public and employee vulnerabilities associated with these natural hazards.

The Forest Service relies on geospatial technology and geographic information systems, remote sensing and real-time sensors such as stream gauges, weather stations, lightning detection, infrared heat detection systems, aerial images and, of course, our experienced cadre of field technicians, professionals and partners.

Forest Service and U.S. Geological Survey routinely share base data to reduce duplication and generate values under the collect once, use many, principles. Our Geospatial Technology and Application Center in Salt Lake City is also collaborating with the U.S. Geological Survey and others in the Interior Department to build a more efficient and effective hazard vulnerability assessment tool.

With respect to the Forest Service Avalanche Safety Program, we are deeply committed to this program which was founded approximately 80 years ago. Unfortunately, avalanches kill more people on National Forests than any other natural hazard. Each winter, on the average of 25 to 30 people are killed by avalanches in the United States. This is why the Forest Service has traditionally been and continues to be the lead agency for avalanche safety.

Work and sport in avalanche country revolves around a tight knit community of which the Forest Service is proud to support and be a part of. Each avalanche death is felt profoundly. This year's victims so far include a well-known and respected skier in Alaska, prominent young skiers in Montana and Colorado, and experienced snowmobile and motorized snow bikers in Wyoming, Idaho, and Montana.

The Forest Service avalanche program consists of two primary parts. First, we operate a Military Artillery for Avalanche Control Program in close coordination with several of the ski areas on National Forest System lands. Second, we maintain a network of 13 backcountry avalanche forecasting operations. I'll discuss each a little bit separately.

The Military Artillery for Avalanche Control Program protects the skiing public by utilizing U.S. Army surplus howitzers to trigger avalanches. Nationally, this program involves close coordination between the Department of the Army, the Forest Service, several departments of transportation including Alaska, Washington and Colorado, and Forest Service permitted ski areas in a wide variety of Western states.

A 2017 Interagency Agreement between the Department of the Army and the Forest Service guides the program's operation. The program is highly valued by the participating ski areas. As such, these ski areas cover its entire operating cost which is approximately $750,000 per year.

The second Forest Service avalanche safety program includes avalanche information and education to the public. This is one of the most visible public safety programs run by our agency and is an excellent example of a robust and successful public-private partnership. The program is comprised of 13 Forest Service Avalanche Centers as well as our partners at the Colorado Avalanche Information Center, the American Avalanche Association, and several non-profit avalanche centers. Each operation is managed locally and partially supported financially by affiliated, non-profit friends' groups.

In order to better communicate all the avalanche information to the public, the Forest Service has partnered with the American Avalanche Association to develop and maintain avalanche.org. Avalanche.org connects the public to backcountry avalanche information and education in the United States and represents a series of collaboration and partnerships that span more than 25 independent operations in 12 states. This initiative also provides a home for the development of technologies which improve our ability to forecast and communicate avalanche hazards.

The Forest Service recently published a peer-reviewed article in a journal, Wilderness and Environmental Medicine, that rigorously analyzed avalanche fatality over the past 20 years. This statistical analysis demonstrated that while the number of backcountry users has increased by at least a factor of eight, the number of avalanche fatalities during that time has remained unchanged with about 25 to 30 fatalities per year.

While we are not satisfied until we can further reduce the avalanche fatality rate, this represents success both for our avalanche program and also for the safety gear manufacturers and educators. The USDA Forest Service is committed to public safety and partnering to ensure resources and evolving technologies are available and used to enhance planning, forecasting and protecting lives.

Thank you for the opportunity to testify, and I look forward to answering your questions.

[The prepared statement of Mr. Casamassa follows:]

STATEMENT OF
GLENN CASAMASSA
ASSOCIATE DEPUTY CHIEF, NATIONAL FOREST SYSTEM
U.S. FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE
BEFORE THE
UNITED STATES SENATE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
CONCERNING
Oversight of Natural Hazards

JANUARY 30, 2018

Madame Chairman and members of the Committee, thank you for the opportunity to present the views of the U.S. Department of Agriculture (USDA) regarding natural hazards on National Forest System lands, specifically around our efforts to monitor, mitigate, and forecast avalanches along with our use of mapping and monitoring systems.

USDA Forest Service Avalanche Safety Program

The USDA Forest Service is deeply committed to our avalanche safety program, which was founded 80 years ago. Unfortunately, avalanches kill more people on National Forests than any other natural hazard. Each winter, an average of 28 people are killed by avalanches in the United States and nearly all of these deaths involve recreation on National Forests. This is why the Forest Service has traditionally been, and continues to be, the lead agency for avalanche safety.

The Forest Service aims to provide reasonably safe recreational opportunities for the public, and to warn the public about imminent danger on our lands. As such, our goal is to provide information, education, and planning tools designed to reduce avalanche risk and improve backcountry and ski area safety.

The Forest Service avalanche program consists of two primary parts. First, we operate a military artillery for avalanche control program in close cooperation with several ski areas. Second, we maintain a network of 13 backcountry avalanche forecasting operations. I will discuss each program in more detail.

The military artillery for avalanche control program protects the skiing public by utilizing U.S. Army surplus 105 mm howitzers to trigger avalanches. Nationally, this program involves close cooperation between the Department of the Army, the Forest Service, several Departments of Transportation (including Alaska, Washington and Colorado), the Alaska Railroad, Alyeska Ski Resort, Alaska Department of Natural Resources, and Forest Service permitted ski areas in Colorado, Utah, Nevada, California, and Oregon. A 2017 Interagency Agreement between the Department of the Army and the Forest Service guides the program's operation. The Forest Service's role in the program is essential for mitigating avalanche danger and maintaining public safety at ski areas that host more than 2 million skier visits each winter. The program is highly valued by the participating ski areas; as such, these ski areas cover its entire operating cost which is approximately $750,000 per year

The second Forest Service avalanche safety program provides avalanche information and education to the public. This is one of the most visible public safety programs run by our agency, and is an excellent example of a robust and successful public/private partnership, with more than half of program dollars coming from non-federal sources, including grants, donations, and non-profit partners or friends groups. Nationally, partners contribute about $1.7 million annually to the program while the Forest Service appropriated dollars contributes $1.5 million. The program is comprised of 13 Forest Service Avalanche Centers, as well as our partners at the Colorado Avalanche Information Center, the American Avalanche Association, and several non-profit avalanche centers. Each operation is managed locally and is partially supported financially by affiliated non-profit 'friends' groups.

Avalanche centers cover terrain in the western United States (Alaska, Washington, Oregon, California, Nevada, Idaho, Montana, Utah, Wyoming, Colorado, Arizona, and New Mexico), as well as one avalanche center in New Hampshire. These operations gather current information

about snowpack and weather conditions in order to provide accurate and timely avalanche advisories and warnings to the public. Advisories are augmented with photos, videos and near-real time observations from the field. These public safety products are accessed more than 10 million times each winter by more than 1 million people who work, recreate, and travel in the mountains. The program also distributes hazard and risk messaging through a robust social media presence and via a strong partnership with the National Weather Service and associated emergency alert systems.

In addition to avalanche advisories, our avalanche centers provide high quality avalanche education to tens of thousands of people each winter. These courses are geared toward the local audience and designed not to compete with guiding and outfitting operations who teach avalanche courses as part of their livelihood. A particularly successful initiative has been the "Know Before You Go" avalanche awareness program (www.kbyg.org) led by the Utah Avalanche Center. Focused on youth, this program includes many cooperators from across the country as well as Canada and reaches close to 30,000 teens each winter. The video developed for this program is posted online and has received close to 1 million views in the past 18 months.

In order to better communicate all available information to the public, the Forest Service has partnered with the American Avalanche Association to develop and maintain Avalanche.org (www.avalanche.org). Avalanche.org connects the public to backcountry avalanche information and education in the United States and represents a series of collaborations and partnerships that span more than 25 independent operations and 12 states. This initiative also provides a home for the development of technologies which improve our ability to both forecast and communicate avalanche hazard.

We have strong evidence that our approach successfully mitigates avalanche danger faced by the public. The Forest Service recently published a peer-reviewed article in the journal Wilderness and Environmental Medicine that rigorously analyzed avalanche fatality data over the past 20 years. This statistical analysis demonstrated that, while the number of backcountry users has increased by at least a factor of 8, the number of avalanche fatalities during that time has remained unchanged, with an average of 28 fatalities per year. Thus, the avalanche fatality rate

(number of fatalities divided by the number of users) has dropped significantly. If our fatality rate had remained constant, we would be seeing more than 200 avalanche fatalities annually. While we will not be satisfied until we can further reduce the avalanche fatality rate, this represents success both for our Forest Service avalanche programs, and also for avalanche safety gear manufacturers and all avalanche educators.

USDA Forest Service Support of Public Safety from Other Hazards

The Forest Service also actively manages public and employee vulnerabilities associated with natural hazards such as; unstable soils, floodplains, debris flows, naturally occurring asbestos, landslides and other geologic hazards. The Forest Service relies on geospatial technology in Geographic Information Systems, Remote Sensing, and real time sensors such a stream gauges, weather stations, lightning detection, infrared heat detection systems, aerial imaging, and of course, our experienced cadre of field technicians, professionals, and partners.

The Forest Service increased usage of geospatial data in strategic decision making to actively plan for natural hazards and events following a 500-year flood which occurred in low lying Forest Service lands along the Little Missouri River in Arkansas on June 11, 2010. This catastrophic event took the lives of 20 people who were asleep in a Forest Service campground facility and drove the review of campground locations, signage, evacuation plans, and other communications to improve visitor safety throughout the national forests.

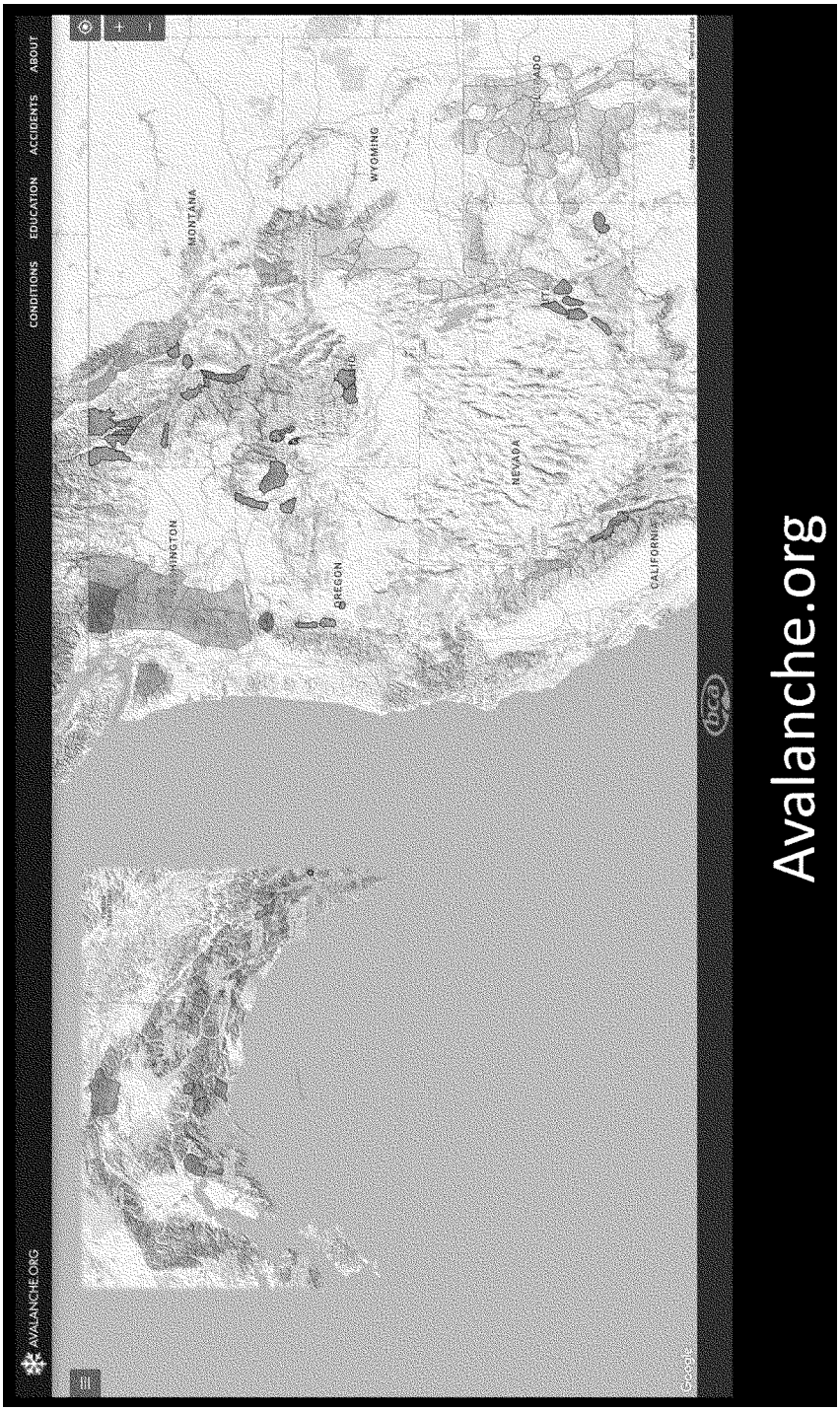
The Forest Service shares our internal data with other agencies such as Federal Emergency Management Agency, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, along with, State and local governments, industry and the public. Standardized "open" data is kept in our Enterprise Data Warehouse and is available on Data.gov. We also rely on partnerships and collaboration with other agencies to collect and supply data such as 3D elevation lidar (light detection and ranging), national hydrography dataset, Alaska interferometric synthetic aperture radar, along with mapping efforts such as nationwide Forest Service Topo 7 ½ inch scale map products, and the US Geological Survey-led Alaska Mapping Initiative. The Forest Service and US Geological Survey routinely share base data to reduce duplication and generate value under the "Collect Once, Use Many" principles.

Optical and thermal imagery and aerial views greatly influence our agency's ability to respond to emergencies and events, as well as recovery and restoration of Forest Service lands and watershed condition. We use these internal and external data sets to drive predictive modelling and mapping techniques to inform our planning and decision making.

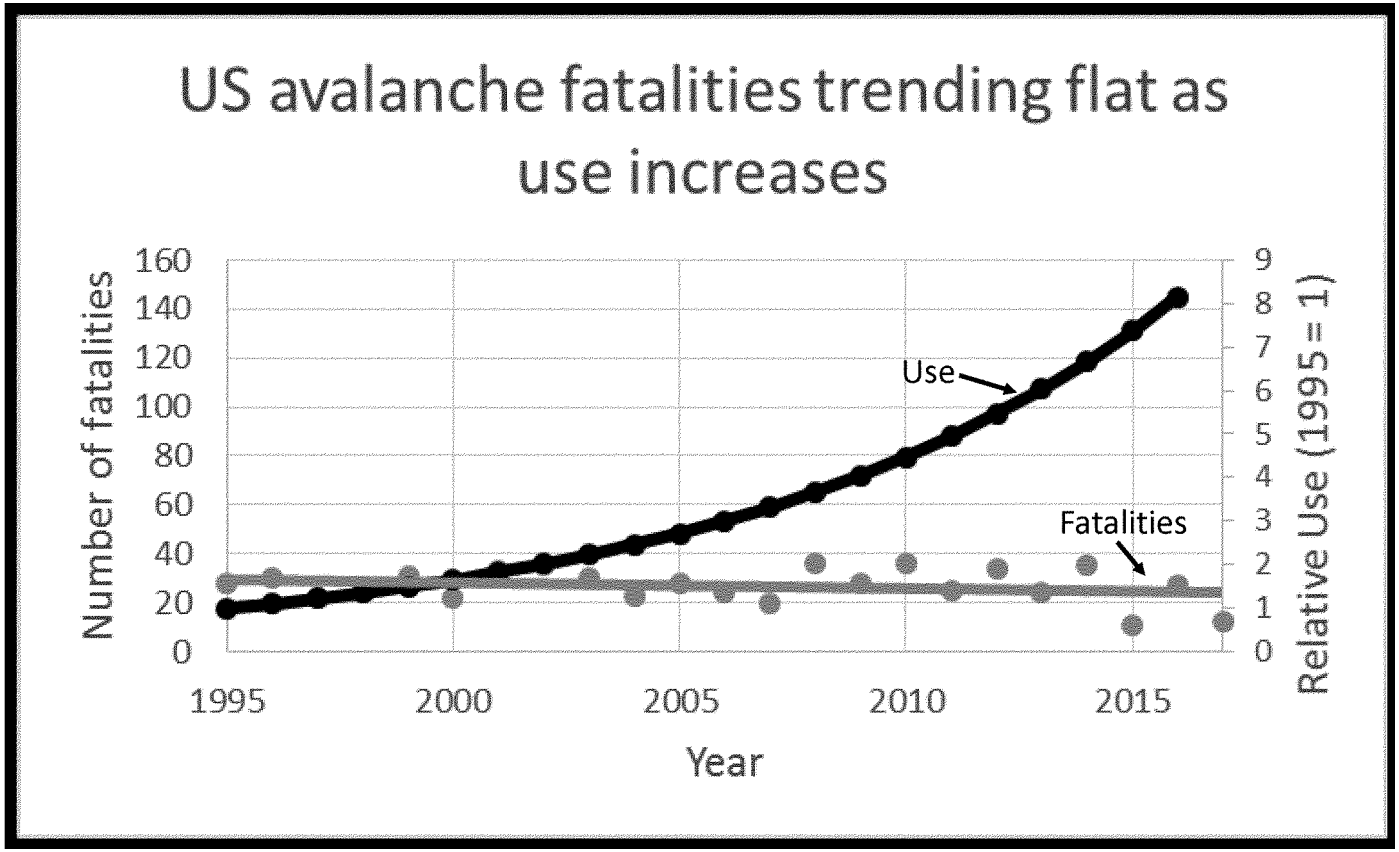
Our Geospatial Technology and Applications Center in Salt Lake City is also collaborating with US Geological Survey and others in the Interior Department to build a Hazards Vulnerability Assessment tool. This assessment tool provides us with a map view of potential hazards and the risks posed to public, employees, assets, natural resources, and our infrastructure. Recent events such as the west coast Tsunami warnings, hurricanes, volcanic and earthquake activity potential across the country, floodplains, drought, insect and disease damage, and other information can be shown using an on-line map viewer.

Conclusion

The USDA Forest Service is committed to public safety and partnering to ensure resources and evolving technologies are available and used to enhance planning, forecasting and protecting lives. Thank you for the opportunity to testify and I look forward to answering your questions.



Avalanche.org


US avalanche fatalities trending flat as use increases
Number of fatalities
160
140
120
100
80
60
40
20
0
Relative Use (1995 = 1)
9
8
7
6
5
4
3
2
1
0
1995
2000
2005
2010
2015
Year
Use
Fatalities

USDA Forest Service OpenData Site Makes it Easy to Access our Data

The Forest Service is a leader in the federal government in open data initiatives with 180 authoritative Agency data sets published in data.gov.

Examples from the Forest Service Hazards Vulnerability Viewer

Buildings and Earthquake Potential

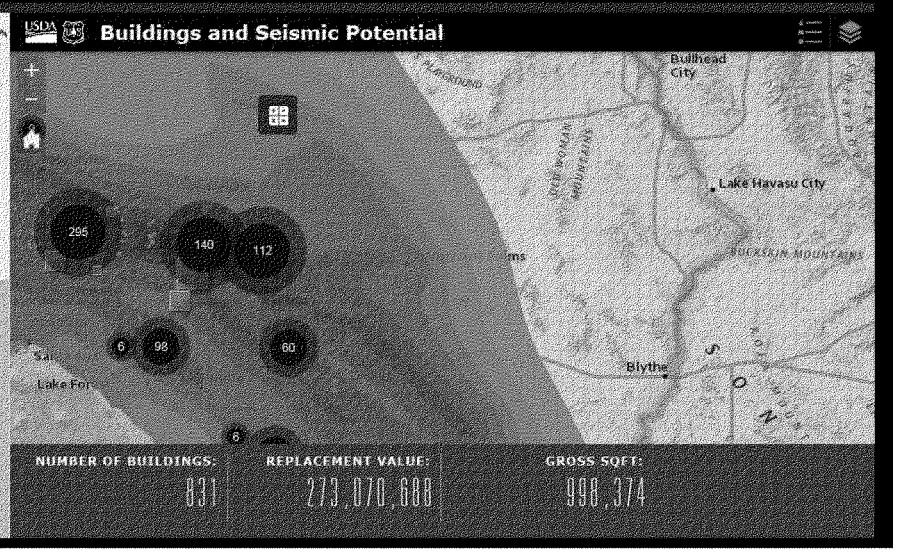
6 Buildings and Earthquake Potential

The map on he right is intended to highlight Forest Service buildings which may be at additional risk from earthquakes.

Forest Service Building data has been overlaid with earthquake probability data and filtered to highlight which buildings may experience higher horizontal ground acceleration.

The numbers inside the black bubble clusters represent the number of buildings in that area. The statistics at the bottom of the map summarize information about the buildings inside inside the horizontal ground acceleration threshold and the current map frame. The blue squares represent actual building locations displayed by current replacement value.

The earthquake risk data is from the USGS and shows the probability that ground motion will reach a certain level. It indicates peak horizontal ground acceleration (the fastest measured change in speed, for a particle at ground level that is moving horizontally due to an earthquake) with a 10% probability of exceedance in 50 years. Values are given in %g, where g is acceleration due to gravity, or 9.8 meters/second^2.



7 Emergency Relief for Federally Owned

The CHAIRMAN. Thank you, Mr. Casamassa.

Mayor Branson, welcome to the Committee.

STATEMENT OF HON. PAT BRANSON, MAYOR, CITY OF KODIAK, ALASKA

Ms. BRANSON. Thank you, Chairman Murkowski, Ranking Member Cantwell. It's an honor to be invited here today to testify on these important issues.

With your permission, I would like to submit written testimony for the record and provide a brief summary in my remarks.

Kodiak people have a long history with preparedness and resiliency in the face of natural disasters and geographic challenges. In fact, the City of Kodiak was founded in the wake of a natural disaster. In 1788, Russian colonists were forced to abandon their original settlement on Southern Kodiak Island and move their capital to the location of our present-day city when a massive earthquake and series of tsunamis destroyed their homes and infrastructure in Three Saints Bay.

We have learned through many brushes with disasters that readiness is a community responsibility. We all have crucial roles to play. We, on the Kodiak archipelago, including our six remote villages, believe that if you are prepared an emergency event need not become a crisis.

At 12:32 a.m., one week ago, Kodiak received a wake-up call. We were jolted awake by a magnitude 7.9 earthquake only 175 miles away and within moments our community sprang into action. Our tsunami alert sirens were activated, the Incident Management Team was assembled and rapidly opened the Interagency Emergency Operation Center and our first responders went to work protecting community assets and shepherding our citizens to safety.

This event was truly an eye-opening incident for us because, though we were hit by a series of minor tsunamis generated by this quake, there was no loss of life. And importantly, it gave an opportunity to evaluate our response and realize that we have critical infrastructure and emergency preparedness needs we must address before the next incident occurs.

One essential need and safety priority is our fire station. Along with protecting the City of Kodiak, the Kodiak Fire Department provides all emergency medical services and transports on the Kodiak road system and mutual aid outside the city, including to our local United States Coast Guard base, the largest in the country. However, the fire station is a 60-years-plus-old structure and the 1964 tsunami came within 10 feet of inundating this facility. Fortunately, this time, we were not hit by a sizable tsunami, but once the all clear was given and the firefighters returned to the station, we discovered that it had sustained significant structural damage from the quake itself with the full extent of this damage yet to be realized until the building finishes settling after most recent tremors. What we do know, however, is that a new fire hall is needed immediately.

Another area of concern is our emergency communications abilities. Patrol officers of the Kodiak Police Department were forced to repeatedly traverse inundation zones to use the PA systems in their squad cars advising people to get out and get to higher

ground because Kodiak does not have an integrated tsunami PA system.

Due to funding shortfalls at the state level, our Alaska State Trooper post has been greatly reduced, and we needed to deploy our city police force outside their jurisdiction to assist in evacuations of citizens living in this area which further reduced the number of officers available within the city. While Kodiak has been diligent in utilizing its limited resources and personnel to maintain our emergency response capability, we have some glaring shortfalls in communications equipment and public safety infrastructure. The cost of eliminating these shortfalls is now in excess of $15 million.

The Trump Administration has recently circulated an outline for a future infrastructure initiative. Under this proposal, 25 percent of the total package would be dedicated to rural infrastructure programs and it contemplates a broad range of eligible activities.

We believe that any proposal crafted by Congress should also include emergency response equipment and public safety buildings. In earthquake and tsunami zones, such as Kodiak, being prepared is a necessary and vital component of maintaining the safety of our residents and local economies. From our own personal experience, both historically and just from one week ago, we cannot emphasize enough the critical importance of adding emergency preparedness infrastructure to the scope of any infrastructure package.

Thank you for this opportunity to speak about our community.

[The prepared statement of Ms. Branson follows:]

Testimony of Kodiak Mayor Pat Branson
Before the Senate Committee on Energy & Natural Resources
Regarding Emergency Response Preparedness for Natural Disasters
January 30, 2018

The people of the Kodiak Archipelago have a long history of responding to challenges and emergency situations. Just as our islands are renowned for their natural and rugged beauty, the resiliency of our people is a fundamental part of our unique home on an isolated island in the North Pacific.

The site that ultimately became the City of Kodiak was actually first established because of natural disaster. In 1788, a devastating earthquake and tsunami destroyed the Russian capital of Russian America in Three Saints Bay, located near the present-day village of Old Harbor. The inhabitants were forced to move farther north and reestablish their capital at the present-day location of Kodiak.

Our long history with disaster doesn't mean we've become fatalistic or paralyzed by fear. It has instead instilled in us a core sense of civic-mindedness and community spirit that were on full display a week ago during our most recent earthquake and tsunami evacuation. In many respects, Kodiak is uniquely prepared for these types of incidents because our culture and heritage is ingrained with the basic principles of the Incident Command System and the National Incident Management System, particularly preparedness, communications and information management, resource management, command, and ongoing maintenance in the face of daily adversities and challenges.

Readiness is a community responsibility. We all have our integral roles to play, from individuals to elected officials. My testimony today will discuss how the City of Kodiak engages in emergency response, how we interact and cooperate with Borough, State, and Federal emergency management partners, issues and concerns we have relating to our existing emergency response capability, and current critical infrastructure gaps and needs for our Archipelago to better protect ourselves when the next event occurs – because if you are prepared, an emergency event need not become a crisis.

Kodiak's Emergency Response Protocols

The Kodiak Emergency Operations Center ("EOC") is staffed by both City of Kodiak and Kodiak Island Borough employees. Per City and Borough ordinances, the Kodiak City Manager serves as the Emergency Services Director ("ESD"), and directs both City and Borough staff in declared emergencies to meet the needs of the community. Once activated, the ESD notifies the Borough Manager of ongoing incidents to facilitate proper notification of Borough officials.

Kodiak's response correlates to the size and complexity of a specific event. Response to events that are within a department's budget, manpower, legal authority, and policy procedures are handled by staff at the department level, up to and including activation of any mutual aid agreements. The Kodiak department chiefs keep the ESD informed of situations that are

expanding in nature and consuming departmental resources which may interfere with normal operations of the department. The ESD may activate some or all EOC manning positions based off on the departmental Incident Commander's needs (i.e. Logistics section to assist in procurement of fuel; full activation when a structure fire has progressed into wild land/urban interface fire and threatens heavily populated areas that require evacuation/sheltering). For larger scale incidents, such as tsunami alerts, the ESD determines directly the response and activation levels based on the severity of the threat. As part of this testimony, we are submitting the Kodiak Emergency Operations Plan for a more detailed understanding of the response protocols.

The ESD has the option to call in support from the State Emergency Operations Center should it be determined that the incident exceeds or potentially exceeds Kodiak's response capability and additional resources are necessary. Interoperability and communication with our Federal counterparts on the US Coast Guard Base are excellent. The Kodiak Police Department maintains the "Public Safety Answering Point" ("PSAP"), a call center responsible for receiving emergency response communications.

The January 23rd Earthquake

At 12:32 AM one week ago, Kodiak received a wake-up call from Mother Nature. We were jolted awake by a magnitude 7.9 earthquake only 125 miles away, and within moments our community sprang into action. Our tsunami alert sirens were activated, the incident management team was assembled and rapidly opened the inter-agency emergency operations center, and our first responders went to work protecting community assets and shepherding our citizens to safety. This event was truly an eye-opening incident for our town, because even though we were hit by a series of minor tsunamis generated by this quake, there was no loss of life – and just as importantly, it gave us the opportunity to evaluate our response and realize that we have critical infrastructure and emergency preparedness needs we must address before the next incident occurs.

One such critical need and safety priority is our fire station. Along with protecting the City of Kodiak itself, the Kodiak Fire Department provides all emergency medical services and transport to the Kodiak road system, as well as any responses requiring mutual aid outside of the City – including to our local United States Coast Guard base, which is the largest in the nation.

However, the fire station is an aging 60 year old structure, and the 1964 tsunami came within 10 feet of inundating this facility. During Tuesday's event, as soon as our fire fighters could regain their footing, they were immediately preparing their evacuation of the station to get themselves, our priceless Fire, Rescue, and EMS vehicles, and a stockpile of emergency supplies out of harm's way and to higher ground in order to continue protecting our community no matter what the evening held in store for us.

Fortunately, we were not hit by a sizeable tsunami, but once the all-clear was given and they returned to the station, we discovered that it had sustained significant structural damage from the quake itself – and the full extent of this damage cannot yet be fully realized until the building finishes settling after this most recent tremor (please refer to the included document

"*Kodiak Fire Station Earthquake Damage*"). What we do know, however, is that a new fire hall is needed immediately to replace our historic 60 year old station.

Another area of concern is in our emergency communications abilities. Patrol officers of the Kodiak Police Department were forced to repeatedly traverse inundation zones to use the Public Address systems in their squad cars advising people to get out and get to high ground, because Kodiak does not have an integrated tsunami PA system at our disposal. Additionally, due to funding shortfalls at the state level, our Alaska State Trooper post has been greatly reduced, and we needed to deploy KPD personnel outside their jurisdiction - up to 12 miles outside of city limits – to assist in evacuations of citizens living in this area, and to remain there to prepare for the possibility of extensive tsunami damage, which further reduced the number of officers available within city limits.

Kodiak's Emergency Response Shortfalls

While Kodiak has been diligent in utilizing its limited resources to maintain our emergency response capability, we have some glaring preparedness shortfalls. These are:

1. Insufficient Staffing;
2. Lack of a PA Capable System;
3. Insufficient Radio Capability;
4. Out-of-Date Public Safety Answering Point;
5. Inadequate Communications Repeaters and Receivers

Insufficient Staffing

Our EOC staff is only large enough to handle the first 24 hours during a major event, at which point the ESD would need to request assistance from the State EOC. This is particularly acute in our Public Works Department with its limited staff experience. We have ten field employees and five employees working at the water and wastewater treatment facility. Of the ten field staff, only three or four can be sent on their own to solve major problems without detailed support. This is especially true when dealing with the water system. It is critical to avoid shutting off water unless absolutely necessary. Contamination of the system is a serious issue when shutting down water so it needs to be done carefully to protect the system and public health.

Public Address Systems

We need to upgrade all of the tsunami warning sirens to a PA capable system, such as the type used in Portland, Oregon and Japan. During the most recent event Kodiak Police Department patrol officers drove through vulnerable neighborhoods using their car-based PA systems to inform people to evacuate to higher ground. Having an Archipelago-wide PA

tsunami alert system integrated into the Public Safety Answering Point would allow Kodiak Police Department dispatch staff to announce emergency information, thus freeing patrol officers to conduct other duties during an evacuation event, and ensuring even those residents living in the most remote villages will be receiving timely evacuation and emergency preparedness information. The cost of replacing and upgrading the tsunami alert system is $2.5 million.

Radio Capability

Radios are also a critical need for Kodiak right now, both for civilians (portable radios able to access emergency broadcast frequencies), as well as new secure radios that allow interoperability and thus communications amongst our First Responders (City, Borough, State, or Federal). Along with radio broadcasts and communications, both our Emergency Response and Emergency Broadcast abilities are limited by aging generator backups. These generator systems are in critical need of upgrade and replacement.

The City and Borough have done extensive research and planning to determine the extent of any upgrade and/or replacement of radios, software, and accessories. We believe that it is necessary to procure fifty-five (55) portable radios and forty-four (44) mobile radios to meet the needs of the local First Responders (ESD personnel, police, fire, and ambulance services). Rough order of magnitude costs for these upgrades is $450,000.

Public Safety Answering Point

The Kodiak Police Department's Central Communications system for the Public Safety Answering Point was last upgraded in 2005. The existing operating systems are no longer supported by the manufacturer, and the spare parts saved from upgrading other systems around the state may not be compatible with our system for firmware and hardware. The Windows XP Operating System is not compatible with current versions of video monitors and other network firmware and hardware, and IT support on the Windows XP systems is expiring and very hard to find. Other PSAPs in the state have upgraded to a new Motorola system with high reliability and ease of use. This system is capable of analog and digital signaling and working in either clear or encrypted mode, with audio and control features that are very robust and programmable. The cost of this upgrade is roughly $400,000.

Repeaters and Receivers

These are the systems that allow the Kodiak Police and Fire Dispatch to make voice audio transmissions.

The main repeaters are located on Pillar Mountain in the communications shelter. The repeaters receive signals from the transmitting radios below and the repeaters amplify that signal to nearly 250 watts and re-broadcast it across the City of Kodiak's jurisdiction and beyond. The existing repeaters are 12 years old with millions of push to talk conversations on them, and are still good for a couple more years. Replacement will be necessary by 2019 to meet anticipated changes in the FCC rules for narrowband digital modulation.

There are three receiver sites with comparators, gateways, and switches that select the best signal from each radio transmitting to the Police Department. None of the radios have problems hearing outgoing signal from Pillar, so the system is designed to capture and improve radio "Talk Back" signal to the system and to dispatch. There are FCC public safety digital mandates coming on line in 2020. Our current receivers are not compatible with new systems coming on line to meet the changing regulatory requirements. We have estimated that upgrade in the repeaters and receivers to improve performance and comply with the FCC mandates will cost roughly $370,000.

In sum, the anticipated cost of upgrading our communications capability to meet preparedness objectives ranges between $1.25 million and $1.5 million. Kodiak does not have the financial capability to meet the full cost of these upgrades.

Kodiak Public Safety Facility Shortfalls

The City of Kodiak identified the need to replace its fire station and has been working toward a replacement plan since 2004. The building has clearly outlived its design life. The building is composed of three structures and sits on a site that is enveloped well within the most-recent tsunami inundation zone modeling (see https://earthquake.alaska.edu/tsunamis/atom). The structure is built of cement block type construction built in the 1950s with two block and wood frame additions added in the 1960s and 1975. The structure poses a significant risk of failure in a seismic event. Cracks in the walls and initial separation of one of the additions from the rest of the structure occurred following the recent large earthquakes of 7.1 on January 24th, 2016, and the 7.9 a week ago on January 23rd, 2018. It has ongoing plumbing, drainage, and water infiltration issues. The facility houses personnel, fire and rescue apparatus, three ambulances, and many types of specialty equipment and medical supplies that support the Advanced Life Support services offered to the entire Kodiak area well beyond the City boundaries. The building condition poses constant challenges and problems to the crews who work and live in the structure. Work to replace this building must continue because it is a key emergency response and life-safety facility for Kodiak and continues to require constant maintenance.

The City has broken this project into phases. Phase I of this project already funded by the City was used to study and select a future site. It included the removal of an old building, site grading, and other work following the demolition of the old building. Phase I is 95% complete. Phase II would involve site acquisition, design and construction. We have estimated that the cost of this phase is $14,000,000.

The role and importance of the United States Coast Guard in our community, State, and Nation

Coast Guard Base Kodiak is the largest Coast Guard unit in the country, and home to over 2,500 active duty and dependent personnel. Formerly a US Navy Base, Base Kodiak serves several tenant commands, including the Air Station, USCGC Munro, USCGC Spar, USCGC Haley, the Aids to Navigation Team, and the North Pacific Regional Fisheries Training Center.

Kodiak's Coast Guard personnel serve under the Coast Guard 17th district in Juneau which encompasses 3,853,500 square miles and over 47,300 miles of shoreline throughout Alaska and the Arctic. The Air Station, with a crew of 350 personnel, maintains and operates 6 MH-60T Jayhawk helicopters which perform search and rescue and deploy to Cold Bay, Cordova, and support Arctic operations in the summer. Four MH-65 Dolphin helicopters deploy regularly on Coast Guard vessels that patrol the Bering Sea. The 5 HC-130 aircraft perform search and rescue, logistics and law enforcement missions in Alaska and the West Coast. USCGC Munro is a 378 foot high endurance cutter that conducts Bering Sea patrols. USCGC Spar, known as 'The Aleutian Keeper," is a 225 foot buoy tender that supports Aids to Navigation efforts in the Aleutians. USCGC Alex Haley, formerly a US Navy salvage and rescue ship, is a 283 foot medium endurance cutter that conducts Bering Sea patrols.

Coast Guard personnel and their families live in or near the City of Kodiak and are an integral and active part of our community. The Kodiak Police and Fire Departments have cooperative responsibility to protect the base through KFD's EMS service; and both KFD and KPD serve Coast Guard personnel and their families who live in town. Our remote and isolated location in the Gulf of Alaska has fostered a mutual respect and dependence between our civilian and military families. Without adequate facilities and equipment to deal with emergencies such as natural disasters, catastrophic accidents, or human-caused devastation, we cannot fulfill our cooperative obligations which may jeopardize not only our community, but the ability of the Coast Guard to perform its various missions both regionally and throughout our Nation.

Recommendation

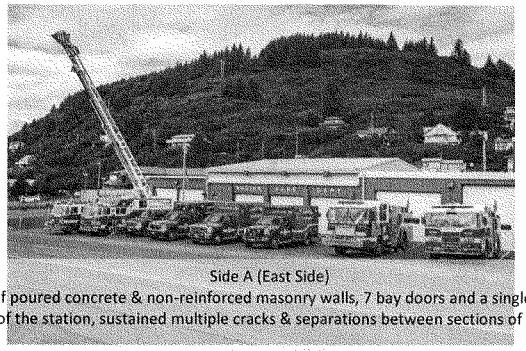
The cost of full upgrading the communications capability and public safety facilities to meet preparedness objectives is staggering. Kodiak is not alone in this regard. Coastal communities throughout Alaska face this daunting task.

The Trump Administration has recently circulated an outline for a future Infrastructure Initiative. Under the Administration's proposal, twenty-five percent (25%) of the total package would be dedicated to a rural infrastructure program. The proposal contemplates a broad range of eligible activities, including transportation, communications, power generation and distribution, and water and wastewater resources. We believe that any proposal crafted by the Congress should also include emergency response equipment and public safety buildings.

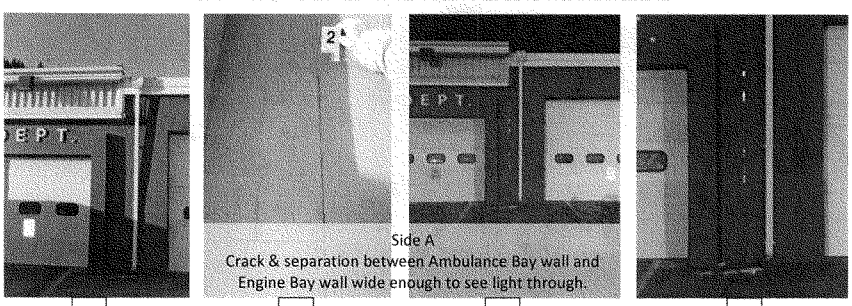
In earthquake zones, such as Kodiak, being prepared is a necessary and a vital component of maintaining local economies, safety of our residents, and peace of mind. From our own personal experience, both historically and from one week ago, we cannot emphasize enough the crucial importance of adding emergency preparedness infrastructure to the scope of any Infrastructure package.

Kodiak Fire Station

1/23/2018 Earthquake Damage

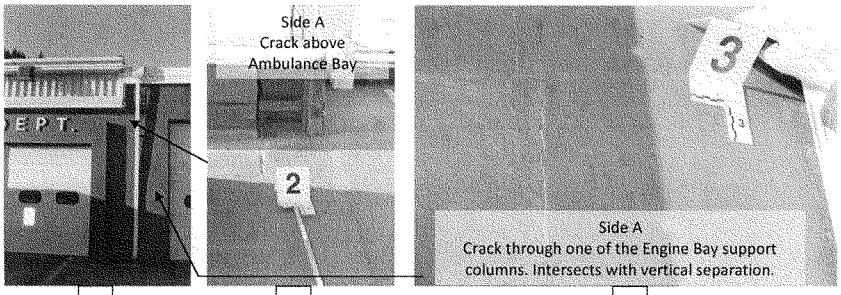


Side A (East Side)
Consists of poured concrete & non-reinforced masonry walls, 7 bay doors and a single man door.
This side of the station, sustained multiple cracks & separations between sections of the station.



Side A
Crack & separation between Ambulance Bay wall and Engine Bay wall wide enough to see light through.

1 2 3 4



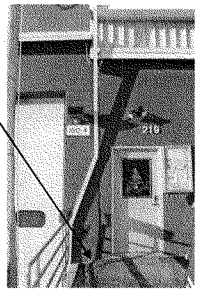
Side A
Crack above Ambulance Bay

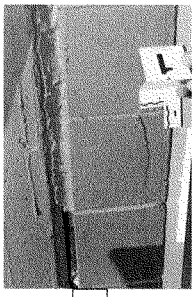
Side A
Crack through one of the Engine Bay support columns. Intersects with vertical separation.

5 6 7

Side A (East Side)
Damage outside the main entrance. Note the cracks in the asphalt, these are expansions from previous damage that have over doubled in size.

Also the expansion of the separation between the lower bay and office area.





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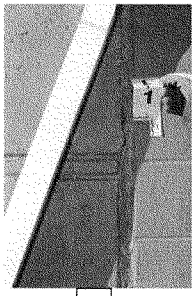

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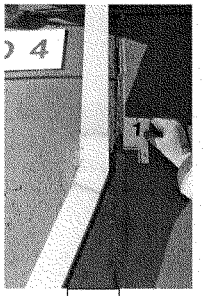

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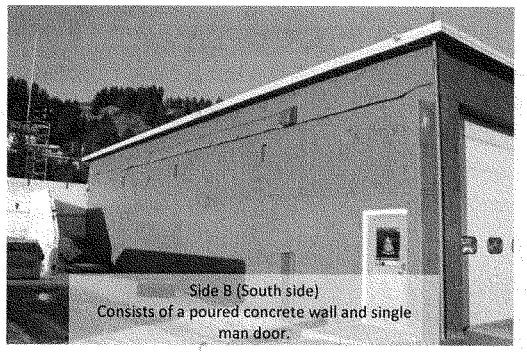

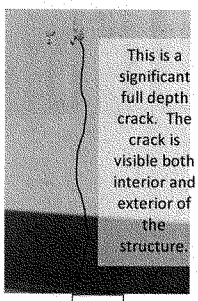

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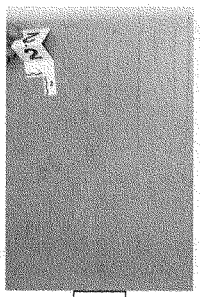

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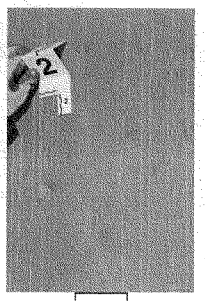

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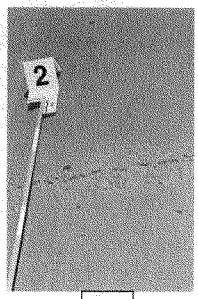

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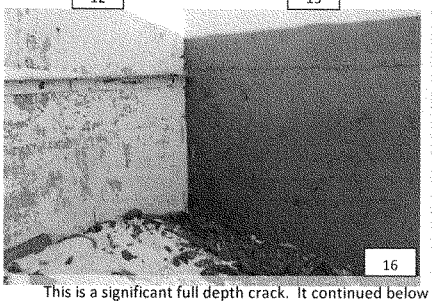

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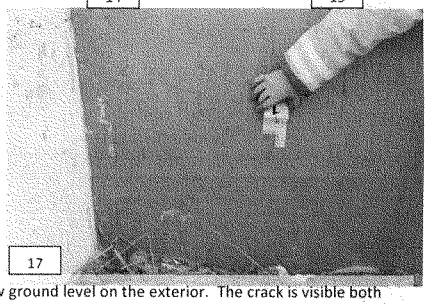
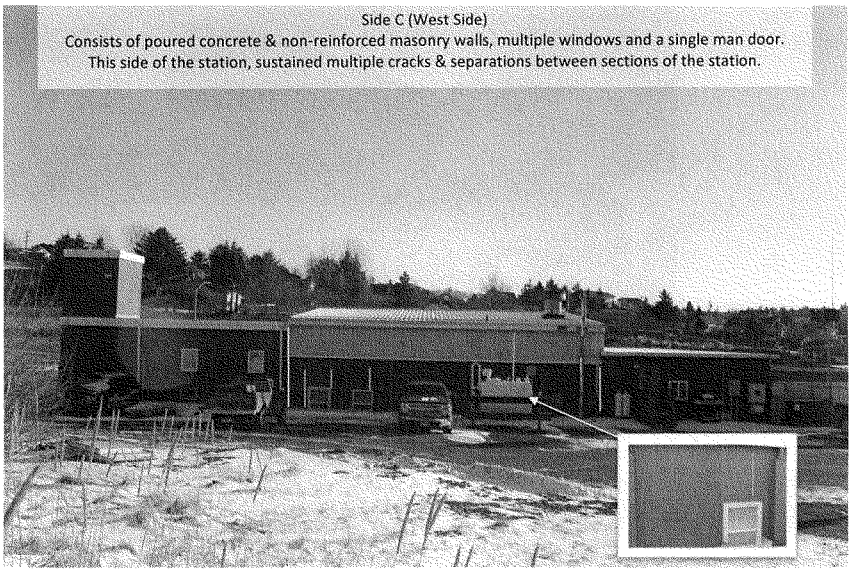
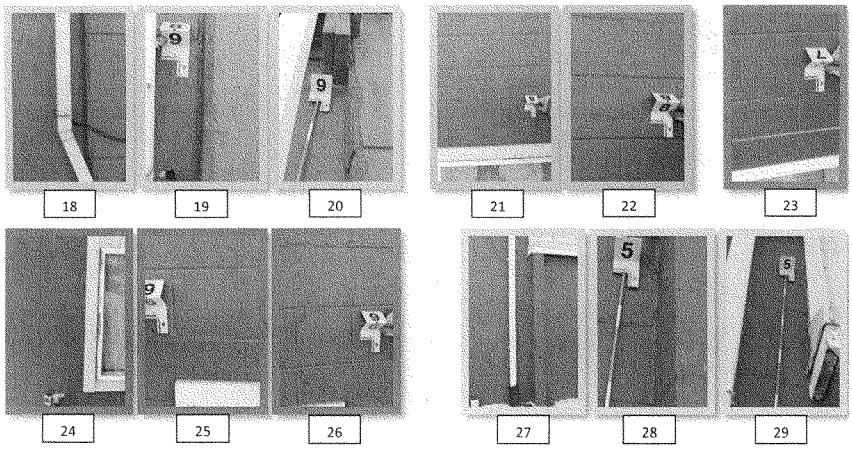


17

This is a significant full depth crack. It continued below ground level on the exterior. The crack is visible both interior and exterior of the structure.


Side C (West Side)
Consists of poured concrete & non-reinforced masonry walls, multiple windows and a single man door.
This side of the station, sustained multiple cracks & separations between sections of the station.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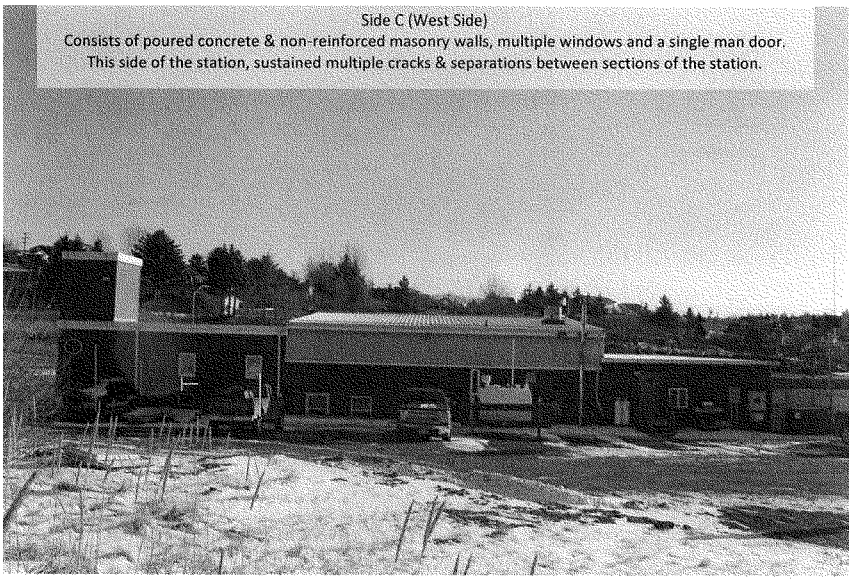
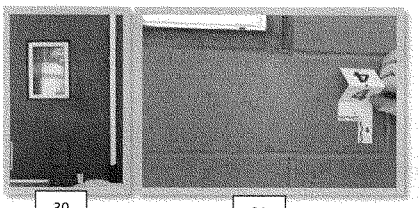

Side C (West Side)
Consists of poured concrete & non-reinforced masonry walls, multiple windows and a single man door.
This side of the station, sustained multiple cracks & separations between sections of the station.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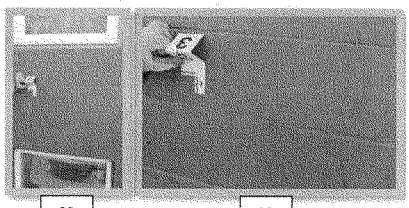
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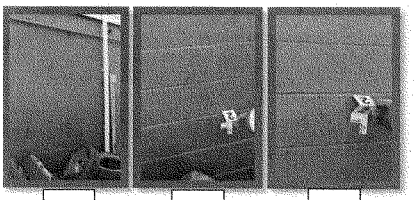
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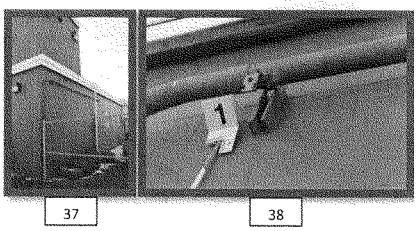
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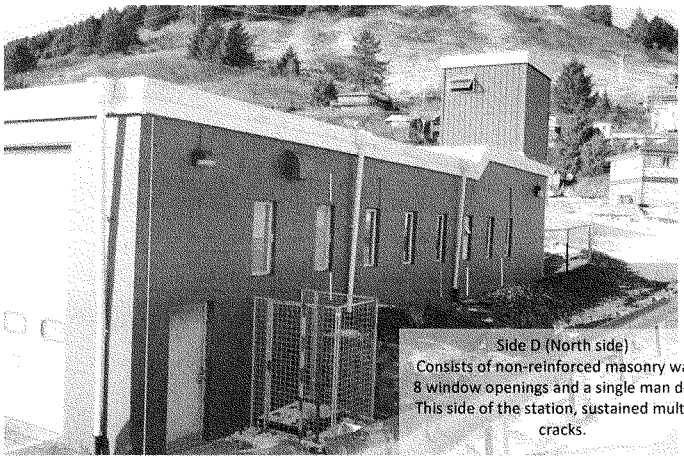
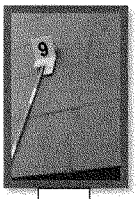


Side D (North side)
Consists of non-reinforced masonry walls, 8 window openings and a single man door. This side of the station, sustained multiple cracks.



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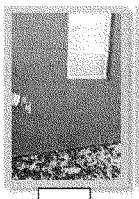

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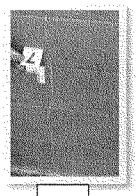

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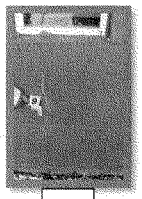

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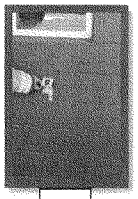

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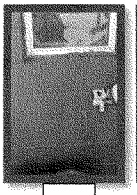

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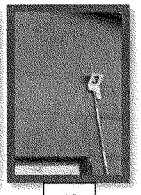

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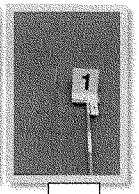

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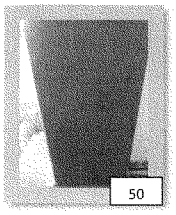

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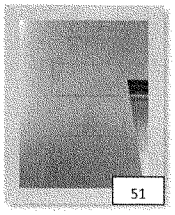

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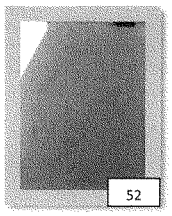

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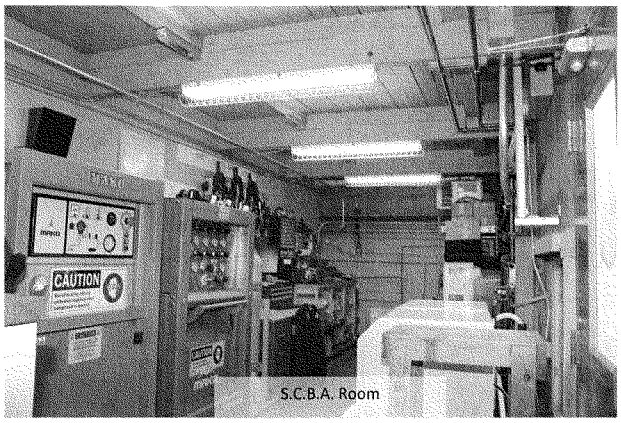

S.C.B.A. Room

Ceiling beams no longer supported by side B wall

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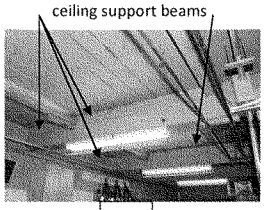
54

Expanding cracks in the ceiling support beams



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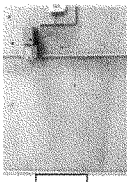
Interior view of full thickness crack mid-B wall pictures from inside the bay



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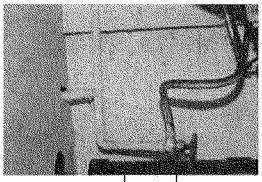
Interior view of full thickness crack end-B wall. Pictures are from in the shop bathroom.



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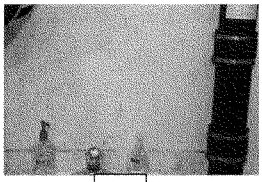

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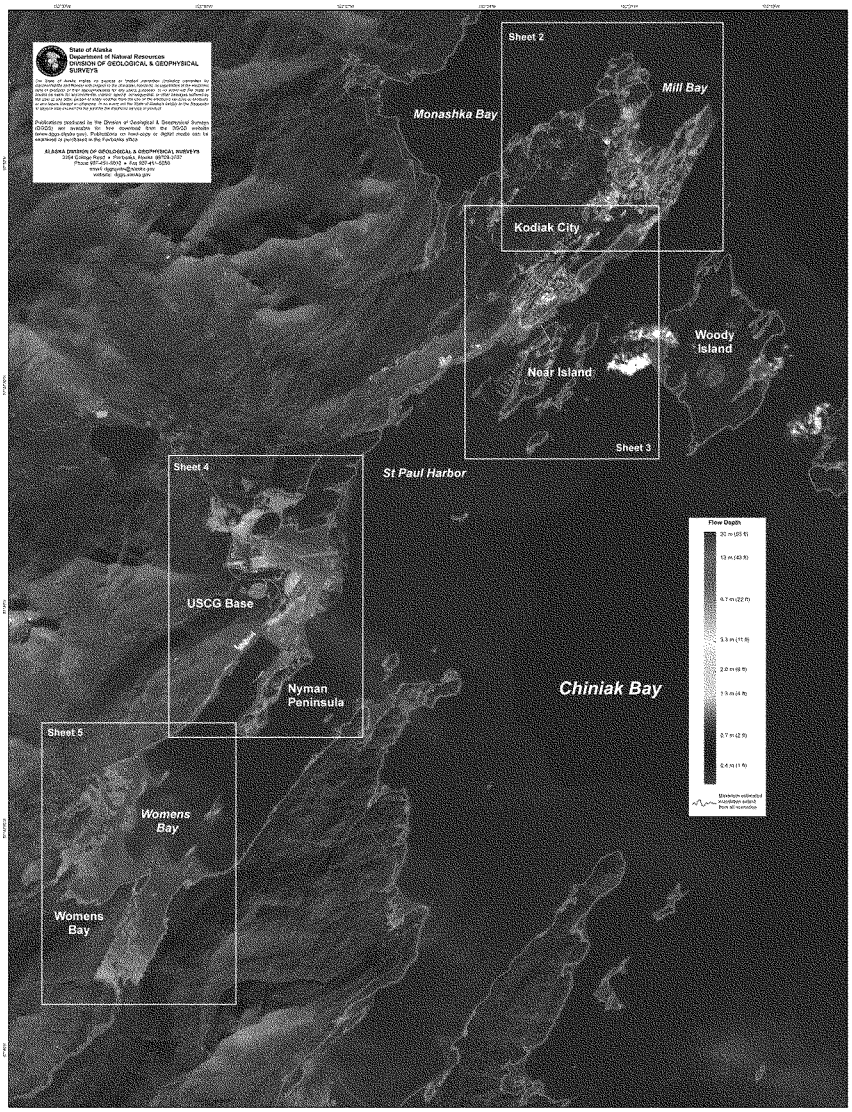


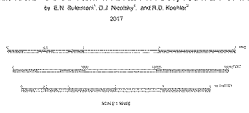
MAXIMUM ESTIMATED TSUNAMI INUNDATION, KODIAK AREA, ALASKA

by G.R. Suleimani[1], D.J. Nicolsky[1], and R.D. Koehler[2]

2017

Location of Map Area

MAP LOCATION



SCALE 1:100,000

This map has been compiled using the best information available and is believed to be accurate and reliable. Tsunami inundation, flow depth, and maximum inland ground substitution during a Cascadiagenic earthquake may vary from those presented. All the necessary causes be guaranteed. Areas permanently flooded will depend on specifics of the earthquake and local ground conditions, and may differ from the areas shown on this map. Information on this map is intended to be used for general planning purposes only. Any other use of the information is not appropriate for site-specific use or for land use regulation. Interpretations of the mapping by qualified experts is strongly recommended.

Affiliation:
[1]Alaska Earthquake Center, Geophysical Institute, University of Alaska Fairbanks, P.O. Box 757320, Fairbanks, AK 99775-7320
[2]Alaska Division of Geological & Geophysical Surveys, 3354 College Rd, Fairbanks, Alaska 99709-3707
P.O. Koehler now at Nevada Bureau of Mines and Geology, Mackay School of Earth Science and Engineering, University of Nevada, Reno, 1664 North Virginia St, MS 178, Reno, NV 89557

The CHAIRMAN. Thank you, Mayor, we appreciate it so much.

Mr. Norman, welcome.

STATEMENT OF DAVID K. NORMAN, STATE GEOLOGIST, WASHINGTON GEOLOGICAL SURVEY, DEPARTMENT OF NATURAL RESOURCES

Mr. NORMAN. Thank you.

Chairman Murkowski, Ranking Member Cantwell, members of the Committee, thank you for inviting me to testify today. I am Dave Norman, the Washington State Geologist representing the Washington Geological Survey, a division of the Department of Natural Resources. I'm also the Chair of the Geological Hazards Committee for the Association of American State Geologists. I'm excited for this opportunity to share some of my views and tell you about some of the geological hazards in Washington State. On a personal note, I'm also keenly interested in Alaska geological hazards, as I have a daughter, a son-in-law and a grandson living in Kenai and they certainly were awakened the other night.

Washington is one of the most at-risk states for a variety of geological hazards including earthquakes, tsunamis, volcanoes and landslides. Recent events in Washington and other parts of the world have highlighted the important role and need for better and more compelling information that can help prevent or minimize the loss of life, reduction of property value and serious disruptions to Washington's and the nation's economy.

Washington is the second most at-risk state for earthquakes, and the active subduction zone off the Washington coast can cause a magnitude 9 earthquake and deliver a tsunami to coastal areas in fewer than 30 minutes. In addition to the Cascadia subduction zone, Washington has many more active faults capable of widespread damage, including the Seattle Fault zone.

We frequently collaborate with the USGS and FEMA to learn more about earthquake hazards, and the data we generate informs building code updates that result in reduced damage and lives saved during the next earthquake.

We encourage reauthorization of The National Earthquake Hazard Reduction Program as it is important to Washington and the nation to help provide funding, maintain expertise, reduce damage and save lives.

Tsunamis pose a great hazard because they arrive quickly and because they can be large, with tsunami waves being as high as 70 feet in some areas of Washington. We need look no further for an example of the damage a large subduction zone earthquake and tsunami can do than the 2011 Tohoku tsunami in Japan that caused over $300 billion in damage and had over 15,000 fatalities.

Reauthorization of the Tsunami Warning Education and Research Act is a critical part of continuing to provide safety for Washington's and the nation's citizens. We thank you for reauthorization of this important Act.

With regards to volcano hazards, Washington is home to 4 of the 18 "Very High Threat" volcanoes in the United States. This number includes Mount Rainier, which is considered the most dangerous volcano due to the size of the at-risk population in the Puget Sound, and Mount St. Helens, as well as Mount Baker and

Glacier Peak. All could erupt again in our lifetimes, and the consequences would likely be high.

With the exception of Mount St. Helens, these Very High Threat volcanoes are moderately to significantly under-monitored relative to their risk. Passage of the National Volcano Early Warning and Monitoring System Act is important to Washington and the nation as it will help fund additional monitoring and collaboration with the USGS and communities along these populated corridors on the flanks of these volcanoes.

With regards to landslides, Washington is one of the most landslide-prone states and has hundreds of thousands of known and unknown landslides. Some of these landslides have been record setting in terms of size, damage and lives lost, such as the Oso landslide in 2014 that caused 43 fatalities. More recently, the ongoing Rattlesnake Hills landslide has caused evacuation of 60 people from their homes and threatens I–82 with closure. The landslide is moving at about three inches per day currently, but it is no longer accelerating. It is currently being monitored using a variety of methods.

We encourage passage of the Landslide Preparedness Act as it is important because landslides are among the most frequently-occurring natural hazards in the nation and this will provide funding for improved landslide inventories, hazard maps, research and monitoring equipment that allows us to learn more about these landslides and save lives and money. Having USGS as a partner and available for collaboration is critical during these events.

Thank you.

[The prepared statement of Mr. Norman follows:]

Testimony of David K. Norman, LG, LEG, LHG

State Geologist

Washington Geological Survey

Department of Natural Resources

Oversight Hearing on:

The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems.

Before the U.S. Senate Committee on Energy and Natural Resources

January 30, 2018

Chairman Murkowski and Ranking Member Cantwell, members of the committee, thank you for inviting me to testify today. I am excited for this opportunity to share some of my views and tell you about some of the geological hazards in Washington State. I am the State Geologist representing the Washington Geological Survey, a Division of the Department of Natural Resources. I am also the Chair of the Geological Hazards Committee for the Association of American State Geologists (AASG).

The natural beauty of Washington, including its lush vegetation, hides many serious geologic hazards that present risks to public safety as well as the State's economic interests. Washington is one of the most at-risk states for a variety of geological hazards including earthquakes, volcanoes, tsunamis, and landslides.

Recent earthquakes and tsunami events in other parts of the world such as Japan (2011), Chile (2010), and Sumatra (2004) have highlighted the important role and need for better and more compelling information that can help prevent or minimize the loss of life, devaluation of property, and other serious disruptions to Washington's economy. According to the Federal Emergency Management Agency (FEMA), Washington is the second most at-risk state for earthquakes. The active subduction zone off the Washington coast can cause a magnitude 9 earthquake and deliver a tsunami to coastal areas in fewer than 30 minutes. In addition to the Cascadia subduction zone, Washington has many more faults capable of widespread damage,

including the Seattle Fault zone, the Southern Whidbey Island fault zone, the Darrington-Devils Mountain fault zone and countless more.

We collaborate with the USGS and FEMA to learn more about earthquake hazards, including paleoseismic trenching across newly discovered faults, performing risk analysis on areas prone to earthquakes, performing detailed geologic mapping to find new, undiscovered active faults, and deploying seismic equipment to refine earthquake locations. The data we generate informs building code updates that result in reduced damage or lives saved during the next earthquake.

The National Earthquake Hazard Reduction Program reauthorization is important to Washington to help provide funding, maintain expertise, and save lives in our state. We have worked closely with USGS and FEMA in the past but funding has been limited.

Tsunamis also present a significant risk in Washington. Tsunamis pose a great hazard because they arrive quickly and because they can be large, with tsunami waves being as high as 70 feet in some areas. A reasonable estimate for fatalities during a Cascadia subduction zone tsunami is 10,000 people. The largest tsunami in Washington in the last 500 years was generated on the Cascadia subduction zone on January 26, 1700. A more recent large subduction zone earthquake and tsunami is the 2011 Tohoku tsunami that cost over $300 billion in total damages and at least 15,894 fatalities. Tsunamis are not just an outer coast hazard in Washington. Geologic evidence demonstrates that an earthquake on the Seattle Fault in the Puget Sound generated a significant tsunami about 1,000 years ago.

We partner with NOAA to model likely tsunami inundation from various earthquake scenarios and use that data to assist local communities in developing evacuation and mitigation strategies.

Reauthorization of the Tsunami Warning and Education Act as the Tsunami Warning, Education, and Research Act was a critical part of continuing to provide safety for Washington's citizens from tsunamis generated from Cascadia subduction zone earthquakes. We thank you for reauthorization of this important act. There are still large funding needs for Washington to help us with inundation modeling, developing evacuation route maps, and educating the public on what to do in the case of a tsunami.

The U.S. Geological Survey (USGS) calls Mount Rainier the most threatening volcano in the Cascades largely due to the size of the at-risk population. According to the U.S. Geological Survey, Washington is home to 4 of the 18 "Very High Threat" volcanoes in the United States. This number includes two well-known volcanoes, Mount Rainier and Mount St. Helens, as well as Mount Baker and Glacier Peak. All could erupt again in our lifetimes, and even if the eruptions were relatively small, the consequences would likely be high. Lahars are volcanic debris flows that can travel far from the volcano and inundate areas with mud tens of feet thick. The most recent example of that is from Mount St. Helens in 1980. However, about 600

years ago a large lahar buried the present site of the city of Orting 30 feet deep and continued to flow down the river to the Puget Sound. If this were to happen today, damage to structures alone will total an estimated $13 billion in the Puyallup river valley.

We collaborate with the USGS to determine risk from these volcanic hazards and to develop evacuation and mitigation strategies with local communities.

The USGS has indicated that, with the exception of Mount St. Helens, these Very-High-Threat volcanoes are moderately to significantly under-monitored relative to their risk. Plans are in place to address these gaps, although there are substantial permitting and resource challenges to overcome before these plans can be put into action. One place where progress is being made is Mount Rainier, where, in partnership with Pierce County, the USGS has recently begun a project to upgrade and expand a lahar detection system for two of the more populated river drainages. Passage of the National Volcano Early Warning and Monitoring system act is important to Washington, as it will help fund additional monitoring along other populated corridors on the flanks of these volcanoes.

Washington is one of the most landslide-prone states and has hundreds of thousands of known and unknown landslides. Some of these landslides have been record setting in terms of size and the amount of damage and lives lost, such as the SR 530 or Oso landslide of 2014 that caused 43 fatalities, the Aldercrest-Banyon landslide that destroyed 137 homes, the Nile landslide that blocked the Naches River destroying 14 homes and Highway 410. The ongoing Rattlesnake Hills landslide has caused evacuation of 60 people and threatens I-82. Additionally, extreme winter precipitation events in Washington can produce thousands of rapidly moving landslides in a period of a few hours, simultaneously affecting entire regions of the state.

We collaborate with the USGS and other agencies when large-scale landslide events occur, sharing both data and expertise. Following large wildfires, we collaborate with the USGS to determine burned area vulnerability to debris flows, much like what occurred very recently in southern California following the Thomas fire.

The proposed National Landslide Preparedness Act is important because landslides in Washington are among the most frequently occurring natural hazards, and they are difficult to quantify both in terms of frequency and in terms of cost. Inventories, susceptibility, and hazard maps for the state are far from complete. Funding for improved landslide inventories, research, and for monitoring equipment allows us to learn more about these landslides and save lives and money. Having USGS as a partner and available for consultation or response is invaluable.

Lastly, an important part of the National Landslide Preparedness Act is the USGS 3DEP program, which is an important partnership that allows us to leverage funding for lidar that can help produce topographic products invaluable to landslide inventory mapping in Washington. We encourage continuation and expansion of this important program.

The CHAIRMAN. Thank you, Mr. Norman.

Dr. West, welcome.

STATEMENT OF DR. MICHAEL WEST, ALASKA STATE SEISMOLOGIST, ALASKA EARTHQUAKE CENTER, AND RESEARCH ASSOCIATE PROFESSOR, GEOPHYSICAL INSTITUTE, UNIVERSITY OF ALASKA FAIRBANKS

Dr. WEST. Thank you, Chair Murkowski, Ranking Member Cantwell, members of the Committee. I'm Michael West, State Seismologist with the Alaska Earthquake Center and current Chair of the Alaska Seismic Hazard Safety Commission.

I'm privileged to work closely with the U.S. Geological Survey, NOAA, and others under collaborations made possible by the legislation that this Committee leads.

As you've heard from others, last Monday night my state was rocked by a massive earthquake. The offshore location and lack of major tsunamis spared us catastrophic impacts, but it is a sobering example of why the nation's earthquake and hazard programs really matter. These programs save lives. They protect infrastructure. They protect our economy.

My written testimony lays out examples that address earthquakes, tsunamis, landslides, and volcanoes. Here this morning I'd like to focus on the monitoring activities that underpin all of these.

I want to first thank many of you for your efforts to reauthorize the National Earthquake Hazards Reduction Program (NEHRP). It was unprecedented when introduced in 1977, and it remains a role model program four decades later. Because of NEHRP, as we call it, we have open, public seismic monitoring networks that during last week's earthquake allowed any agency or even individual with an internet connection to see and evaluate the situation in real time.

Under the auspices of NEHRP, in 2000, Congress authorized the Advanced National Seismic System, a visionary program founded explicitly on collaboration between the states and the Federal Government and the USGS to establish robust monitoring systems across the U.S. The program was charged with operating at high performance standards to create "information products and services to meet the nation's needs."

Eighteen years later, however, we have yet to achieve many of those basic performance standards and nowhere is that more true than in Alaska. When last week's earthquake hit, much of Alaska's seismic monitoring network was temporarily offline as a result of an unrelated, modest, regional power failure. Much of the Alaska data and products served to the Tsunami Warning Centers, the National Earthquake Information Center and to private stakeholders, including the Alyeska Pipeline Service Corporation, were simply not available for an hour or more.

We're fortunate to have some redundant capabilities between our respective organizations, but this was an abject failure and it was due to well-known vulnerabilities and outdated systems.

The programs that you're considering would strengthen the nation's monitoring infrastructure. It's the FCC-compliant radio systems that would be replaced under the National Volcano Early Warning System. It's the backup power and communications that

might finally be afforded under the Advanced National Seismic System. It's the geodetic instrumentation needed for more accurate tsunami assessments and earthquake early warning.

Your efforts on NEHRP and other bills have the potential to reinvigorate these hazard programs and retool them for a new era, but only if you take the time to ensure that the new language and, to be frank, the funding levels, address each state's specific needs. So stay involved.

So how do we move forward in the current climate? One way is through collaboration. Many agencies operate monitoring equipment. The states and USGS, of course, but also NOAA, the National Science Foundation (NSF), even the Air Force. We need collaborative projects.

One such example, again just a sample drawn from my state, is the opportunity to adopt the National Science Foundation's USArray facility. NSF's $40-million investment in state-of-the-art seismic and meteorological stations is slated to be decommissioned in 2019. Surely we can come together, between agencies, state and federal, to sustain portions of this facility that served the needs of earthquake monitoring, tsunami warning, volcano hazards, weather forecasting, forest fire staging, aviation, and national defense. It seems like a no-brainer.

To wrap up, I encourage you to always show restraint when authorizing new legislation, but the combined cost of these collaborative programs, something like $1.00 per American per year, is absolutely trivial compared to the impact of one major disaster. And without strong Congressional language, these collaborations stop.

Without Congressional authority, federal agencies are gripped by uncertainty, uncertainty that ripples out of Washington into the states to people like me and ultimately it impacts our municipal stakeholders who are just trying to build safe, resilient communities. These are not partisan or even controversial topics. These are goals that we can all support.

I welcome whatever questions you have today or in the future.

Thank you.

[The prepared statement of Dr. West follows:]

Testimony of Michael West, Ph.D.
Alaska State Seismologist
Alaska Earthquake Center
Research Associate Professor
Geophysical Institute, University of Alaska Fairbanks

Hearing to conduct oversight of the United States Geological Survey
Before the US Senate Committee on Energy and Natural Resources

January 30, 2018

Good morning Chair Murkowski, Ranking Member Cantwell and members of the committee. I'm Michael West, State Seismologist with the Alaska Earthquake Center and current chair of Governor Walker's Alaska Seismic Hazards Safety Commission. In my roles, I am privileged to work closely with the USGS, NOAA, the National Science Foundation and private entities to improve Alaska and the nation's resilience to earthquake, tsunami, volcano, and landslide hazards.

My objective today is to share with you the importance of the various natural hazards legislation bills you are considering. My examples are drawn largely from the state I represent. These are just a tiny sample of the broad impacts of these programs across the country. As a late-breaking addition, I will also touch on the magnitude 7.9 earthquake which impacted my state just last week. This earthquake provides a sobering example of the importance of strong earthquake and tsunami programs, as well as an example of why we still have a long way to go in preparing the nation to weather such events.

Why authorizing legislation matters

This committee has been instrumental in bringing an impressive suite of natural hazards bills. On behalf of the organizations I represent and our peer organizations around the country, I thank you. These bills matter. Whether it is the National Earthquake Hazards Reduction Program (NEHRP), the National Volcano Early Warning System (NVEWS), or the Landslide Preparedness Act, these bills provide a national framework for coordinating across federal agencies, between states, and with community and private stakeholders.

Many of these activities exist at the state and regional level whether or not there are congressional authorizing bills. However, it is these bills that provide the national umbrella to coordinate and support these activities. Each of the following programs is different, but the theme cutting across them is the same. By ensuring that our efforts are coordinated—across agencies, across states, across the public-private entities—we can achieve the greatest reductions in natural hazards risks in the most efficient and cost-effective ways.

National Earthquake Hazards Reduction Program
The reauthorization of the National Earthquake Hazards Reduction Act is deeply important for Alaska and the nation. This act was visionary in 1977 by spanning four agencies and countless activities to create a unified national strategy for earthquakes. It was developed and has been maintained with huge grassroots efforts crossing disparate advocacy groups, professional societies, and academic organizations. That breadth is a testament to the 40-year impact of NEHRP.

Alaska has benefited from NEHRP by inclusion in national programs and standards. Without a national vision, it is likely that federal agencies would often overlook Alaska's needs with the all-too-common "Alaska is an outlier" excuse. I have been told of proposal calls a few decades ago that included a latitude cutoff intended specifically to exclude Alaska. Though Alaska's population remains relatively small, the extreme nature of our infrastructure, combined with the fact that we are home to three-quarters of all domestic earthquakes, gives Alaska citizens an outsized vulnerability. Having a national vision, set by NEHRP, has helped keep Alaska from being completely written off in the earthquake discussion.

A lot has changed in 40 years however. Updating NEHRP to reflect past progress and new needs is an important part of reauthorization. I encourage you to continue listening to each of your states' priorities and to ensure they are being met by the next iteration of this landmark legislation.

Advanced National Seismic System
One of the most vital components of NEHRP is the Advanced National Seismic System (section 7707). The ANSS was intended to provide a collaborative framework for ensuring strong earthquake reporting and analysis across all regions of the country. Developed on an explicitly collaborative model between states and the USGS, the ANSS was a visionary program when introduced. The 2000 congressional authorization for the Advanced National Seismic System stated it would:

> *Establish and maintain an advanced infrastructure for seismic monitoring throughout the United States that operates with high performance standards, gathers critical technical data, and effectively provides information products and services to meet the Nation's needs.*[1]

The ANSS remains a vibrant, diverse collaboration with huge potential. It blends national consistency under the powerful leadership of the USGS with strong state and regional earthquake centers tailored to state-level needs and stakeholders. It is a model of healthy collaboration between state and federal entities.

However, after 18 years, many of the most basic goals set for the ANSS have yet to be met. Across the country, earthquake centers have struggled to maintain basic monitoring infrastructure. They have not been able to conduct basic research on how to

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[1] *Assessment of Seismic Monitoring in the United States: Requirement for an Advanced National Seismic System, http://pubs.usgs.gov/circ/1999/c1188/circular.pdf, (p. 20) last retrieved Jan. 22, 2018*

operate more effectively and efficiently. And, with just a few exceptions, they have not been able to implement breakthrough technologies such as integrated geodetic monitoring and earthquake early warning.

For example, in Alaska, the most basic ANSS performance standards for earthquake reporting accuracy[2] have never been achieved for more than half of the mainland. The National Science Foundation operates an impressive geodetic network through its Plate Boundary Observatory program. However, unlike much of the rest of the country, the Alaska data are largely unavailable in real-time or in processed forms usable by existing earthquake monitoring systems. While earthquake early warning is being aggressively pursued in CA, OR and WA, Alaska does not even have the backbone seismic network and hardened communications systems to begin experimenting with early warning. Each of these are examples of ways in which the ANSS needs to continue striving, and needs to evolve, to meet modern stakeholder demands.

The Alaska component of the ANSS is operated by the Alaska Earthquake Center at the University of Alaska Fairbanks. The success or failures of the center's monitoring network has ripples across many agencies. This network is the primary long-term source of Alaska seismic data for NOAA's tsunami warning centers. It is also a critical component of Alaska's volcano monitoring, providing broad regional coverage for volcanoes that do not have dedicated instrumentation. Over the past dozen years, at least three volcanic eruptions were detected or principally monitored under the auspices of the ANSS using the assets of the Alaska Earthquake Center. Despite this track record, the collaborative funding model used to support the ANSS has withered in the past half dozen years. Responding to long-term declines in federal support, as well as more recent declines in state support, the Alaska Earthquake Center has had to slash staffing and reduce services for stakeholders including the USGS, NOAA's tsunami warning centers, and partner state agencies. In response to these funding reductions, in August of 2016 the center suspended most maintenance and repairs of the Alaska seismic network. The impacts were immediate, and within a few months the percentage of data returned from the network dropped to its lowest level in several years. One-time stopgap funding in mid-2017 provided a reprieve and allowed the center to begin addressing some of the long-standing deferred maintenance needs. But a long-term sustainable model is not yet in site. The precise issues vary from state to state, but the earthquake centers that operate in most other regions are facing their own version of these issues.

The ANSS remains a strong foundation with huge potential to improve earthquake and tsunami hazard efforts in all states. But with funding that has languished for years, many of these basic objectives have simply not been achieved. It is my great hope that we will recognize this before the next catastrophic earthquake makes it abundantly clear.

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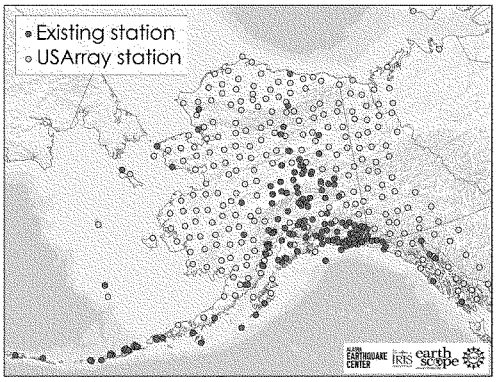
[2] *Advanced National Seismic System Performance Standards*
http://earthquake.usgs.gov/monitoring/anss/docs/ANSS_Perf_Standards.pdf (p. 2) last retrieved Jan. 22, 2018

The USArray Opportunity

The National Science Foundation's USArray project is now fully installed in Alaska, with a total of 192 new monitoring stations arranged in a grid across mainland Alaska. Agencies including USGS, NOAA, NASA, BLM, NPS, and NSF are benefiting USArray network capabilities ranging from seismic to meteorological monitoring. These agencies have drafted multiple reports and white papers extolling the contributions, and potential for expanded capabilities, of USArray for their missions in Alaska. Data from the network are in full operational use for: earthquake and volcano monitoring; tsunami warning; weather and fire forecasting; and Arctic domain awareness. In-state, the Alaska Earthquake Center, the Tsunami Warning Center, the Alaska Volcano Observatory, the National Weather Service, and the Interagency Coordination Center for forest fires are using the data in their respective 24/7 missions.



Map of Alaska's seismic monitoring network with and without the National Science Foundation's USArray stations.

Recognizing this opportunity to strengthen Alaska's monitoring systems, in the spring of 2016 Governor Bill Walker requested a study on the benefits of enhanced earthquake monitoring and potential earthquake early warning in Alaska. The Alaska Seismic Hazards Safety Commission addressed this request by conducting a survey of a diverse set of stakeholders. The report was delivered to the governor in June, 2016. Among other recommendations, the commission concluded that there are significant regional disparities in monitoring that should be remedied, and that there should be a baseline capability for characterizing earthquakes across all regions of Alaska. The commission highlighted the specific opportunity afforded by the USArray project:

> *It is in Alaska's best interests to improve monitoring wherever practicable through the adoption of seismic stations. The USArray Transportable Array offers a proven and unparalleled opportunity to enhance earthquake monitoring and provide more consistent earthquake information*[3].

Planning for the 2019 decommissioning of USArray is already underway. In November 2016, congressional staff and staff from the Office of Science and Technology Policy participated in a workshop[4] with representatives of several federal and state agencies to brainstorm the long-term sustainability of this state-of-the-art monitoring network. The

[3] *http://seismic.alaska.gov/download/ashsc_meetings_minutes/ASHSC_Benefits_EQ_Monitoring_6_27_16.pdf (p. viii)*
[4] *https://www.arcus.org/meetings/2016/usarray*

network is integrated by design with Alaska's existing seismic network. The Alaska Earthquake Center is uniquely positioned to assume long-term operation on behalf of state and federal stakeholders. But despite years of discussion, including last November's workshop, no unified plan has emerged to secure the facility's ongoing operation.

The first of the November 2016 USArray Sustainability Workshop's recommendations addressed the need for a joint solution:

> ***USArray sustainability should be guided by a multi-agency state and federal partnership.*** *The USArray facility has stakeholders across many agencies and programs. A governance model that represents this breadth will ensure a diversified and cost-effective long-term facility.*

The USGS has developed an implementation plan focused on the specific federal needs of the USGS Earthquake Hazards Program emphasizing the populated southern tier of Alaska[5]. This is an excellent step forward. The National Weather Service has been a great champion in coordinating partner agencies around the USArray opportunity including NASA, BLM, NPS, BOEM, and the Air Force. These agencies have met in person and coordinated on a white paper under the leadership of NWS. This, too, is excellent progress. To date, however, there is still no adoption plan that accounts for the needs of NOAA's tsunami program or NOAA's weather forecasting mission. Several things will need to happen rapidly in order to create a sustainable partnership in time to head off NSF's scheduled removal of the network in 2019. A thorough implementation plan and budget, integration with the complementary USGS efforts, and coordination with state-level stakeholders would help bring this effort to fruition in time. Without these, however, the USArray assets could end up fragmented between a variety of unrelated programs.

The second recommendation from the November 2016 workshop spoke to this danger by presenting a vision for how the facility could be sustained to the benefit of all stakeholders:

> ***The sustained portions of USArray should be supported as a unified facility.*** *Shifting multiple subsets of the array into the sponsorship of different agencies would splinter the uniformity that is a hallmark of the facility. Several models exist to pool resources across organizations.*

Preserving the array as a unified state-operated facility ensures that its real value—which derives from its geographic scale and flexible station design—remains focused on serving as many Alaska stakeholders as possible, rising above the winds of budgets, politics, and competing missions.

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[5] This plan was requested in the FY17 budget language to the Department of the Interior but has not been released at the time of writing.

Tsunami Warning Education Research Act
This legislation, passed in spring 2017, is worth revisiting today because it is a shining example of a successful state-federal natural hazards collaboration. Administered by NOAA's National Weather Service, TWERA provides tsunami warning and tsunami preparation capabilities for the entirety of the coastal U.S. This collaboration of scientists and emergency managers collectively addresses issues ranging from tsunami monitoring instrumentation to tsunami warning coordination to community education and preparedness.

The program's reach is particularly deep in Alaska. Under TWERA, NOAA supports a considerable amount of the seismic monitoring instrumentation in Alaska operated both by the National Tsunami Warning Center and the Alaska Earthquake Center. This collective capability is the foundation for the rapid tsunami warnings issued by NOAA. Individual communities plan and drill for tsunamis using detailed maps of anticipated tsunami inundation and pedestrian evacuation. The evacuation routes that mark Alaska's coastal communities are based on these same maps, also produced under the auspices of TWERA.

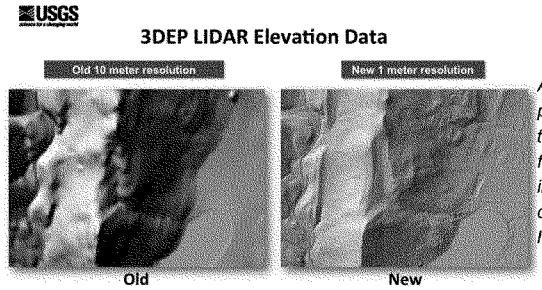
Tsunami inundation scenario for Seward. Such maps are the foundation for tsunami evacuation planning and for the siting of emergency facilities. This work is performed at UAF and supported largely under the authorization of TWERA.

Though TWERA will not be on the congressional docket again for a few years, it is a model program, offering proven examples for how other hazards programs might organize to provide the maximum benefit to communities while enlisting the broadest set of collaborators and stakeholders.

Geologic Mapping for Hazards
The National Cooperative Geologic Mapping Program (NCGMP) is a hallmark program within the USGS. Since 1992, the program has contributed $129 million to geologic mapping through grants to state geologic surveys. The states have matched this through one-to-one matching funds. The program has generated over 7,000 new geologic maps, produced in

large part at the state level in accordance with state priorities. State monies are left on the table each year, however, because of limits in the federal contribution.

These mapping programs support a wide variety of end uses, with natural hazards being a particularly critical end-use. High resolution mapping is the foundation for landslide evaluation, as it is practically impossible to assess landslide hazards without good topography. Our understanding of earthquake hazards is also limited by incomplete mapping. Geologic and topographic maps provide a mechanism for identifying and assessing fault lines that might otherwise remain hidden until the next big earthquake. Mapping provides one of the more cost-effective ways to scan large regions for hidden faults.



An example of the added resolution provided by modern mapping technologies. Many features, such as fault lines, that may have been invisible in older data, can be discovered and assessed in modern high resolution topography images.

Many people will assume that mapping the nation was completed decades ago. But while the program has been very productive, only 17% of the nation is mapped at the scale needed for land use planning and resource development (1:24,000). At the current rate of progress, some parts of the country will not be adequately mapped for centuries—an unacceptable timeframe given the life-health-safety, commercial, and national mineral and energy security benefits realized from geologic mapping.

The proposed 3DEEP program within the USGS would address these issues, and more, through a combination of topographic, geologic and geophysical mapping. Improved natural hazards preparedness would be just one of the many ancillary benefits.

NVEWS and Volcano Hazards

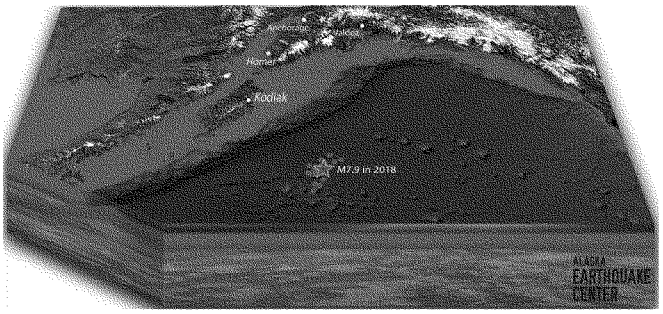
Alaska is the most volcanically prodigious state in the nation. In the past decade, Alaska has experienced more than two dozen eruptions, some of which posed significant threats to air-traffic over the North Pacific. The National Volcano Early Warning and Monitoring System Act proposes a national plan to monitor the nation's most hazardous volcanoes at levels commensurate with their threat. There are 54 active volcanoes in Alaska and another 16 in the Pacific Northwest, as well as active volcanoes in the Pacific and Caribbean Islands, which threaten large population, commercial and agricultural centers, and domestic and international air traffic. On an average day, 50,000 people and 90% of the nation's air cargo to Asia follows routes that pass over Alaska's volcanoes. NVEWS would create a national system to improve on existing eruption forecasting and research. Together these would improve the overall level of volcano monitoring across the country.

Alaska has an additional volcano instrumentation issue related to the phase-out of analog communications equipment as stipulated by the National Telecommunications and Information Administration. The need for so-called spectrum compliance runs the risk of rapidly making obsolete the Alaska Volcano Observatory's chosen equipment at many volcanoes. If this were to happen, a significant portion of the observatory's proximal monitoring would go offline and the ability to forecast eruptions using seismic data would be severely compromised.

The upgrades of analog equipment are related to NVEWS in that they would help achieve the overall goal of modern instrumentation at volcanoes with substantial threat levels. However, the issue is also independent of NVEWS in that the requirements to comply with appropriate spectrum use exist regardless of whether the NVEWS program is passed into legislation.

January 22 Magnitude 7.9 Offshore Kodiak Earthquake

This earthquake occurred just a few days before this testimony was submitted. Full analyses of this earthquake and tsunami are just beginning to come together at the time this testimony was submitted, but some early observations are pertinent to this hearing. Fortunately, the earthquake occurred a couple of hundred miles offshore in the Gulf of Alaska. This greatly limited the impact of the shaking, though it was felt very strongly by the vast majority of the Alaskans. Tsunami warnings were sounded for this earthquake based on input from the National Tsunami Warning Center and based on the vigor and duration of shaking in local communities. Based on the information available, this was the correct thing to do.



Location of the January 22 earthquake. Star marks the epicenter. Small circles mark preliminary aftershocks. The offshore setting limited the shaking impact of the earthquake but raised legitimate concerns about a potential tsunami.

This particular earthquake was scientifically unusual (and unexpected) and ruptured in a way that minimized the formation of a tsunami. However, the vast majority of earthquakes of this size in similar locations are likely to generate significantly larger tsunami waves than were observed last week.

Parts of Alaska's intertwined earthquake and tsunami monitoring systems worked well. Initial warnings were issued in under five minutes. There were significant failures during this earthquake as well however. An unrelated power outage at Golden Valley Electric Association caused much of the state's seismic data to be unavailable at the time of the earthquake. Though some systems had backup power, the failure caused internet outages that essentially shut down parts of the seismic network for more than an hour. As a result, much of Alaska's monitoring data was not immediately available to the Alaska Earthquake Center, the National Earthquake Information Center, or the National Tsunami Warning Center. The systems designed to warn and evaluate the safety of the Trans-Alaska Pipeline System were similarly affected. The performance of all of these agencies were negatively impacted by the power outage.

While it is fortunate that this earthquake turned out to be non-lethal, the lack of capacity for continuity of operations led to an abject failure of the state's monitoring system. This failure can be traced directly to the long-term declines in support for earthquake monitoring at both the federal and state level. Without robust funding for adequate maintenance of field instrumentation, sufficient staffing, and explicit continuity of operations, it should be no surprise to anyone when systems fail catastrophically. This has been clearly identified for several years as the single biggest vulnerability in Alaska earthquake monitoring. However, to date, agencies and stakeholders have not found this to be a high enough priority to support.

The authorization bills in discussion today are a great first start at tackling these problems. It is important to follow them up, however, with adequate funding and congressional oversight to ensure that the stated goals are being met.

Conclusions

New legislation is something we should always approach with caution, but the value of these bills and the programs they support are beyond dispute. They do cost money. But their combined cost, about one dollar per American per year is absolutely trivial compared to a single major disaster. The fact that NEHRP and other programs have languished for years without reauthorization has directly hurt us. The agency individuals I rely on, some in this room, are doing an admirable job of holding together the coordination and relationships that these laws enable. But the uncertainty that comes from not having an authorized program ripples across these agencies, it ripples out of Washington, into the states, to people like me, and ultimately impacts our municipal stakeholders who are simply trying to build safe, resilient communities.

These bills under consideration have real world consequences. Authorizing NEHRP and the related natural hazards programs would send a very strong message. It would send a message that, as a nation, we are proactive about disasters. It would send a message that we value safe construction, safe public buildings, responsible resource development, resilient infrastructure, informed emergency management, and educated citizens. These are not partisan or even controversial topics. They are programs and goals that we should all be able to get behind.

I sincerely appreciate the opportunity to testify. I hope I have provided solid on-the-ground perspective, and I would welcome whatever questions you have today or at a later time.

The CHAIRMAN. Thank you, Dr. West, we appreciate that.

Ms. Berry, welcome to the Committee.

STATEMENT OF KAREN BERRY, STATE GEOLOGIST AND DIRECTOR, COLORADO GEOLOGICAL SURVEY AT THE COLORADO SCHOOL OF MINES, AND PRESIDENT-ELECT, ASSOCIATION OF AMERICAN STATE GEOLOGISTS

Ms. BERRY. Chairman Murkowski, Ranking Member Cantwell, I want to thank you for the opportunity to discuss mapping, monitoring, and mitigating geologic hazards.

Colorado is a diverse state with the nation's highest elevation, wide river valleys and rugged canyons. It has hundreds of mountains that reach elevations of 11,000 to 14,000 feet. Geologic hazards, such as landslides, rockfall, debris flows, sinkholes, expansive soil and collapsible soil are present in every part of the state from the plains to the highest peaks. My written testimony contains some examples of this.

In the next three decades, Colorado's population is expected to increase by 40 percent. As the population increases in hazard-prone areas, community resilience, or the ability of a community to withstand the effects of a disaster, is greatly dependent on knowing vulnerabilities to hazards and planning for those hazards.

Many communities in Colorado and throughout the nation, do not have the basic tools needed to build community resilience, a map of potential hazards and land-use plans that address those risks. In Colorado, only 38 percent of the state has been mapped at the scale needed to build community resilience.

We have seen the lack of basic tools impact military families. When military personnel are transferred, they get ten days to find a good house in a good school district, close to a base, at a price they can afford, make an offer and evaluate the condition of the house. That's barely enough time to find a good real estate agent, let alone investigate potential geologic hazards. Military and veteran families have unknowingly purchased homes that were later destroyed by wildfire, debris flows or landslides.

When a geologic-related disaster destroys or damages a community's business hub or closes a major transportation route, there are losses due to lost economic opportunities.

Tourism is the largest industry in Colorado. It is estimated that businesses, in the mountain resort area along our Interstate 70 corridor, conduct $6.4 million in tourism-related transactions each day. It doesn't take long for a road closure due to an avalanche or a landslide to impact communities and businesses. Many cities and towns are almost totally dependent on revenue from tourism to fund the critical services they provide to their citizens.

What is Colorado's vulnerability to geologic hazards? Since most of the state is not mapped, we really don't know. However, of the areas that are mapped, it is estimated that $2.9 billion in state-owned assets are vulnerable to landslides, rockfall, debris flow, and potentially unstable soil.

Colorado is now analyzing vulnerability of private assets to known geologic hazards. Residential and commercial properties in Colorado are valued at $76 billion. Though our assessment isn't

complete, we know many areas with significant private and public investments have significant geologic hazards.

The seismic hazard in Colorado is rated low to moderate. However, we really don't know our risks. We have limited knowledge of potentially active faults, and we have a sparse seismic network to monitor earthquakes. The largest known earthquake in Colorado occurred in 1882 and had an estimated magnitude of 6.6. If that event were to occur today, modeling suggests the economic losses would exceed $22 billion, up to 1,000 lives would be lost and 14,000 injured.

How do we reduce risks and protect public safety? An insurance industry study looked at the relationship between state requirements for local government comprehensive plans and claims paid by insurance companies for losses between 1994 and 2000. During the period studied, insurance companies paid out more than $26 billion for disaster-related claims to residential property. The study indicates that insured losses would have been reduced by $257 million, or one percent, excuse me, if all states had required consideration of natural hazards in local land use plans. Again, to address geologic hazards in a plan requires knowing where the hazards are located and what are the risks. Basic information many communities lack.

We need the Committee's assistance to fill those gaps. Reauthorization for the National Cooperative Geologic Mapping Program will allow state surveys and USGS to map the nation at the scale needed for land-use planning. Reauthorization for The National Earthquake Reduction Program will provide critical funding for research, monitoring, and mitigation, in order to reduce fatalities, injuries and economic losses caused by earthquakes. It also has an important land-use planning component. Without the LiDAR provided by the 3DEP program, state geological surveys would not be able to effectively map and monitor all types of geologic hazards. This program is an essential building block to increasing community resilience.

Passage of and adequate funding for the National Landslide Preparedness Act; the proposed programs of research, mapping, and monitoring; combined with public education and land-use planning are important steps to enhance community resilience. The planning tools that are outlined in the Act can be used for other types of geologic hazards.

In summary, the Association of American State Geologists encourages reauthorization of NCGMP and NEHRP and passage of 3DEP and the National Landslide Preparedness Act into law.

I appreciate the opportunity to discuss these important programs with the Committee.

[The prepared statement of Ms. Berry follows:]

Karen Berry, PG, AICP
State Geologist and Director
Colorado Geological Survey at the Colorado School of Mines
and
President-Elect
Association of American State Geologists

Senate Committee on Energy and Natural Resources
Hearing on Natural Hazards
January 30, 2018

Introduction

Chairman Senator Murkowski, Ranking Member Senator Cantwell and members of the committee, my name is Karen Berry. As President-Elect of the Association of American State Geologists, and as the Director of the Colorado Geological Survey at the Colorado School of Mines, I would like to thank you for the opportunity to discuss the importance of protecting public safety and reducing economic losses by mapping, monitoring, and mitigating geologic hazards.

Colorado is a geologically diverse state with the nation's highest average elevation, wide river valleys, and rugged canyons. It has hundreds of mountains that reach elevations of 11,000 to 14,000 feet. Geologic hazards, such as landslides, rockfall, debris flows, sinkholes, expansive and collapsible soil are present in every part of the state from the plains to the highest peaks.

In addition, nowhere else in the United States are avalanches more deadly. The reason lies in Colorado's snowpack. It is shallower, colder, and weaker than the deep, dense snowpack found in the mountains to the West. Each year, avalanches in Colorado threaten major transportation corridors; and on average, catch 100 or more victims, six will suffer serious injury, and six will die.

In the next three decades, Colorado's population is expected to increase by 40%. As the population increases in hazard prone areas, communities are more vulnerable to loss of life and economic damages. Community resilience, or the ability of a community to withstand or mitigate the effects of a disaster, is greatly dependent on knowing vulnerabilities to hazards and planning for those hazards.

Many communities in Colorado, and throughout the nation, do not have the basic tools needed to build community resilience: a map of potential hazards and land-use plans that address these risks. In Colorado, only 38% of the state has been mapped at the scale needed to build community resilience. Many other states have similar issues.

In Colorado, we have seen the lack of basic tools, to educate and inform the public, negatively impact military families. When military personnel are transferred, they get ten days to find a house in a good school district, close to base, at a price they can afford, make an offer, and evaluate the condition of the house. That's barely enough time to find a knowledgeable real estate agent let alone investigate potential geologic hazards and hire a geologist or geotechnical engineer to evaluate a property. Military and veteran families have unknowingly purchased homes that were later destroyed by wildfire, debris flows, or landslides.

Examples of Past Disasters in Colorado

Year	Event	Impacts
1976	Big Thompson Canyon flood, landslides and debris flows	143 people killed and over $35 M in damages.
1984	Western Slope floods, debris flows and landslides.	Over $6.6 M spent in disaster assistance;10 homes condemned and 1 killed.
1999	Front Range floods, mudslides, and landslides	Over $30 M in infrastructure and property damage.
2004 and 2006	Rockslides I-70 Mountain Corridor	Up to 17 miles of road closed and 1 killed.
2010	Landslides-Statewide	9 people killed and 4 injured. Direct losses due to property damage exceeded $9 million.
2013	Front Range floods, landslides and debris flows	Over 600 debris/mudflows and landslides cause flood surges and contribute to overall damages estimated at over $2 billion. 3 killed by debris flows.
2013	Rockslide on USFS trail	Family of 5 killed
2014	West Salt Creek Landslide Complex	Three people killed. Landslide moved 3 miles down valley in minutes, with little advance warning, and covered a square mile. The landslide volume estimated at 38 M yd3. Remaining landslide block still poses a threat.

Indirect Economic Costs of a Natural Disaster

When a geologic-related disaster damages or destroys a community's business hub, or closes a major transportation corridor, there are losses due to lost economic opportunities. Tourism is the largest industry in Colorado. The Colorado Department of Transportation estimates that businesses, in the mountain resort region, along I-70 conduct $6.4 M in tourism-related transactions each day. It doesn't take long for a road closure due to an avalanche or landslide to impact businesses and communities. In Colorado, many cities and towns are almost totally dependent on revenue from

tourism to fund the critical services they provide to their citizens. Similar types of economic impacts occur across the nation.

Vulnerability to Geologic Hazards

Value of State Owned Assets at Risk by Type of Geologic Hazard

Landslide	Rockfll	Mud and Debris Flows	Potentially Unstable Soil
$528,000,000	$19,000,000	$2,255,000,000	$88,000,000
Colorado Natural Hazard Mitigation Plan, 2013			

What is Colorado's vulnerability to geologic hazards? Since most of the state is not adequately mapped, we don't really know. However, of the areas that are mapped, it is estimated that that approximately $2.9 billion in state-owned assets are vulnerable to landslides, rockfall, debris flows, and potentially unstable soil.

The State of Colorado is now analyzing vulnerability of private assets to known geologic hazards. In 2016, residential and commercial property in Colorado was valued at $76 B. Though the assessment isn't completed, we know many of the counties with significant private and public investment also have significant geologic hazards.

Currently, the seismic hazard in Colorado is rated low to moderate. However, we really don't know our risks. We have limited knowledge of potentially active faults and we have a sparse seismic network to monitor earthquakes. Other states have similar issues. The largest known earthquake in Colorado occurred in1882 and had an estimated magnitude of 6.6. If that same event were to occur today, earthquake modeling (2011) suggests that economic losses would exceed 22 billion, up to 1000 lives would be lost, and 14,000 injured.

How Do We Reduce Risks and Protect Public Safety

An insurance industry study looked at the relationship between state requirements for preparation of local government comprehensive plans and claims paid by property insurance companies for losses due to storm-related natural disasters (including some types of mass movements) between 1994 and 2000. During the period studied, insurance companies paid out more than $26 B for disaster-related claims arising from losses to residential property. Analyses indicate that insured losses to residential property, over the period studied, could have been reduced by $257 M if all states had required consideration of natural hazards in local comprehensive plans. Again, to address geologic hazards in a comprehensive plan requires knowing where the hazards are located and what are the risks. Basic information many communities lack.

We need the committee's assistance to fill those gaps.

- Reauthorization of and adequate funding for the National Cooperative Geologic Mapping Program will allow State Geological Surveys and USGS to map the nation's geology at the scale needed for land-use planning. Current mapping rates can be increased if more funding is provided.
- Reauthorization of and adequate funding for The National Earthquake Reduction Program will provide critical funding for research, monitoring, and mitigation, in order to reduce fatalities, injuries and economic losses caused by earthquakes. It also has an important land-use planning component.
- Without the LiDAR provided by the 3DEP program, state geological surveys would not be able to effectively identify, map and monitor all types of geologic hazards. Continuation and expansion of this program is an essential building block to increasing community resilience.
- Passage of and adequate funding for the National Landslide Preparedness Act; the proposed programs of landslide research, mapping, and monitoring; combined with public education and land use planning are important steps to enhance community resilience. It will give communities the tools they currently lack to avoid, reduce, and mitigate landslide disasters. The planning tools that are outlined in the Act can be used for other types of geologic hazards.

In summary, the Association of American State Geologists supports all four programs, and encourages reauthorization of NCGMP and NEHRP and passage of the 3DEP and the National Landslide Preparedness Act into law. AASG also supports of passage of the National Volcano Early Warning and Monitoring System Act. I appreciate the opportunity to discuss these important issues with the committee.

The CHAIRMAN. Thank you, Ms. Berry.

I appreciate the input from each of you here this morning. Good information and lots to talk about.

We did have a good number of members that were here and, of course, my hope was that they were all captivated——

[Laughter.]

——about these natural disasters that our states face, but it is clear that Alaska, Washington State, probably the Pacific Northwest, are perhaps a little more vulnerable. So don't take it as a lack of interest from the others.

Some years ago, when I had just introduced the Volcano Monitoring System bill, Alaska was experiencing a string of eruptions, some that had shut down air traffic over Anchorage International Airport, really locked the state down. Most of us can remember days off work because you were not cleared to use your computers because the air filtration system was going to gum everything up and it was a real mess. I was actually mocked for introducing that legislation. I was ridiculed that who needs to watch a volcano? Who needs to monitor a volcano? This was a big, fat Alaskan earmark, they said. And then, the eruption in Iceland that shut down all of the European air traffic occurred and all of a sudden there was a wow, how do we keep on top of all this? How about that cool Volcano Monitoring System?

I look back on that and think that we have come a long way when it comes to how we are monitoring these natural hazards, whether they be volcanoes or earthquakes and early warning systems. The issue of landslides which is more and more troubling, certainly tsunamis. So we have come a long way, but I agree there is so much more that we need to do.

Dr. West, you speak to the issue of collaboration here because we have so many, we have a host of different agencies that are involved. We see that just represented here on the panel from USGS to Forest Service, to our states, to our universities, to our local communities. Making sure that we are doing right by all of this is so important.

Let me start with you, Dr. Applegate, and this relates to the seismic monitors. I was pleased when I first learned the effort that the National Science Foundation had made in placing these in Alaska, and then I was deeply troubled when I learned that they were going to pull them all out at considerable expense to NSF. So you go to the effort, the financial effort, to install them, to gain all this important data, and then we are just going to pick up and leave.

Dr. West, you have mentioned this as well. Now you have indicated that there is a strategy for retention of these stations. I have been pushing on this now for a couple years, but can you give me assurance that these monitors are not going to have to be removed at the end of the year, that the negotiations or the discussions with USGS and NSF and NOAA for the adoption of these, that we are in a good place now?

Dr. APPLEGATE. Chairman, this is a good government opportunity, as you point out. This is a significant investment that's been made.

We appreciate the opportunity to have, you know, worked with the state, worked with private sector and others to look at this opportunity, understand it, prioritize it.

So, I'll say, we've got, discussions are underway with NSF. The report that will be arriving as this prioritization we will, you know, I would say we're making a good faith effort to try to be able to capture as many of these as we can and——

The CHAIRMAN. Is that based—when you say capture as many as we can, is that going to be determined by budget or——

Dr. APPLEGATE. Right.

The CHAIRMAN. ——what exactly do you mean by that?

Dr. APPLEGATE. So, obviously, a key determinant of it is funding sources. As you indicated, it's not just about the USGS, it's about other agencies as well but, you know, I think we've laid the groundwork to know which are the ones that as we do have resources available, through whatever means, that we're capturing the ones that are most important for our earthquake monitoring, for tsunami monitoring, for volcano monitoring and, you know, for the state.

The CHAIRMAN. Dr. West, what happens if we do not preserve these monitoring stations that we have? What happens to us, as a state? We are one-fifth of the size of the country. We have got a lot of area to cover and we know that we are in one of the most seismically active areas in the country. What happens if we do not make the smart funding decision here and are not able to protect what we put in place with this monitoring infrastructure?

Dr. WEST. Well, we revert to where we were prior to this once-in-a-lifetime, sort of, opportunity which is more than half the state doesn't really have modern seismic instrumentation of any sort.

We have, I mentioned in my testimony, consistently fallen short of basic performance standards that we try to achieve. Nationally, Alaska has areas where that has simply never been achieved. So we go back to there. I——

The CHAIRMAN. And when you go back to there you put people's lives at risk.

Dr. WEST. Well, that's right. I remain optimistic though. I actually think we are moving in a good direction. I'm pleased with the diligence that the USGS has brought to the federal earthquake piece of this effort. I've seen tremendous enthusiasm from NOAA for the tsunami and the meteorological components of this.

The State of Alaska, frankly, has struggled to be a strong partner in this, as it could be, because of its fiscal situation. But that said, I firmly believe the state wants and needs to be engaged in this. We've had some troubles, some challenges, in finding a really strong, collaborative model for legitimate reasons, actually, but rules about, you know, fed-only discussions and sensitivities and what not have made it difficult for everyone to sit in one room and, kind of, hash this out. I think we still have work to do to bring NOAA into the fold and make sure their needs are fully addressed.

And again, the state, I think, has potential that we've not yet been—we've not yet achieved. But I do think there's a path here.

The CHAIRMAN. Let me ask, and I guess this is back to you again, Dr. Applegate, and this relates to our volcano monitors.

They are currently operating on an analog system, and in 2020 the National Telecommunications and Information Administration will eliminate the frequency that is used to transmit that data. What progress are we making with regards to conversion of those to digital monitors? Can you give me a progress report here on how many more monitors need to be converted?

Dr. APPLEGATE. Absolutely. About 117 stations remain to be transferred from the older analog technology to the digital technology. And I'll say that there is advantage here, not only the issue of the spectrum availability and that driver for this, but this is also an upgrade in capability that will allow us to bring in additional data streams. So, this is, I think, part of that, sort of, long-term National Volcano Early Warning System (NVEWS) goal is to have this modernization.

The CHAIRMAN. Are you satisfied with the progress then? Are we going to make that 2020 date?

Dr. APPLEGATE. The progress, at this point, we have been able to accelerate with the additional support, we've been able to go from, opportunistically, maybe 6 to 7 a year, up to on the order of 12 to 15, but there is still——

The CHAIRMAN. That is not going to get you there.

Dr. APPLEGATE. Yeah, it's not going to get us there. So we certainly are looking at the waiver issue in terms of that deadline, but yeah, the progress is there but it's not, certainly not, going to get us to the deadline.

The CHAIRMAN. I would like to have further conversation with you insofar as what you anticipate it would take, from a budget perspective, to accelerate this conversion. So we will talk further on that.

Dr. APPLEGATE. Yes, we can provide that.

The CHAIRMAN. Senator Cantwell.

Senator CANTWELL. I want to continue with you, Dr. Applegate.

Can you talk about some of the things that the system actually does for people?

Dr. APPLEGATE. For the volcano system?

Senator CANTWELL. Yes.

Dr. APPLEGATE. Yeah.

Well, so, I think the really key thing about volcanoes is that and the importance of having ground-based monitoring is to have that earliest detection. The way we put it is, you don't want to be playing catch-up with an active volcano. You want to be able to see that earliest unrest, earliest indications, and that's why it's critical to have ground-based monitoring.

And so we have this, the NVEWS report is identifying, you know, with each of the volcanoes, what is the highest threat, which are the very highest threat volcanoes, both for local populations as well as for distant ones. I mean, I think the other key here is, as we saw with the Iceland situation, there's no such thing as a remote volcano because of the air traffic considerations.

So we are bringing a range of different monitoring capabilities to bear as we can but, you know, the ground-based monitoring is a key piece of that. Again, to be able to provide as much lead time as possible as we see these potentially active volcanoes waking up and then, of course, to be able to give as good information as we

can, as actionable information as we can, to those communities at risk.

Senator CANTWELL. I think, as you just said, that waking up is the issue. I'm not a scientist, but I am assuming the reason why we are monitoring this is to monitor the behavior of the volcanoes.

I think Mount St. Helens has shown some activity of late, and that information allows us to look from a perspective to do planning and warning to the communities in case that activity does increase. So it is just as it says, an early warning.

So you have told us about the importance of that. Yet, in the last year's budget the Administration proposed cutting that early warning system, including cutting funding for the development of a LiDAR detection at Mount Rainier. How are we supposed to interpret last year's request to eliminate funding for this system?

Dr. APPLEGATE. The FY18 request involved a lot of hard choices and essentially focused on our core monitoring capabilities, sort of our existing monitoring capabilities, as opposed to expansion of those capabilities.

Senator CANTWELL. So where is the Administration now?

Dr. APPLEGATE. We don't yet know what the outcome is going to be, certainly for '18. And you know, should Congress support these activities, we'd certainly follow the will of Congress, and the '19 budget isn't out yet.

Senator CANTWELL. I appreciate that, but I hope someone in the Administration watches this hearing and sees that there are communities here who are asking for help and resources, that these are serious issues and that monitoring science is a good thing and that it gives us a chance to be prepared.

What I have found very much lacking in the State of Washington is if you don't have the information then you can't do any of the preparation. We already have a gap, as Mr. West is saying, for very logical reasons. It is very easy for a NOAA scientist to say to the people on Long Beach, Washington, this is the impact of a tsunami if it happens at this degree. But if you are talking about a very rural community, as Mayor Branson just said, who then is left to do the preparation? How are they supposed to do the preparation without the help? As Dr. West has said, there is a gap here.

But guess what? We need good science to begin with and then we need to figure out how to bridge this gap.

So, Mayor Branson, what about—we're now talking about a different program, but on the tsunami side. Is there not enough money from the Federal Government to the states? Because I think these are grants to the states.

Ms. BRANSON. Senator Cantwell, there's never enough money——

[Laughter.]

——on any level. I'm not being funny here, but that's the truth and as most residents and, certainly, Senator Murkowski is very much aware, our state is having a fiscal crisis at this point.

So we will be talking to the Governor. And the Governor graciously did call Kodiak and talk to me after the earthquake happened to see what we could do and what the state could do. So we will be revisiting with the Governor about that. And certainly, more help is needed financially, as well as education, as you just mentioned, and information to residents.

In our debriefing with our community, we're going to go back and make sure that people know where to go, our residents know where to go, not on Pillar Mountain, but a higher ground. And so, this is an opportunity for not only talking to our community, but also talking to the federal and the state government about what our needs are and what our gaps are.

Senator CANTWELL. Well, I certainly believe as we have approached the same issues in our state—and I am not sure which of the witnesses mentioned the Japan tsunami and the devastating impacts of that—but this is what we need to do.

I certainly believe the Federal Government should step in and do its share. That is how we got the early warning systems that we have now on Long Beach and a very susceptible area of our state because of elevation and on the coast.

I definitely believe that we should have an adequate assessment of what an early warning detection system for tsunami looks like. The fact that we have been able to get these buoys is great because it gives us time, but now we have to say what is the system that helps warn our citizens in a timely fashion and, in this case, in the middle of the night was a very critical issue.

Dr. Norman, isn't part of the landslide issue getting good mapping and information and wouldn't this help in many parts of the country as we see changes in weather and more rain events that are causing dramatic impacts?

Mr. NORMAN. Yeah, there's no question.

The key to good—understanding landslides is, first of all, we found that having high resolution LiDAR, quality level one LiDAR is important, and then going through and doing mapping of the, or the inventorying of, the known landslides. Landslides tend to occur where landslides have been before.

So it's one of those, but then there's also looking at the other terrain and steep terrain. It would benefit the entire country, there's no question about that. There's ground failures everywhere in the United States of one form or another and it certainly is, a key part of it is the landslide mapping and the geological mapping that goes along with that.

Senator CANTWELL. I think that what we are seeing is, again, I am pretty sure in the Oso event there was a very dramatic rain event, larger than what they had seen in that window and time period. And I see that happening in other parts of the United States, not just in Washington, but throughout the United States. So we are having a change in weather events that makes it very necessary to have this kind of information.

Mr. NORMAN. That's true.

The precipitation is a key factor in many landslides. The Oso landslide certainly had, it was a wet winter leading up to that. There are other landslides in our state and across the country that are driven by precipitation and that includes, certainly, when you have fires and then debris flows afterwards. Those are key factors in very rapid landslides that can occur as well.

Senator CANTWELL. Thank you.

Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator.

I am just reminded of our recent visit to Puerto Rico after the hurricane there took down so many of those trees. Then the wet season comes upon Puerto Rico and the number of landslides. I understand USGS has been onto the island, but yes, these heavy rain events that you are talking about, combined with the other natural disasters, is a double disaster.

Senator Wyden.

Senator WYDEN. Thank you, Madam Chair.

I think this is an important hearing, and Senator Cantwell has already picked up on a couple of our key issues in the Pacific Northwest.

I want to start with you, if I could, Dr. Applegate. I am going to be on the Oregon Coast for town hall meetings this weekend. They will be asking me about tsunamis and my hometown, of course, is Portland. We have 12 major bridges spanning the Willamette River. We have real concerns about the capacity to make sure those bridges can withstand a large earthquake.

So let me, if I might, with you Dr. Applegate, start with a question about the earthquake early warning systems. And obviously, we have these proposals to cut the budget. Could you tell us, if these cuts go through, what capabilities would suffer under the earthquake early warning system specifically?

Dr. APPLEGATE. So we are currently about half way toward the implementation for the earthquake early warning system with the Congressional funding support.

What the President's, the 2018, budget would do would basically focus on our existing capabilities for earthquake monitoring. So it would not focus on the early warning system, it would focus on our current capabilities, what we can deliver now in terms of situational awareness.

Senator WYDEN. But no capabilities would suffer, in your view, with respect to the earthquake early warning system?

Dr. APPLEGATE. It's a system that is in development. It's a future——

Senator WYDEN. That is a yes or no question. Would any capabilities suffer?

Dr. APPLEGATE. Not current capabilities.

Senator WYDEN. Okay.

I am going to ask you a question that I would like a response on in writing within a week because this is so important to me. Your written testimony says the early warning system will provide, "an additional layer of safety and a significant boost in capabilities." Yet you seem to be suggesting that, well, this cut is not going to be that big a deal and maybe it is redundant. So I want to have you square your written testimony with my question. Can I have that answer within a week? It would go to the Chair and the Ranking Minority Member.

Dr. APPLEGATE. Absolutely.

Senator WYDEN. Great.

Dr. APPLEGATE. Absolutely.

Senator WYDEN. One last question, if I might then, for you—where is our wonderful person from the Forest Service? There you are, Mr. Casamassa. Thank you.

Mr. Casamassa, as you know, we have been working hard on this Committee. It has been the longest running battle since the Trojan War to end fire borrowing and this horrible practice that really discourages the prevention that we need. If Congress fixes the Forest Service's persistent budgeting issue that results in fire borrowing, my view is that would allow the agency to have more resources available to tackle the very emergencies that we are talking about today. Is that a view you share?

Mr. CASAMASSA. Well, certainly, if we did have additional appropriated dollars that we could allocate toward other programs, we could then, actually, deploy resources to look at and monitor and evaluate other catastrophic events.

Senator WYDEN. So fixing fire borrowing, specifically. I do not want to just go off into the la-la world of more resources. Wouldn't ending fire borrowing help you have more resources to address emergencies?

Mr. CASAMASSA. It would make more resources available, yes.

Senator WYDEN. Right, thank you.

Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator Wyden.

Senator Daines.

Senator DAINES. Thank you, Chairman Murkowski, and thank you for holding this important hearing.

I want to thank the witnesses today for providing important information on what our scientists and the government are doing to prepare for and mitigate natural hazards and disasters.

I am very fortunate. I come from the beautiful and great State of Montana. I will say, I didn't get to pick my Montana ancestors, but I am sure glad they came to Montana.

With the beauty that we have in our state, the mountains, rivers, the plains and, of course, our national parks, there are serious geological and natural hazards, such as landslides, avalanches, earthquakes, et cetera. I spend a lot of time outside when I am not in Washington, DC. I can tell you, I do not have a coat and tie on when I am back home. But because of this, it is important that the public, local businesses, ski resorts, local governments have the information they need to keep Montanans and visitors safe.

It is also important we have the tools necessary to get communities back up on their feet after these hazards occur, specifically making sure that electricity and telecommunications return quickly.

I want to thank you, Dr. Applegate and the USGS, for all the recent work you have done in monitoring the Yellowstone Caldera. I hope that our predictions are true and that the eruption is still hundreds of thousands of years away. However, your continuous monitoring and updates help put people at ease and will provide lifesaving information, if ever needed.

The question I have for both Mr. Applegate and Mr. Casamassa—both of you spoke about the partnerships that your agencies engage in to provide information to the public. I know that Avalanche.org is an important tool for those that ski at our world-class resorts and world-class backcountry. Can you tell me some of the other partnerships you have in Montana that can pro-

vide information to our hikers, our hunters, our snowmobilers, skiers, and communities that will keep them safe?

Let's start with you, Mr. Applegate. I should say, Dr. Applegate.

Dr. APPLEGATE. No, no, sure. No, thank you so much.

And I'll say I got to do geologic field work in the Bitterroot Mountains and spectacular part of your state.

I'm glad you mentioned Yellowstone. The Yellowstone Volcano Observatory is a great example of partnership involving the USGS, universities, but also then the state geological surveys, including the state survey in Montana. And that is really critical because, this was mentioned earlier, you know, we can generate scientific information, but the point is, it has to get to the people who need that, who have those questions. And so, our partnerships with the states are absolutely critical for that.

Likewise with earthquake monitoring, of course, Montana has had, you know, back in the '50s, the Hebgen Lake earthquake. We're talking magnitude 7 event, so a significant earthquake hazard. And there again, the partnership with the Montana state survey has been a really important one for us.

Senator DAINES. Thank you, Doctor.

Mr. Casamassa?

Mr. CASAMASSA. Senator, we have three avalanche forecast centers—one in Bozeman, one in Missoula and another in Kalispell—that provide a wide variety of information associated with avalanches for a whole host of uses up to and including hunters and fishermen who are going into those kinds of avalanche-prone zones.

We do work with, you know, the Montana Fish and Game. We work with the Park's Snowmobile Safety Program as well as the State Recreation Trails Program providing that information and educating as many people as we can. And then in the Flathead area we have the Flathead Avalanche Center out of Kalispell, working in conjunction with the Park Service to provide that information up there as well.

Senator DAINES. Well the good news is we are having a very good snow year, snow well above average which is wonderful for snowpack and so forth, but we are also seeing more and more Montanans and others access the backcountry. The avalanche risk has been great this season, and we have already had some fatalities in Montana.

I am grateful for those who are studying the science of avalanches and understanding better what really goes on, an incredible field of sometimes still learning about what happens with snow.

What are some of the biggest hurdles the communities face after a disaster and how can Congress help to make sure that they are back up and running as soon as possible?

Who would like to take that question? It is, kind of, open here to the panel.

Ms. BRANSON. Thank you, Senator. I'm Pat Branson, the Mayor of the City of Kodiak. We just experienced an almost disaster last week——

Senator DAINES. Yes.

Ms. BRANSON. ——12:32 in the morning on Tuesday.

So our needs are great. I was speaking earlier about, we have a tsunami siren go off every Wednesday afternoon at two o'clock. No one pays much attention to it. I think they will now.

But it's a matter of housekeeping, if you will, is that what we need are infrastructure support, siren support, PA system support and, certainly, staffing support because our command center, we only have people there for 24 hours. So we would have to call the state to make sure that they could provide assistance to us as well.

So it's not just equipment. It's infrastructure as well. We have a 60-year-old, more than 60-year-old fire station that's cracking. That's why I brought the duct tape here showing that we can't repair things as we normally do in Alaska.

Senator DAINES. We call that cowboy chrome back in Montana.

[Laughter.]

Ms. BRANSON. It's Kodiak emergency preparedness.

[Laughter.]

Not working this time.

So those are the kinds of things that we would need.

We were very lucky that we had electricity. We had a phone system working which is how we received the tsunami warning.

And so every community is different with their needs, but that's what we are looking at right now. And it's being, having that information, from the scientific background and from the different agencies and relaying that to our citizens as well and on a continuing basis, not just Wednesdays at two o'clock, but very frequently as things change.

So those are the kinds of needs that we have and we just experienced, and we'll do a debriefing from our experience from last week.

Senator DAINES. Thank you, Mayor.

Thank you, Chairman.

The CHAIRMAN. Thank you, Senator Daines.

I am often reminded this time of year of, again, the value of things like the Avalanche Monitoring, whether it is in Montana, Colorado, or Alaska, we have, a lot of us are skiers. I am not the backcountry skier that my sons are, but making sure that there is an understanding of avalanche extreme conditions and just how safe you are in the outdoors is something that we can never overtrain or over prepare for. So I appreciate your bringing that up.

I want to ask a few questions. I love the fact that I get the gavel.

[Laughter.]

Which some would say that means you have to stay for the whole hearing, and that means I get to stay for the whole hearing.

I have a whole series of questions that I would like to engage you all in, if we may. This relates to the warnings, the early warnings that we are talking about that can help people get to higher ground if there is a tsunami coming or, again, how we alert people.

There have been a whole series of articles that have come out, post the earthquake last week. There was the discussion about the buoy that showed a big wave—why, in Alaska, a buoy showed a big wave that wasn't there—the case of the phantom tsunami. You have the buoy monitoring systems out there that register one thing, how the communication is shared.

I was woken up on Tuesday morning to a phone that was just wild with communication from friends all over Alaska. But I got, not only the tsunami warning that came from, I guess it was the AlaskaLandMine.com, I don't know where that one comes from, but from the Tsunami Warning Center. I have one here from my QuakeFeed that gives me the magnitude of the different quakes afterwards and the timing, the emergency alert that I received. And then the chatter that goes on, invariably, that goes on because we all have access to these. And the last one was, this was not an official one, this was friend alert, "Just heard Kodiak channel is empty."

So the swirl of news and, kind of, the not-so-news that is shared that causes anxiety, panic at times and real fear, is something that, I think, from an emergency management perspective we all want to make sure that the information that we are communicating is accurate and almost as instantaneous as we can make it.

In one of the articles that I was reading about, and this goes to your comments, Dr. West, about collaboration between the agencies, there was a discussion about parts of the emergency alert system that failed.

You have the National Tsunami Warning Center there in Palmer. You have the intersect with the National Weather Service. You have some with the EMnet, the Emergency Management Network, the state contracts for that service. IPAWS, or the Integrated Public Alert and Warning System, is run by the Federal Government. So you have lots of things going on at the same time. It is my understanding we will learn more, certainly about the Emergency Alert System and where we saw failures there.

Mayor Branson, you mention that we got lucky here with this, that we did not have a tsunami. But it certainly woke the people of Kodiak up and I talked with the Mayor of the Aleutians East Borough. I know down in Sand Point, in King Cove, folks heard the sirens, went through the drill, went to higher ground. You could say it was a really good trial run in which we learned a lot and nobody was hurt.

But I would like to hear, and I will open this up to all of you here, in terms of how we can do a better job with the communication that goes on.

I understand, Dr. West, that some of Alaska's earthquake monitors were actually offline at the time of the quake last week. So I am curious to know about how that impacted anything; but also, the steps that we go through to notify emergency managers and the partnerships with NOAA when we have a tsunami warning, an earthquake warning. How are we doing and what do we need to be doing better? Because I think about your statement, Mayor Branson, that Tuesday, or excuse me, Wednesday at two o'clock everybody just hears the sirens and they think—oh, it's two o'clock. They don't think about tsunami. They think it is two o'clock. We do not want people to get numb to the drills, but we also do not want to overly concern people. It is a fine line there.

So if we can just begin the discussion there, and I will let anyone jump in. Dr. Applegate, do you want to start?

Dr. APPLEGATE. Yeah, absolutely.

You know, this is, it's about getting the right information to the right people at the right time. And that is made more complex by the fact that communication is no longer just a one way from the emergency manager, you know, to the folks.

The CHAIRMAN. Right.

Dr. APPLEGATE. There's all of that interaction, person to person. And one of the things that we found is the criticality of delivering our information in multiple streams.

So, for example, we actually will use the Twitter feeds. We both collect information as people, you know, they will themselves be feeling the shaking. You can actually watch the seismic waves going out as people pick that up. But we can also then inject our authoritative information into that bloodstream, as it will, of communication because people want the authoritative information. And it's figuring out how do we make sure that we get it there. And part of that is getting it in the form, not just the alerts that go to, you know, emergency management, but also getting that information out there, whether it's through tweets or other means.

The CHAIRMAN. So what about the concern that comes when you spread it too far? The example I will use is that folks in Anchorage where my husband was that night, our home there, they get the tsunami alert. They do not need the tsunami alert in Anchorage, but I understand that it is an issue where you have—the way it was described is an issue dealing with the intersection of weather service forecast areas and census areas. And so, you want to err on the side of alerting more people than not. In other words, we do not want to fail to alert some. And so, in an overabundance, possibly, of caution, more people get the alert. But then, when you get multiple alerts and it is "always a false alarm," you have people, kind of, tuning that out. How do we bridge that? Anybody have any ideas? Dr. West?

Dr. WEST. Yeah, let me address that and maybe in a somewhat positive note.

No, but you've captured well that that requires the intersection of everyone from the scientific community through to the municipal level on an emergency management need. Those connections are what's required.

And on the tsunami side, Mayor Branson had an image of a graphic here showing projected inundation zones in and around Kodiak. That's actually a brand new publication that came out in September of this year, updated to specifically incorporate the lessons learned during the Japan earthquake which Mr. Norman referenced.

That's actually a really dynamic, vibrant, new study, if you will, made possible by a program that was slated, year after year, for being cut until the Tsunami Warning Education Reauthorization Act was passed again last year.

That group of emergency managers, scientists, and community folks is meeting right now in Seattle. Almost all the tsunami scientists in this country are in Seattle right now. I wish Senator Cantwell were here to hear that. But they're gathering, our once annual meeting, to specifically address those kinds of issues.

So while it is not solved at all and there are, I think, the Anchorage alert issue highlights some of the challenges and the hyper-

connectedness of all these different communication channels that you see on your phone and certainly folks like the USGS grapple with them at an operational level. While we certainly don't have those all figured out, it's the existence of programs like that, the continued existence, year in and year out, that builds those relationships that are needed.

It was fascinating to sit—Mayor Branson and I met yesterday, and it was fascinating to debrief her views of this event last week. She has a particular sphere of knowledge and influence which is very different than mine. And finding those points of intersection, but that takes, kind of, that takes forced collaboration.

The CHAIRMAN. It is an issue that, again, I think we learn from these events. We have learned, not only from this event, earthquake, potential tsunami in Alaska, but when we think about the alert that the people of Hawaii faced about a month, well, a little less than a month ago now. A different kind of alert, not a natural hazard, but a very threatening alert to the public. And when we think about these emergency systems that broadcast to communities, trying to do early warning. Again, making sure that there is an accuracy, but also a timeliness is something that I think we recognize is absolutely critical.

I wanted to ask you, Dr. Applegate, and this is kind of a follow-up on Senator Wyden's question because I believe that he was trying to get to the adequacy of a funding issue for earthquakes and warning systems.

But it is my understanding that what we are doing with earthquake early warning is a system that is not yet up and operational all throughout. It has been tested in Washington, Oregon, and California. I understand that it is being used in Japan. But it is not a system that is fully implemented and in place. I don't think it is being used in Alaska, is it, Dr. West?

Dr. WEST. No.

The CHAIRMAN. So, is that—what is the status of the earthquake early warning and how is that different than what we are monitoring currently when it comes to our earthquakes?

Dr. WEST. Sure.

So, a key for about earthquake early warning, it is built on our existing monitoring capabilities——

The CHAIRMAN. Good.

Dr. WEST. ——and essentially is, can we get a dense enough network and fast enough computing and algorithm and telemetry, and all of those pieces, to be able to beat the strong shaking?

So, a key point is that it is an extension, it's a new tool, it's a new capability that is built and requires that existing investment on our current monitoring capabilities.

There are a number of countries that have deployed earthquake early warning systems. Japan is the most advanced and has had it in place for a number of years. But there are several other countries as well.

We have a prototype system for the West Coast for California through Washington that is currently in a, sort of, a beta test phase. There's some use by test users; for example, the Bay Area Rapid Transit System users for whom, at this point, like a false alarm isn't a big problem. They slow the trains down for lots of rea-

sons, right? So there's one. There's a use that can have a fairly high tolerance for a missed alert. On the other hand, there are lots of other uses that you need to have that fully developed system.

So we're very much in a prototype phase. And so, it is not something that is broadly, publicly available yet. It is a system being built. But the key is it's being built on top of that existing monitoring, and it's the strengthening of it.

The CHAIRMAN. Does it work well in Japan where it is fully implemented?

Dr. APPLEGATE. Absolutely.

In Japan, I think a good example would be—so the magnitude 9 earthquake that we had discussed, one of the capabilities with the earthquake early warning system is to slow down the bullet trains. They had, I believe, 26 bullet trains operating, you know, several hundred miles an hour. They're able to slow those trains down before the strong shaking arrives. They had no derailments from that event. Think of the number of folks who were on that.

There was a successful earthquake early warning. There are relatively few fatalities from the earthquake itself, but that's, of course, both a testament to the quality of their building codes, again, all of those things you do before the event, the quality of building codes, but also the early warning for the earthquake.

The CHAIRMAN. You are saying that in order for us to move forward with a more robust early warning system, whether on the Pacific Northwest, Alaska or wherever, the monitoring stations that we have in place, are, kind of, the base for that.

Dr. APPLEGATE. Exactly.

And it's a densification of those stations and ensuring that they have the fastest telemetry, all of that. So, it's an, really it's an end state outcome of this Advanced National Seismic System that we're building, you know, in partnership with the regional seismic networks.

And it would be an additional capability that a, you know, a robust monitoring network can deliver on top of this, sort of, real-time, after the event. So again, it's—we're trying to deliver the fastest possible information, the best information that we can.

The CHAIRMAN. Sure.

Senator Cortez Masto, I have been having a wonderful time with this panel.

[Laughter.]

But you are more than welcome to jump in and have a conversation.

Senator CORTEZ MASTO. Thank you.

And let me just say thank you for the hearing today and all of you coming here. I apologize, I had two other Committee hearings. I am trying to cover everything, but thank you for your testimony, your written testimony. So helpful.

And let me start with Dr. Applegate, because you mentioned Nevada—I am from Nevada—in your speaking points as well.

I don't know if you are specifically aware of the work that is being done and the collaboration. If you are, I would love you to elaborate, but let me just highlight because I know this is something important for us.

There is a partnership between the University of Nevada, Reno, with the Department of Energy's Berkeley National Lab, to develop an advanced computer-based tool to predict the earthquake response of critical nuclear facilities during an earthquake. It will also provide important information on solving earthquake soil-structure interactions for many applications, to also include benefits for transportation systems, pipelines, hospitals, schools and other public infrastructure.

I am aware that this important earthquake engineering research that takes place there is something that is, obviously, important for USGS and the work that you do as well.

I am wondering if you can elaborate, not only on that, but the importance of your interaction with and partnerships and collaborations that you have going, ongoing, across the country.

Dr. APPLEGATE. Absolutely.

And I'll say the University of Nevada, Reno, is one of our key partners. They maintain regional seismic monitoring and that's been a long-time collaboration.

I think what the partnership that you're describing is a very key part of this, what we call this broader National Earthquake Hazards Reduction Program. It is about taking that, you know, whether it's, you know, foundational research, whether it's in the geosciences or in engineering and then translating that into applications. And as you described, one of the most important applications is critical infrastructure.

Senator CORTEZ MASTO. Right.

Dr. APPLEGATE. There was a question earlier about, you know, what are some of the most important aspects of recovery from an event? And it is the dependence on your critical infrastructure. How fast you come back up is going to depend on the lifelines and certainly the power grid and so forth. So I think the partnership you're describing is getting at one of the most critical aspects of earthquake preparedness.

Senator CORTEZ MASTO. Thank you for saying that.

Do you mind? Here is the other issue that is concerning: These are long-term projects and they require long-term funding, and quite often we here in Congress don't think of funding in a long-term perspective and we are doing it on an annual basis. So when you are in the middle of doing important research like that and then all of a sudden, the money is cut off for that research, the implications not only to the project that is going and the work that is being done are dramatic, but then to long-term impacts to all of our communities.

Can you talk a little bit about just the funding piece and how important it is long-term, and for that commitment long-term to address the needs that you see?

Dr. APPLEGATE. I think for earthquakes, in general, and some of these other geologic hazards that we're talking about, one of the big challenges is that these are very high-consequence events, but events that for any given location, they're not part of your everyday existence. And so, it is a classic area where government investment, it may be looking at, sort of, very long-term payoffs.

It's also an area where the criticality is in long-term monitoring, to be able to build these datasets, both for the real-time applica-

tions but also to improve our understanding of what it is, what is that hazard that we're dealing with?

So, I'll say certainly, the annual appropriations cycle is not necessarily conducive to that, but things like this long-standing National Earthquake Hazards Reduction Program partnership that was authorized by Congress, having those, sort of, longer-term, you know, essentially, it's a statement of the importance of this investment over the long haul that is very important.

Senator CORTEZ MASTO. I appreciate that. Thank you.

I notice my time is just about up.

I thank you all for coming and it is good to see some of you again. I appreciate the comments today and the written comments that you have provided.

Thank you.

The CHAIRMAN. Thank you, Senator.

Just a couple more questions here.

Dr. West, I asked the question, you affirmed it, but I would like to ask why several of the Alaska earthquake monitors were offline?

Dr. WEST. Sure.

The CHAIRMAN. Is it funding? What is our situation with our monitors?

Dr. WEST. Do I have to answer that?

Twenty minutes or so before the earthquake occurred, unrelated, Golden Valley Electric Association had a modest regional power outage. The UAF Geophysical Institute, where my organization is located, weathered that relatively well; however, there was networking equipment that was offline at that time. So, essentially, the Alaska Earthquake Center, all of its data and products were dark for about an hour or so. Yeah, not a proud moment, really. We've been clear with our stakeholders.

The CHAIRMAN. So totally coincidental to the fact you were about to have——

Dr. WEST. Correct, not caused in any way.

The CHAIRMAN. Wow.

Dr. WEST. I know, we make up these scenarios to plan for and test internally, say, oh, that won't happen, you know, well they do.

But we've been clear with stakeholders for several years now that we do not have backup systems in place.

The CHAIRMAN. You have no backup systems?

Dr. WEST. We do not have modern continuity of operations. I mean, the reason is fairly simple. Over the last half dozen years every one of our federal and state funding lines have been cut back. A few years ago, I reduced my staff by nearly a third. I laid off career—painfully laid off career individuals.

Last year we received a $1 million short-term infusion, through you, frankly, which was, I cannot tell you in the last few months how much of a difference that has made. But I've described this to many people as more like a stay of execution.

Yeah, I don't know where to go from there. I mean, in order to maintain meaningful monitoring in Alaska and, frankly, many of the states on this Committee—Utah, Nevada, Oregon, Washington—they're having the same issues, same issues. I'd be happy to put anyone in touch with my peers there to explain. But in order to maintain, you know, a meaningful monitoring, we need the new

collaborations, the base funding, the Congressional support that we're here talking about today. So it's not fun to talk about, but this is what a declining funding environment in the natural hazards looks like.

The CHAIRMAN. Well, this is important information. The funding is certainly one part of it. But it is a reminder to us that you want to have a backup to your emergency network systems, your monitoring systems.

We talk about the need for redundancy and I want to turn to you, Mayor Branson, because your community, you are on an island. You are a pretty significant island, but you are an island, nonetheless. And when an emergency happens, you are on your own.

Ms. BRANSON. We are.

The CHAIRMAN. Fortunately, you have the largest Coast Guard station there on Kodiak. But as soon as that warning hits that a tsunami is coming, the Coast Guard needs to get their assets out of there because they are right in the path of a tsunami coming their way.

So you think about what happens in a natural disaster and when you are a remote state, like Alaska or Hawaii or Puerto Rico or the U.S. Virgin Islands. When disaster happens you are your buddy system there with everybody who happens to either be on that island or in that remote area. And I think, when we go through drills, when we think about how we better prepare, whether it is earthquakes, tsunami, flood, there is a realization and a recognition that in certain parts of the country emergency preparedness takes on even more criticality because you do not have neighboring states that can send their assets. We have a significant earthquake that takes out, whether it is ports, harbors, airports, we are significantly at a disadvantage.

So I asked yesterday, when we were visiting, Mayor, about whether or not our mayors, our leaders at the local levels, talk about how you need to prepare as isolated communities for these natural disasters that really leave you in, perhaps, a more vulnerable position than others. You know, your food sources are cut off, and access to medical care to a certain extent.

This is a hearing about natural disasters and natural hazards, I understand that, but I think we are also talking about the public awareness as to how one responds. If you would share just a little bit here.

Ms. BRANSON. Well, I think there are a couple of things to point out and I think Dr. West has pointed some of this out, as you have, Senator Murkowski.

And that redundancy and having a backup plan and, most importantly, being proactive as much as possible because we find ourselves in these, kind of, disasters reactive, not knowing what kind of resources that might be available, as you've just described. And we are very vulnerable, certainly not just Kodiak, but Alaska and other remote communities as well. So how we buddy up, if you will, with other communities and share information, I think that's most important. Dr. West mentioned that as well.

So I think it's being proactive, collaboration and sharing that information, as we talked about yesterday with the coastal mayors of

Alaska, maybe even a broader sense with the Pacific Northwest coastal mayors as well, and communities and to learn from one another how information is shared and being more proactive in a way that's best to protect our communities and our residents.

The CHAIRMAN. Thank you.

Again, it is a warning for us all.

We have not touched much on landslides and that is something that, unfortunately, I think we are seeing more of these events in different parts of the country.

Mr. Casamassa, after the 2015 landslide in Sitka, local managers there partnered with Forest Service, USGS, and others to conduct this risk mapping. I was actually just reading in the news clips yesterday about what the community is doing now that they have that mapping, some of the decisions that they need to make. You have a community that is looking for areas that they can build out, but you now have, perhaps, a better indication in terms of the vulnerability. I want to ask you, kind of, where we go next now that we have that mapping?

But to the others on the panel, Dr. Applegate, Ms. Berry, we seem to be doing a relatively good job in terms of the monitoring, when we have been talking about earthquakes and volcanoes and tsunamis, avalanches, but it does not seem that we are doing as much as we need to be doing when it comes to landslides themselves and ensuring that we are mapping these high-risk areas and then notifying the public when their lives and property are in danger.

Again, sitting next to Senator Cantwell and just reliving the horror of the Oso incident, but now to know that you have Washington residents that are watching daily this Rattlesnake Ridge, kind of, creeping along. And okay, maybe it is stabilized now, but can you speak a little bit to where we are with doing a better job when it comes to landslides?

And also, if you could help me identify what federal agency should be coordinating these efforts. Who should be the lead agency when it comes to landslides?

Mr. Casamassa, you can begin.

Mr. CASAMASSA. Yeah, thank you, Senator.

You know, one of the things that I think is really, would be very advantageous is after we have mapped out the hazards, after we have looked at specifically where the infrastructure or community assets are at risk, we do a bit of planning around risk management and for the Forest Service——

The CHAIRMAN. Who is "we," Mr. Casamassa?

Mr. CASAMASSA. We, the collective, the community.

The CHAIRMAN. Okay.

Mr. CASAMASSA. Any entity that has a stake in it.

The CHAIRMAN. So not just the federal agencies?

Mr. CASAMASSA. Absolutely.

The CHAIRMAN. Yes.

Mr. CASAMASSA. It would be, certainly, locally based.

But for the Forest Service piece of it, I think, it would be advantageous to know with the community where we could take actions that would potentially, would be something that we can pre-position on the National Forest, certain aspects of ingress and egress,

we need to get to this spot in order to do these kinds of things the community says. And then, instead of trying to figure that out and be reactive, as Mayor Branson said, we should be looking at—okay, we would need to pre-position assets here. We need to build catchment basins here. You know, just being a bit more thinking through what are the risks, where are the assets, how could we take actions that could mitigate the damage that could occur. And we could be a part of that on the National Forest.

The CHAIRMAN. And I know, Mayor Branson, in Kodiak, you have real concern of potential for landslide right there off of Pillar Mountain.

Ms. BRANSON. We do and it's right above Pier Three where all of our goods come in on ships, barges, twice a week and that would also cut us off from the Coast Guard base and there's also a potential hazard out by the Coast Guard base itself. So we know the Coast Guard is there to assist us in such a disaster. So landslides, mudslides, we've had mudslides from Pillar Mountain that have wiped away homes. So it's certainly an ongoing hazard for Kodiak residents as well.

The CHAIRMAN. What about who should be the lead agency? Any comment on that?

Mr. Norman?

Mr. NORMAN. Yes, I don't think there's any doubt that the USGS should be the lead agency for the federal agencies. They have established expertise on landslides. They have integral working relationships with the State Geological Surveys, and they have a proven track record of managing other natural hazards programs. So I think it's the USGS for the federal agencies.

The CHAIRMAN. Do you agree, Dr. Applegate?

Dr. APPLEGATE. This is a very important part of our hazards mission and what I think is so good about the Landslide Authorization bill that's being considered is the recognition that while there is a key federal role, and absolutely, we see this as an important part of our task. This is such a distributed hazard and it's one that plays out on, you know, on local scales all over. It's the partnerships with the states that is absolutely essential.

We have expertise that we can bring to bear to help support, you know, Dave Norman and Karen Berry and their colleagues. But they have the folks, you know, on the ground who are doing much of the work in this. We're seeing this play out right now in California with the debris flows there. We work very closely with the Forest Service and other land management agencies after wildfires, for example, to support the burned area emergency response teams. We'll do these hazard assessments. When it comes to the, really, the boots on the ground doing assessments like what's happening in the Thomas fire, it's the California Geological Survey that's there supporting CalFire. And as Dave mentioned, I mean, this is an area where the criticality, you know, we do not have a national landslide hazard assessment the way we do an earthquake assessment.

The CHAIRMAN. Do we need one?

Dr. APPLEGATE. I think it would be, yeah, I think it would be very beneficial. It certainly is a long-term goal that we've set. The National Academy has looked at the USGS landslide program and

really, when it talks about it, the Academy before talked about a national program. And again, emphasizing it's not a federal program, it's one that does have to involve many agencies at both the federal and state level.

But additional geologic mapping, high resolution LiDAR, all of these are key, enabling technologies, enabling capabilities that could then form the building blocks to eventually get to that point of a national landslide hazard assessment.

The CHAIRMAN. I was struck by Ms. Berry's comments though that in Colorado you are so far behind when it comes to mapping.

In Alaska, I was at a ceremony where we celebrated 52 percent of Alaska being mapped. Only in Alaska would you celebrate 52 percent.

[Laughter.]

But it seems like we are actually doing much better when it comes to the LiDAR. We are at 92 percent coverage on that, I understand.

But it is hard then to be able to talk about this collaboration that you are discussing, Dr. Applegate, if the states don't have that map, that base mapping to begin with. So it seems to me that there is an inequity, if you will, around the states before we can get to any kind of a national understanding of what the hazards really are.

Senator Cortez Masto, did you have further questions?

Senator CORTEZ MASTO. Just one follow-up—and I may have missed this conversation.

Obviously I am from the West and fire management is key. And it is not just management to prevent fires, forest fires, right? We know that after a fire has come through and devastated the land, there is the concern of rain and flooding and landslides. And so, there has to be remediation that occurs as well.

I am curious. This discussion on state, local and federal coming together and the protocols and policy of who takes the lead in how you manage that. Is that something that every state is working with the federal agencies on, that there is a policy or protocol to address those needs because they are going to be different in each state? That is my first question.

And the second is, at the federal level I know you do not have enough resources. So how do you triage? Where to put the resources at the time?

Mr. Casamassa, I would start with you.

Mr. CASAMASSA. Yeah, thank you, Senator.

And for the most part, I think it varies from state to state in who would take the lead and how best that coordination occurs. At least that's been my experience and I know that plays out in that way.

You know, one of the things that we do, and Dr. Applegate alluded to it, is that in the burned area emergency rehab work that we do and our response is centered around determining which areas are the most impact, where is there medium impacts as well as low. And then we really focus in on that triaging around the more severely burned areas to do the kind of work that we need to for remediation.

Senator CORTEZ MASTO. Thank you.

The CHAIRMAN. Thank you.

Well, I thank all of you. We have hit the noon hour and I think that this has been good, important discussion.

Hopefully, we learn, again, from these natural hazards that do not bring about disaster so that in the event that we do have that next big earthquake, that next big tsunami, the next big volcanic eruption, that there is a level of awareness and preparedness.

I often share with folks a situation some years back when my boys were—it was spring break and they were home skiing for spring break, as good Alaskan boys would. They had taken a buddy of theirs from Maryland, and the mother was concerned because he was going to the wilds of Alaska. I said, don't worry, this is going to be a very safe spring break. The day that they were due to fly back, the volcano blows. And so, air traffic is grounded. I have to call the mom in Maryland and say, they will be here tomorrow.

[Laughter.]

Only the next day the airplanes also were not flying and I had to call her again and say, well, it is fine in Alaska, but the planes are grounded because we are dealing with a little bit of fallout.

[Laughter.]

This is getting to be a really good spring break for the boys. The third day comes and, of course, now all the flights are backed up and so I can't get them out for the following day. The next morning that they go to the airport there is an avalanche that has come across the road and they can't get to the airport. They missed their flight. It was the best spring break that those boys ever had.

[Laughter.]

But it was for this mom, who says to me, what happens in Alaska that you have all of these natural disasters, natural hazards?

Fortunately, no one was hurt. It was a wonderful spring break for them. But there was a lot of inconvenience. And I think we recognize that the more prepared we can be, the better off we will all be.

I thank you for the expertise that you have shared with the Committee today. We have a lot of work to do. It comes with resourcing. It comes with monitoring. It comes with preparedness, and we appreciate all your efforts.

With that, the Committee stands adjourned.

[Whereupon, at 12:03 p.m. the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED

U.S. Senate Committee on Energy and Natural Resources
January 30, 2018 Hearing: The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems
Questions for the Record Submitted to Dr. David Applegate

Questions from Senator Ron Wyden

Question 1: Dr. Applegate, your written statement to the Committee emphasized the work USGS has done on *ShakeAlert*, the West Coast early warning system, "with new funding directed by Congress in recent years." Your testimony also states that *ShakeAlert* will "provide an additional layer of safety" and a "significant boost in capabilities," yet the administration's budget slashes the program's funding. I asked in our hearing what capabilities would suffer if that funding were cut, which is what Donald Trump is proposing. You replied that the Trump budget would focus on existing capabilities.

Please explain: 1) how USGS will be able to build and operate *ShakeAlert* if Congress cuts funding, and 2) what aspects of *ShakeAlert* USGS will scale back with less money.

Response: The President's Fiscal Year 2018 budget did not request continued funding for *ShakeAlert* and would suspend USGS efforts to build *ShakeAlert*, including internal USGS implementation efforts, external funding to partners, and cooperative development with private and public sector users. The administration's FY18 proposal preserves core USGS functions, including critical monitoring capabilities and heavily used public information products. The USGS has always worked with Congress to address concerns about our mission and budget priorities, and we maintain that commitment going forward, including working to determine the appropriate federal, state and local cost share associated with any future ShakeAlert developments.

Question from Senator Joe Manchin III

Question: Both the USGS and the Forest Service have certain areas of expertise and resources for certain types of natural disasters. For the Forest Service you have expertise in avalanche response, and the USGS takes the lead in monitoring, researching and forecasting earthquakes, volcanic eruptions, landslides, and even space weather. Fortunately we don't have much volcanic activity in West Virginia, but we do experience natural disasters from time to time. When I was governor, I worked hard to keep in touch with county commissioners and folks on the ground to hear what concerns or problems they may be having, and to let them know we have two lines of communication open.

With that in mind, what process do you follow in alerting local authorities, local governments and other federal agencies to prepare for the possibility of natural disaster?

Response: The USGS develops methods and tools to assess natural hazards. We also maintain monitoring systems that are used to alert local authorities about impending hazards either directly in the case of certain geologic hazards or through the National Oceanic and Atmospheric Administration's National Weather Service (NOAA NWS) in the case of floods and storm surge.

U.S. Senate Committee on Energy and Natural Resources
January 30, 2018 Hearing: The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems
Questions for the Record Submitted to Dr. David Applegate

USGS and NOAA collaborate with local authorities to integrate this science into their own emergency response plans.

Questions from Senator Mazie K. Hirono

Question 1: The Hawaiian Volcano Observatory is the oldest of the five volcano observatories in the United States and monitors two of the highest priority volcanoes, Kilauea and Mauna Loa. Earlier this Congress I joined Chair Murkowski and Ranking Member Cantwell in introducing S. 346, the National Volcano Early Warning and Monitoring System Act.

Can you talk about the importance of updating and unifying the five volcano observatories across the nation and how provisions within this bill will help protect communities and save lives?

Response: The USGS operates five volcano observatories that each have their individual areas of responsibility but are managed under a single USGS Volcano Science Center and use a common alerting scheme. Each has its subject matter experts, and response plans developed in collaboration with local authorities. In these plans, roles and responsibilities during volcanic crises have been well defined.

Fully implementing a National Volcano Early Warning System (NVEWS) would promote further coordination of the observatories' work.

NVEWS as authorized by S. 346 would support many efforts already under development by the USGS including upgrading and augmentation of existing volcano monitoring networks, installing new networks on significantly under-monitored volcanoes, and modernizing networks opportunistically. Activities not yet initiated by the USGS that would be supported by this bill include the establishment of a 24-7 volcano watch office and a National Volcano Data Center, and creation of an external grants program for volcano research. The USGS agrees with the bill's objectives and we are actively pursuing opportunities to fulfill those objectives.

Question 2: USGS personnel at the Hawaiian Volcano Observatory are currently monitoring lava flowing from Kilauea Volcano and are also actively monitoring earthquake activity from Mauna Loa. Mauna Loa occupies over half of Hawaii Island and the last time it erupted threatened Hilo, the largest population center on Hawaii Island. Hawaii County (comprised of Hawaii Island) is the fastest growing county in the State and the potential for an eruption from Mauna Loa to threaten lives and property in Hawaii is very high.

With the population of Hawaii Island increasing, volcanic air pollution, or vog, has the potential to have significant health impacts, not to mention other impacts on agriculture and drinking water. I know that this month is the 9th annual "Volcano Awareness Month" on Hawaii Island, so there are ongoing educational programs being conducted to educate the public. However, can

U.S. Senate Committee on Energy and Natural Resources
January 30, 2018 Hearing: The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems
Questions for the Record Submitted to Dr. David Applegate

you discuss specifically some of the efforts USGS is undergoing to educate and alert the public about vog? Is there a vog warning system, similar to weather alerts, in place that is easily accessible and understandable by the public?

Response: In Fiscal Years 2010 and 2011 the USGS funded development of a prototype vog forecast system, the Vog Measurement and Prediction Project (VMAP), through a cooperative agreement award of $331,000 to the University of Hawaii at Manoa[1] (in addition to support from the NOAA Air Resources Laboratory). VMAP provides a visualization of volcanic air pollution for public awareness. It uses data from daily USGS volcanic gas measurements at Kīlauea Volcano and NOAA wind field data, among other data sources, to predict the concentration and dispersion pattern of vog 58 hours into the future. Then NOAA's National Weather Service, in coordination with USGS and NOAA's Volcanic Ash Advisory Centers (under NOAA's National Environmental Satellite Service), issue Ashfall Warnings/Advisories and other alerts to help keep people on the ground safe from volcanic air pollutants.

Question 3: Our forests in Hawaii are under continuous threat by invasive species, whether it be fast-growing invasive albizia trees that fall over during high wind events and damage our infrastructure, or Rapid Ohia Death that kills our native ohia trees and threatens our watersheds and ecosystems. Resources provided by USGS such as mapping albizia and the field test kits developed for Rapid Ohia Death detection are crucial to helping our state prepare and respond to these hazards.

In addition, researchers in Hawaii working on Rapid Ohia Death have successfully competed for Service First funds in the past, which is a partnership authority available to agencies within the Department of the Interior and the Department of Agriculture. I understand that the Department of the Interior is awaiting FY18 appropriations to be enacted before proceeding with the program, but I understand that researchers in Hawaii will once again be competing for these funds and I think it is important for our folks in Hawaii to have the resources necessary to continue this important work before our native ohia forests are decimated.

Outside of the potential for additional Service First resources, can you discuss any ongoing or future plans that USGS has in mapping or monitoring of albizia or Rapid Ohia Death in Hawaii?

Response: Scientists from USGS, universities, the U.S. Department of Agriculture, the Department of the Interior, and others comprise a Rapid Ohia Death (ROD) working group, which is coordinating research. The USGS Pacific Island Ecosystem Research Center is determining how the disease spreads, developing improvements to the field test kit, and conducting an analysis of environmental factors in disease-prone areas. Using this information, we hope to predict areas in which the disease is more likely to spread.

[1] mkwc.ifa.hawaii.edu/vmap/

U.S. Senate Committee on Energy and Natural Resources
January 30, 2018 Hearing: The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems
Questions for the Record Submitted to Dr. David Applegate

USGS is not currently mapping or studying the factors that determine the spread of albizia.

Questions from Senator Catherine Cortez Masto

Question 1: I am aware of the important earthquake engineering research that takes place at the University of Nevada, Reno, Earthquake Engineering Laboratory, in partnership with some of our Department of Energy National Laboratories and the regional seismology studies of the Nevada Seismological Laboratory. Does the USGS develop partnerships and collaborations with others doing earthquake and geologic hazard work?

Response: The USGS partners with state geological surveys and university and private sector researchers in a variety of hazards monitoring and applied hazards research as well as with several universities in the operation of seismic monitoring networks. Among these, we provide competitive, peer-reviewed, external research support through grants and cooperative agreements that enlist the talents and expertise of the academic community, State government, and the private sector. For example, the USGS directly supports the Nevada Seismological Laboratory at the University of Nevada, Reno in a longstanding partnership for earthquake monitoring in Nevada and Eastern California. The Nevada Seismological Laboratory is funded by the USGS to operate the Nevada Seismic Network, which is a participating regional seismic network in the USGS Advanced National Seismic System. The USGS also provides support for the Western Great Basin Geodetic Network operated by the Nevada Geodetic Laboratory within the Nevada Bureau of Mines and Geology, also at the university.

The earthquake engineering research that is conducted at the University of Nevada Earthquake Engineering Laboratory is supported by the National Science Foundation (NSF), a partner of the USGS within the National Earthquake Hazards Reduction Program (NEHRP).

Lastly, USGS has a very close relationship with NOAA. USGS research, monitoring systems and expertise directly support NOAA's mission to warn people against a wide variety of geological-related hazards, specifically tsunamis, volcanic ash, lahars, landslides, mudslides and debris flows from wildfire burn scars.

Question 2: How does the USGS leverage the knowledge and capabilities at U.S. Universities and other research organizations and agencies?

Response: The USGS Earthquake Hazards Program provides grants and cooperative agreements to undertake targeted, applied research toward earthquake loss reduction, to operate regional seismic and geodetic networks, and in recent years, to develop the *ShakeAlert*

U.S. Senate Committee on Energy and Natural Resources
January 30, 2018 Hearing: The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems
Questions for the Record Submitted to Dr. David Applegate

earthquake early warning system. Last year, the USGS awarded more than $20 million in external grants and cooperative agreements for these purposes.

Question 3: There are tremendous technological advancements underway in terms of advanced sensors, the ability to remotely collect and distribute data, and high-performance computing. What is the USGS doing to take full advantage of emerging technology advancements that can improve and advance our ability to understand geologic hazards such as earthquakes?

Response: The USGS strives to leverage the latest technologies for earthquake loss reduction. For example, for earthquake monitoring, the USGS has pioneered the use of low-cost, internet-connected sensors, such as the *NetQuakes* device now in use nationally to supplement regional seismic network coverage. The USGS also uses crowd-sourcing for collecting information about earthquake damage, through the *DidYouFeelIt?* application, and both collects and distributes earthquake information using Twitter. USGS scientists, and scientists at the USGS-supported Southern California Earthquake Center, use high-performance computing to simulate ground shaking from scenario earthquakes. This work employs resources available through the National Science Foundation (NSF), the Department of Energy and other sources.

Question 4: How does the scientific knowledge of earthquake phenomenon and earthquake hazard generated by the USGS inform the engineering community and impact the ability to design and build infrastructure that is more earthquake resilient and ultimately saves lives?

Response: The USGS is a member of the four-agency National Earthquake Hazards Reduction Program (NEHRP) partnership within which the basic and applied research and assessments supported by the NSF and USGS, respectively, is handed off to National Institute of Standards and Technology and the Federal Emergency Management Agency (FEMA) to then be applied to improving earthquake resilience through construction standards and code requirements. Over $1 trillion in new construction every year follows state and local building codes with seismic safety provisions derived from USGS seismic hazard assessments, and USGS seismic hazard data are critical inputs to siting and design of critical infrastructure from water utilities to nuclear power plants.

Question 5: While there are areas of potential earthquake hazard throughout the U.S., three highly seismically active states include Alaska, California and my home state of Nevada. What specific activities are being executed by the USGS that will help us better understand earthquake hazard and be better prepared for major earthquakes in these regions of very high seismicity?

Response: In seismically actives states such as Nevada, the USGS:

- Provides 24x7 reporting on domestic and global earthquakes;
- Delivers earthquake impact and situational awareness products to emergency response officials;

U.S. Senate Committee on Energy and Natural Resources
January 30, 2018 Hearing: The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems
Questions for the Record Submitted to Dr. David Applegate

- Develops and maintains seismic hazard maps, associated databases and tools;
- Reduces uncertainties in assessments of earthquake occurrence and ground motion;
- Assesses the risks from earthquakes to people, businesses and critical infrastructure;
- Communicates earthquake information to the public and to key stakeholders, including State emergency response agencies and disaster relief organizations.

These activities are partnered with state organizations, such as the Nevada Bureau of Mines and Geology and the University of Nevada, Reno.

Question 6: Natural hazardous events, like earthquakes, landslides, or wildfires can create a lot of damage to our infrastructure, and can have disastrous effects on people's lives and well-being. I am aware that the USGS has an office, the Office of Environmental Health that studies these events on their impacts on people's health in particular. Can you describe the factors USGS studies in how people's health is effected? Why is this important?

Response: Disasters can release into the environment large volumes of potentially hazardous materials such as raw sewage, crude oil, volcanic ash, and other contaminants from natural and artificial sources. They can also facilitate the spread of zoonotic diseases like the Zika virus or avian influenza.

The potential health hazards posed after disasters often receive considerable media attention and public concern, but their actual impacts may not always be adequately known.

Over the last two decades, the USGS has responded to many different disasters, including the World Trade Center collapse, to help understand the nature of contamination and the hazardous materials they produce.

Question 7: Can you describe the factors USGS studies in how people's health is effected? Why is this important?

Response: The USGS does not study human health impacts directly. Rather our experts in geology, geochemistry, analytical chemistry, hydrology, remote sensing, and biology work with experts in medicine and public health to help them understand the nature of environmental contaminants and pathogens to which humans are exposed.

Question 8 and 9: Does most of USGS' research in this regard typically take place following a disaster?

How could preparedness and response be improved if further study was made before a disaster occurs?

What factors, if any, prohibit USGS from performing pre-disaster research?

U.S. Senate Committee on Energy and Natural Resources
January 30, 2018 Hearing: The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems
Questions for the Record Submitted to Dr. David Applegate

What areas of study are currently lacking and where can Congress be helpful in that effort?

Response: As noted in our response to Question 6, the USGS has carried out numerous post-disaster responses but we also work with partners to help prepare for likely environmental contamination from future disasters. We work with these same partners to anticipate emerging contaminant hazards.

Question 10: Both USGS and U.S. Forest Service generate an immense amount of daily information – whether it's in regards to seismic activity, volcanic activity, or anything else. How do you translate all of this science and measurements into an emergency management plan that the public can understand and policies that help protect people's lives?

Response: For all hazards of all types, FEMA maintains the National Preparedness System, which defines an organized process for preparedness efforts, including planning at all levels of government.

Specifically for earthquakes, risk reduction is coordinated by the four agencies of NEHRP and their stakeholders through the development of seismic provisions in model building codes, public preparedness activities like the Great ShakeOut drill, and public awareness campaigns. Large-scale scenarios developed by USGS and partners form the basis for emergency response exercises and catastrophic event plans.

USGS streamflow data and flood-frequency statistics are essential to the quantification of the extent and frequency of flood hazards faced by communities across the Nation. In addition, NOAA uses USGS streamflow data, both real-time and historical to calibrate, verify, and initialize their forecast models used to generate river forecasts and warnings Together with USGS elevation data and hydraulic models, flood frequency statistics permit the delineation of floodplain maps that are the operational basis of the FEMA National Flood Insurance Program (NFIP) and that are a key component of local zoning and building codes for more than 20,000 participating communities. Half of all NFIP Flood-Insurance Rate Maps are based on USGS streamflow data and flood statistics, most delivered through USGS StreamStats.

U.S. Senate Committee on Energy and Natural Resources
January 30, 2018 Hearing: The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems
Questions for the Record Submitted to Mr. Glenn Casamassa

Questions from Senator Joe Manchin III

Question 1: Both the USGS and the Forest Service have certain areas of expertise and resources for certain types of natural disasters. For the Forest Service you have expertise in avalanche response, and the USGS takes the lead in monitoring, researching and forecasting earthquakes, volcanic eruptions, landslides, and even space weather. Fortunately we don't have much volcanic activity in West Virginia, but we do experience natural disasters from time to time. When I was governor, I worked hard to keep in touch with county commissioners and folks on the ground to hear what concerns or problems they may be having, and to let them know we have two lines of communication open.

With that in mind, what process do you follow in alerting local authorities, local governments and other federal agencies to prepare for the possibility of natural disaster?

Response: The Monongahela National Forest has a high level of engagement with local communities. The Forest Supervisor and District Rangers engage in ongoing and active communication with local communities, developing partnerships and preparing for natural disasters.

We are currently partnering with local communities, government officials, and organizations on emergency preparedness, 2016 Flood restoration, economic development through outdoor recreation tourism, and stewardship projects on the Forest, just to name a few examples. Working together and keeping the lines of communication open during good times help to sustain us all during bad times, for example during the 2016 flood.

In late June 2016, Forest leadership was monitoring National Weather Service forecasts. When the water began to rise on June 23, 2016, employees spanned out across the forest warning recreationists to move to high ground. Calls were made to our Offices of Emergency Management, offering Monongahela employees and equipment to help. On June 25, the Forest established an Incident Management Team (IMT) to manage emergency response to the flood. The IMT worked with the West Virginia Department of Homeland Security and Emergency Management, City of Richwood, Greenbrier County Office of Emergency Management, and West Virginia State Department of Highways to respond to immediate health and safety emergencies.

Open lines of communication are key to all aspects of emergency response and provide the framework for each process the Forest identifies. Such as Emergency Action Plans (EAPs) for high hazard dams and flash flooding in recreation areas. These plans identify specific employees or positions and members of local communities that are to be notified during an event. Maintaining local level relationships is the foundation of our management organization and paramount to the success of responding to emergencies.

U.S. Senate Committee on Energy and Natural Resources
January 30, 2018 Hearing: The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems
Questions for the Record Submitted to Mr. Glenn Casamassa

Additionally, through long standing relationships with the Natural Resources Conservation Service, non-governmental organizations such as Trout Unlimited, and private landowners, the Forest Service is leveraging additional resources to improve critical streamside roads and road-channel crossings to be more resilient to large storm events.

Question 2: In West Virginia, and greater Appalachia, we are susceptible to landslides and heavy rain that can cause flash floods and wreak havoc such as what we saw in 2016. Even relatively minor landslides can cause significant damage that is expensive and timely to fix. Or worse, damages critical infrastructure that can impact thousands of people in the surrounding areas.

What assets does the Forest Service have located in or dedicated to the Mon—for example, mapping capabilities, staffing expertise to help respond to a natural hazard like a mudslide?

What else do they need?

Response: When disaster strikes, employees of the Monongahela National Forest stand ready to help. Many of our employees' expertise lends itself to emergency operations, such as engineering staff (professional engineers, field technicians, and surveyors); heavy equipment operators; chain saw teams; Geographical Information System (GIS) expertise; geologists, hydrologists and soil scientists; and communications specialists at the Central Appalachian Dispatch Center, which is currently located in our Supervisor's Office.

We have a responsibility to follow through with our commitment to local communities to repair damage caused by the 2016 Flood. Timely funding of our 2018 Emergency Relief for Federally Owned Roads (ERFO) request of $2.1 million by the Federal Highway Administration would help us fulfill this commitment.

To be better prepared for the next disaster, the Monongahela needs people and infrastructure. Plans are underway now to increase staffing in the timber program and other support areas to produce more forest products. These full-time employees, partners, and contractors would give us additional capacity to respond to natural disasters. We have priority infrastructure needs for road access related to ongoing restoration of flood damages, forest management, prescribed fire and wildland fire suppression.

Question 3: The Secure Rural Schools program is currently expired and counties now receive only about 25% of what they previously received under SRS. Several counties in West Virginia that traditionally relied on SRS received experienced a sharp reduction in funds, forcing many school districts to make difficult decisions and painful cuts. For example, in 2017, Pocahontas County received $72,000 in SRS, down from prior year amounts close to $750,000. Through forced reductions, Pocahontas County schools lost at least 14 staff members. These forced

reductions have stretched the resources extremely thin in countries that are already grappling with challenged economies.

Another county, Hardy County, informed me that schools did receive the counties payment for FY2017 in the amount of $7,265.65. They were appreciative, however they fairly pointed out that Hardy County has previously received approximately $65,000 per year of SRS funds. That's a decrease of 88%.

I understand that this may not be something we see in the FY19 proposed budget because it needs reauthorization but will you please commit to working with us and the Ag Committee on getting this vital program reauthorized?
What has the Forest Service seen in terms of how these missing SRS funds affect rural communities and the Service's partnerships with those communities, if any?

Response: The Forest Service will work with Congress to provide information to pursue Secure Rural Schools Act reauthorization. The Forest Service is committed to working with Congress, states, and counties to implement a successful Secure Rural Schools program should it be reauthorized.

When the Secure Rural Schools Act was first enacted in 2000, its intent was to continue safety net payments to counties to stabilize payments from 2000 through 2006 as counties adjusted to declining timber sale receipts. The Act was intended to provide temporary relief until counties' sources of funding stabilized. The Act has been reauthorized several more times until ultimately expiring on September 30, 2015. We appreciate the essential role Congress played in reauthorizing the Secure Rural Schools Act for nine years.

As you have experienced in Pocahontas and Hardy Counties, the Secure Rural School Act's expiration impacts funding that many counties have come to rely on. Due to the fact that the Act was not reauthorized, the Twenty Five Percent Fund Act formula was used to calculate payments for the 2016 receipts year, resulting in $54 million in payments distributed in March 2017, which is, on average, 80 percent less than the 2015 SRS payments distributed.

Question from Senator Mazie K. Hirono

Question: As you know, Hawaii doesn't have a National Forest, but we do rely on U.S. Forest Service experts and resources to help manage our forests. Our forests specifically are under threat by invasive species, whether it be fast-growing invasive albizia trees that fall over during high wind events and damage our infrastructure, or Rapid Ohia Death that kills our native ohia trees and threatens our watersheds and ecosystems. Resources provided by the Forest Service

such as mapping and monitoring are crucial to helping our state prepare and respond to these hazards.

In addition, researchers in Hawaii working on Rapid Ohia Death have successfully competed for Service First funds in the past, which is a partnership authority available to agencies within the Department of the Interior and the Department of Agriculture. I understand that the Department of the Interior is awaiting FY18 appropriations to be enacted before proceeding with the program, but I understand that researchers in Hawaii will once again be competing for these funds and I think it is important for our folks in Hawaii to have the resources necessary to continue this important work before our native ohia forests are decimated.

Outside of the potential for additional Service First resources, can you discuss any ongoing or future plans that the Forest Service has in mapping or monitoring of albizia or Rapid Ohia Death in Hawaii?

Response: The Forest Service continues to work closely with Hawaii in support of efforts to manage invasive species, including the mapping and monitoring of albizia trees and the Ceratocystis pathogen causing Rapid Ohia Death (ROD).

Forest Service scientists are diligently working on managing albizia, including research on biocontrols and hazard abatement near communities in collaboration with the Big Island Invasive Species Committee. More than $350,000 has been invested in these efforts over the past three years. The University of Hawaii received two Special Technology Development Program grants in FY 2017 for about $100,000, and are developing better unmanned aerial vehicle (UAV) technologies to map and manage invasive plants, including albizia.

The Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) has received its fiscal year 2018 Forest Health Protection grant for $200,000, and it prioritized $50,000 for 1:1 cost-matched funds to monitor Rapid Ohia Death (ROD), including via ground and aerial surveys. The remainder of funds support other DOFAW priorities including bio controls for invasive plants, coordination on alien pest species, and monitoring Koa disease resistance. The Forest Service has further committed $188,000 this year for additional ROD-related work prioritized by the interagency Working Group, and is continuing to provide technical assistance and aviation safety training in support of DOFAW's aerial survey and mapping program.

In addition to albizia and ROD, the Forest Service contributes research, technical assistance, and helps implement projects on several other invasive species. We estimate that over 15 Forest Service scientists and specialists spend at least 2,000 hours per year at a cost of more than $150,000 to provide technical assistance to Hawaii as requested and practicable. Biocontrol efforts are underway or in development for invasive plants such as strawberry guava, melastomes, Himalayan ginger, Himalayan raspberry and faya tree. Invasive grass and fire

management are in progress on degraded agriculture lands at Puu Waa Waa to restore Koa trees. Weed control at the Hawaii Tropical Experimental Forest is ongoing to improve watershed health. To date, the Forest Service has invested more than $1 million in these efforts.

Questions from Senator Catherine Cortez Masto

Questions: As you know, USFS partners with several avalanche centers in the country, and one is particularly important to my state, the Sierra Avalanche Center that provides avalanche, snow, and weather information for the greater Lake Tahoe area (headquartered in Truckee, CA). How does USFS work with these centers specifically, and how does USFS coordinate this partnership with first responders, local agencies, and other relevant stakeholders?

Response: The Forest Service manages a network of 13 avalanche centers across the country, including the Sierra Avalanche Center. As with all of our avalanche center operations, the Sierra Avalanche Center is jointly operated by both a non-profit organization and the Forest Service. We employ Forest Service avalanche specialists who conduct field work, assess avalanche conditions, and provide avalanche advisories and other safety products for the public. The associated non-profit raises money to help cover the costs of the operation, and it also provides a great deal of avalanche education to the community. The Sierra Avalanche Center operates like many of our avalanche operations across the country- in fact, across the agency, more than half of the operating budgets for our avalanche centers is provided by grants, donations, and support from associated non-profit groups.

In terms of coordinating with first responders, local agencies, and other stakeholders, this is done locally by each avalanche center. Typically our avalanche centers coordinate closely with local Search and Rescue operations to provide support and assistance in the event of any avalanche accidents. Our avalanche centers also act as a local hub of information exchange for all stakeholders involved in avalanche safety in their local areas.

A map of the avalanche centers operations and the current avalanche danger across the country is available at www.avalanche.org. This website is another successful public/private partnership, and is jointly run and maintained by the American Avalanche Association and the Forest Service.

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February 8, 2018

U.S. Senator Lisa Murkowski
Chairman, Senate Committee on Energy and Natural Resources
304 Dirksen Senate Building
Washington, DC 20510

U.S. Senator Maria Cantwell
Ranking Member, Senate Committee on Energy and Natural Resources
304 Dirksen Senate Building
Washington, DC 20510

RE: *The Role of the U.S. Geological Survey and the U.S. Forest Service in Preparing for and Responding to Natural Hazard Events, as well as the Current Status of Mapping and Monitoring Systems*

Dear Chairman Murkowski and Ranking Member Cantwell:

We applaud you for holding this important hearing on natural disasters. For the reasons discussed in the witnesses' opening statements, and with the multiplicity of natural hazard risks Americans experienced across the country in 2017, this is a vital conversation for our nation to have.

The written statement of David Applegate referenced *"current USGS activities that are helping make communities and the Nation safer and more resilient."* Our goal in submitting this statement and the attached materials for the record is to contribute to the committee's understanding of how the private sector's investments in research and development are complementing the efforts of federal agencies and are contributing to this fundamental idea of ensuring communities are safer and more resilient.

CoreLogic's natural hazard and catastrophe solutions allow for insurers, enterprise risk managers, lenders, and state and federal government agencies to fully understand the property-level hazard risk across their portfolios. Structure insurance, reinsurance, and recovery plans are all vital elements to understanding and planning for natural disasters. As the Committee recognizes, natural hazards including, but not limited to, earthquakes, floods, wildfires, hurricane winds and tornadoes present threats to Americans and the economy every year. We believe that having access to the latest technology and most accurate hazard risk insights can help improve how communities prepare for and respond to these types of natural hazards. Using proprietary science, our predictive modelling has helped risk managers, government agencies and even industrial sectors answer three critical questions: What could happen? What if it happened? And, what did happen?

CoreLogic applied these questions to the record-breaking catastrophes across the United States in 2017. The results of our research scientists' efforts are reflected in the attached *2017 Natural Hazard Risk Summary & Analysis Report*. The report contains our qualitative and quantitative evaluation of last year's natural hazard events. We hope this report can serve as a resource to the Committee as it works with federal agencies, state governments, local communities, and private sector businesses to evaluate options and tools available to strengthen preparedness, response, and post-loss assessment capabilities across the United States.

Sincerely,

Stuart Pratt
Global Head, Public Policy and Industry Relations
CoreLogic

Attachments: https://www.energy.senate.gov/public/index.cfm/2018/1/full-committee-hearing-on-the-u-s-forest-service-and-usgs