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U.S. SENATE COMMITTEE ON APPROPRIATIONS
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AND GENERAL GOVERNMENT

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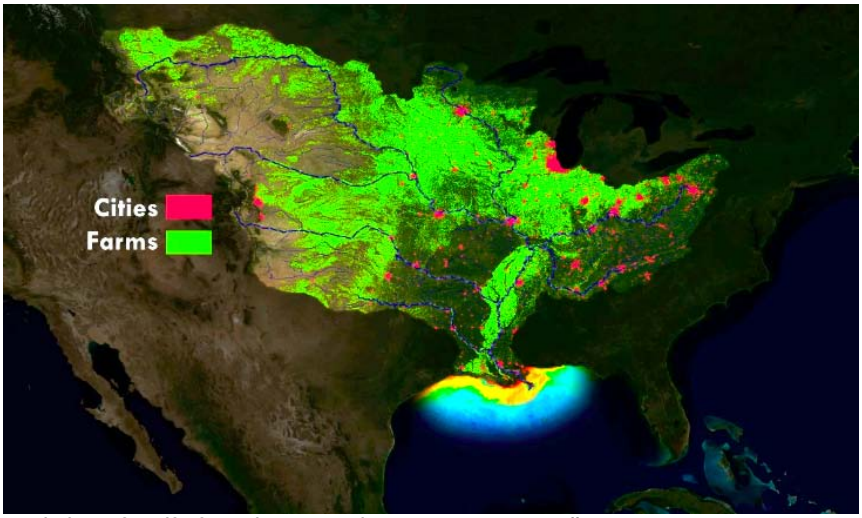
Good morning Chairman Durbin, Ranking Member Moran and Members of the Subcommittee. My name is Dr. Kathryn D. Sullivan, and I am the Assistant Secretary of Commerce for Environmental Observation and Prediction for the National Oceanic and Atmospheric Administration (NOAA). Thank you for the opportunity to testify today at this hearing about the Federal Government's role in mitigating the economic impact of severe weather events. High impact weather sometimes takes the form of relatively short-lived but extreme events such as tornadoes, flash floods, hurricanes, wildfires, tsunamis, dust storms, or heat waves – but also of longer term events such as floods and drought, which have broader impacts across many economic sectors. NOAA's short-term weather forecasts of conditions out to about two weeks have been critical to saving lives and property in the days leading up to and during the extreme events we've been seeing this spring and summer. NOAA's long range weather and seasonal forecasts, also known as "climate forecasts," have been critical to making the advance planning decisions, from weeks to months ahead of time, that allow rapid response to the onset of these weather events.

An Historic Year in the Making

The year 2011 has already established itself in the record books as an historic year for weather-related disasters and it is not over – in fact hurricane season is just getting underway. Just past the year's midpoint, we have already seen eight $1-billion-plus disasters.. Total damages from weather- and water-related events since January for the United States are well over $32 billion and climbing (Lott, et al 2011). 2011 is tied for fifth as the deadliest tornado year for the United States since modern recordkeeping began in 1950, with 537 people killed so far. April 2011 ranks as the most active tornado month on record with 875 tornadoes, breaking the previous record of 542 set in 2003. More tornadoes occurred on April 27 of this year than any other day in the past 61 years. On May 22, a large portion of Joplin, Missouri was devastated by an EF-5 (winds greater than 200 mph) tornado, resulting in over 150 fatalities and over 1,000 persons injured. The Joplin tornado was the deadliest this year and is ranked 7th among the deadliest tornadoes in U.S. history.

Prime wildfire conditions prevailed across portions of the Southern Plains and Southwestern States, with a record breaking 1.79 million acres burned across the country in April alone, with Texas, New Mexico and Arizona bearing the brunt of the wildfire activity. Nearly 6 million acres have burned nationwide – double the ten year average by this time of year.

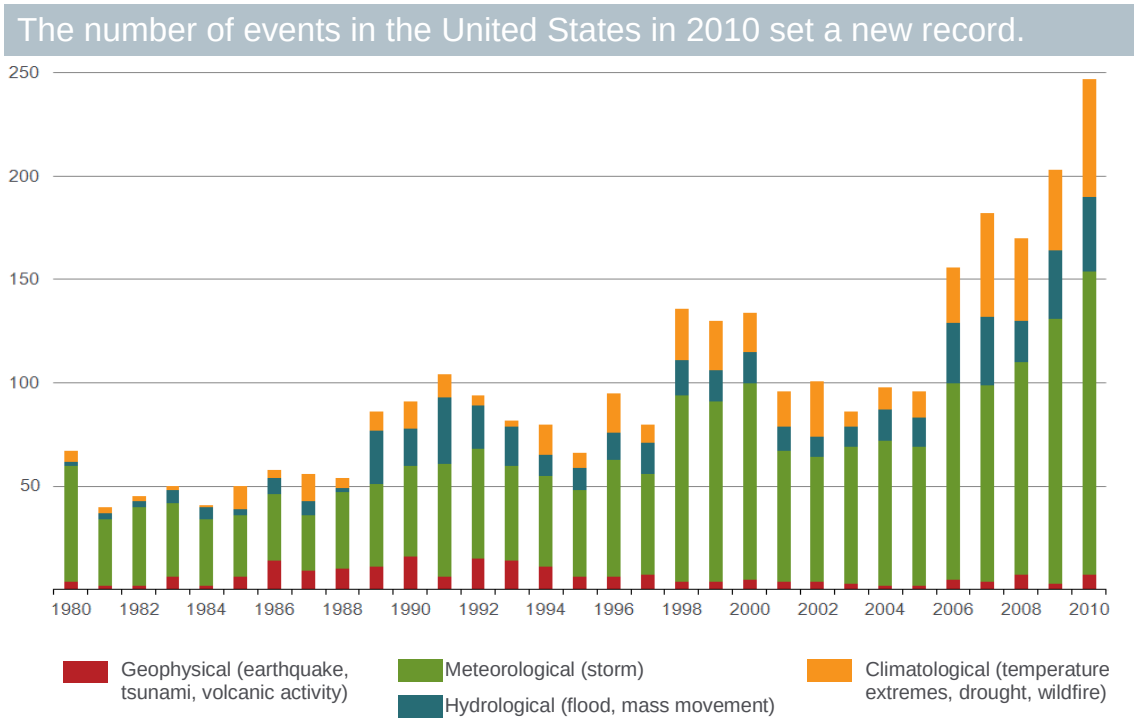
Fueled by record-setting precipitation totals, historic flooding has hit the Midwest and Ohio Valley, from the smallest streams to the largest rivers. The Ohio Valley region had its wettest April on record, and the record goes back to 1895 for some states. Record breaking heavy rains across Montana and the Dakotas, combined with runoff from record winter snowpack, caused tremendous flooding across those states, with Minot, North Dakota, being among the hardest hit. Forecasts now indicate this season could rival the Great Flood of 1993. In that year, the upper Midwest endured persistent, record-breaking floods from April through August, impacting nine states and causing more than $25 billion in damages (adjusted for inflation)(Lott, et al 2010). The effects of floods are felt far downstream as well. Following the 1993 flood, the spatial extent of the hypoxic zone, or "dead zone" in the Gulf of Mexico more than doubled its size, to over 18,000 km^2, and persisted at that size through midsummer 1997. The tremendous amount of water flowing into the Gulf of Mexico from this year's record spring flooding is expected to cause the largest ever “dead zone,” surpassing that of 1993 (Rabelais, et al 2011). Dead zones – areas lacking the necessary oxygen and salinity to fuel marine life – are primarily caused by the effects of runoff from floods, which carry not only the upstream sediments such as agricultural nutrients, but also the tremendous freshwater influx to the Gulf waters. This stimulates an overgrowth of algae that sinks, decomposes, and consumes most of the life-giving oxygen supply in the water. The Gulf of Mexico dead zone is of particular concern because it threatens valuable commercial and recreational Gulf fisheries that generate about $2.8 billion annually.



Depiction of Gulf of Mexico Hypoxia Zone *Image Credit: NOAA*

WHAT IT MEANS

Nearly 90 percent of all Presidentially-declared disasters are weather and water-related, and our vulnerability to the impacts is increasing as our population grows. As shown in the chart below, the, the number of these events is trending upward, with 2011's numbers on track to surpass last year's record.



Source: Munich Re NatCat*SERVICE*

Over the past thirty-plus years, the United States has seen a total of 107 weather-related disasters each totaling over $1 billion dollars in damage. Total standardized losses since 1980 exceed $750 billion.

Demographic trends and population growth and an increased reliance on technology, coupled with this trend in extreme weather events, have made our society more vulnerable to high impact events. As a result, many agricultural, business and urban planners are looking for ways to increase community resilience now. For example, the City of Chicago is taking steps to prepare for the likelihood of intense storms striking more often, of rainfall events causing more flooding, and of warmer temperatures. Local climate studies, along with recent trends such as an increase in the frequency of heavy rainfall events, have led them to conclude that this is the soundest action to take in order to mitigate the cost and impact of these events. New York City is also engaged in adaptation planning, with particular focus on the risk of flooding from rising sea level. The Navy's Task Force on Climate Change has advised that the Navy should prepare to police the equivalent of an extra sea as the Arctic ice melts. These cities and organizations, among many others, recognize the need to understand changes and trends

in weather patterns, and to apply this to planning that may reduce vulnerability to high-impact weather and water events. Their recognition for the need to reduce their vulnerability to weather and water extremes is an important first step. However, there is much more that needs to be done in other sectors of our economy and with the general public to increase our resiliency to the impacts of these events.

There is more that can be done, and that communities and businesses are mobilizing to do. This is why NOAA's mission to understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine resources is so vital. Our vision for healthy ecosystems, communities, and economies, that are resilient in the face of change, can lead to improved economic viability of weather-dependent sectors like agriculture and other businesses, as well as more lives saved.

NOAA'S ROLES

Many Federal Agencies have a critical role in preparing for weather and water disasters, including the United States Geological Survey (USGS), the United States Army Corps of Engineers (USACE), and the Federal Emergency Management Agency (FEMA). NOAA works collaboratively with these federal agencies to ensure preparedness and a coordinated approach to preparedness.

Research, Observations and Prediction

NOAA scientists have been at the forefront of weather and climate science, forecasting and public preparedness for decades—our science helps save lives and livelihoods. NOAA has a leading role in understanding changes in weather and climate extremes, such as trends in severe local storms and extremes in precipitation—too little or too much, too often or too infrequent.

Longer lead-time forecasts for droughts, seasonal flooding, heavy rainfall events, heat waves and cold spells provide tremendous economic value for the Nation. NOAA provides a spectrum of critical information across a range of time and space scales, which is used by government, business, emergency managers, planners, and the public. That information's value increased when businesses, farmers, energy producers and utilities, as well as the general public, are prepared and have effective plans of action to mitigate impacts.

Our Nation's environmental predictive capabilities are supported by four foundational pillars: observations, computer models, research, and our people, who provide forecasts, warnings, and decision assistance to key decision makers. By strengthening the pillars – through improved satellite and in-situ observations, computational capacity, and coupled atmosphere, ocean, land models, and necessary research – we can revolutionize the forecast process across the entire spectrum, from relatively small-scale, short range applications to long range weather and climate predictions. For example, on the larger scale, coupled models provide improved simulations of the interaction between the ocean

and atmosphere, resulting in more accurate predictions of tropical cyclone behavior. On smaller scales, higher resolution observations and models can provide the type of short-term severe weather predictions that will one day allow us to "warn on forecast," or know up to 60 minutes ahead of time where a tornado will touch down.

We know that shifts in weather patterns are often regional in nature, and have variable time spans. For example, El Niño and La Niña, which have become household words, are generally predictable over fairly definable areas and time spans. During the 1997-1998 El Niño and 1998-1999 La Niña, the U.S. agricultural sector experienced damages of $2.4-2.8 billion and $3.6-10.7 billion (in 2010 dollars), respectively (Adams, et al. 1999). We are coming to understand many of these larger scale phenomena, such as the North Atlantic Oscillation, which is a change in the water temperature in the North Atlantic that is strongly correlated with heavy snowfall events in the Mid-Atlantic and Northeast states. However, we still do not always fully understand how these pattern shifts relate to or affect one another, and there are likely many other phenomena we have yet to discover. For example, while there are some known correlations between the La Niña phase and tornadic activity across the United States, significant research is required to improve our scientific understanding of links between climate patterns and local weather extremes.

Our tornado warnings have improved significantly over the past two decades primarily because of past research efforts. More research would help us better understand the rapid evolution of severe thunderstorms and why some produce tornadoes and others do not. We face a similar challenge with our understanding of hurricanes. While our track forecasts have improved greatly – our forecast location for 5 days out is now as accurate as the forecast location for 3 days out was 15 years ago – we still do not understand what causes some tropical systems to jump two intensity categories in less than 24 hours, while others do not. Understanding these atmospheric evolutions will help us increase forecast lead time and accuracy for these damaging and deadly storms.

Getting the Word Out

As the federal government's sole official voice for issuing warnings during life-threatening weather events, and as an established reliable and trusted source, NOAA provides the Nation's first line of defense against severe weather. NOAA operates the Nation's geostationary and polar orbiting satellites, a nationwide network of Doppler weather radars and surface observing stations. Scientists develop computational models that combine these observations with equations describing the physics of our atmosphere and ocean, and our forecasters interpret and deliver critical information. Alerts and warnings for severe weather and other near term hazards (tornadoes, hurricanes, severe thunderstorms, winter storms, most floods, chemical spills, volcanic ash, tsunami, space weather, etc.,) are delivered through multiple redundant mechanisms, including: NOAA Weather Radio, which triggers the Emergency Alert System; NWSChat, which focuses on real-time coordination with local core customers in the broadcast media and emergency management; the Internet; and, through our private sector partners,

commercial television and radio, which communicate critical information to much larger audiences and effectively inform those in harm's way to take appropriate action.

Preparedness

Our prospects for success in this role, and of achieving our vision of resilient communities, lie in our unique enterprise capabilities. The goal of disaster resilience is to enhance the capacity of a community exposed to hazards to adapt, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure. The preparedness challenge remains essentially the same across both short-term and long-term weather and water events: public awareness, education, and plans of action to mitigate impacts on the personal, community and regional scales provide the best protection against potential disasters. NOAA has long-held and strongly established ties to the emergency management community, through state, local and tribal officials, which help ensure appropriate action is taken to prepare communities for weather and water events. NOAA and its partners, such as the National Sea Grant network, use integrated research, training, and technical assistance to enhance the ability of communities to prepare for, respond to, and rebuild after disasters strike. For example, we are developing a Coastal Resilience Index that provides a tangible way for communities to identify gaps and examine how prepared they are for storms and storm recovery, and provide guidance on how to increase resilience through measures including strengthening infrastructure or adopting stricter building codes.

The historic floods currently spanning from Montana across the Dakotas, into northern and central plains and southern Mississippi Valley are an excellent example of why we need to prepare for catastrophic events. The NOAA/NWS spring flood outlook highlighted those particular areas as having the likelihood of major flooding. Our River Forecast Centers and local Weather Forecast Offices worked with Federal, state and local emergency managers and planners to help prepare for and plan to mitigate the impact of the flooding. Based on our forecasts, communities took extensive actions to limit the impact of the flooding, including massive levee reinforcements and eventual evacuations to prevent loss of life. FEMA prepositioned relief assets, and the USGS ensured their river gauges were operational – all of the agencies worked together to help mitigate the potential impact.

NOAA often plays a key federal role throughout these events as an integrator of the many federal capacities applied to alert communities and regions to an event and its likely impacts, and to help mitigate those impacts as they're occurring and afterward. For example, due to the large extent of the Midwest floods this year, we are predicting a very extensive "dead zone" in the Gulf of Mexico, due to the excessive fresh water flowing into the Gulf. This will have a significant impact on the lives and livelihoods of those in the Gulf region. NOAA is working to ensure the Gulf region, its communities, and the commercial interests are aware of the impacts and timing of this event, and supporting mitigation efforts.

Unfortunately, in spite of our best efforts, severe weather events still cause loss of life and significant damage. More of this could be mitigated with more timely, accurate and focused warnings. The impacts and lives lost from the disasters mentioned above would have been far worse without critical data input of observations from satellites and in-situ observations, and the extensive work of NOAA and our federal, non-federal, state and local partners to improve the Nation's preparedness for these events through education and outreach. However, as evidenced by the tragic loss of life in a number of these events, there is a long way to go to truly achieve a Weather-Ready Nation.

ACHIEVING A WEATHER-AND WATER-READY NATION

We have made tremendous strides thanks to the modernization of the National Weather Service two decades ago. Because of advances in data assimilation and modeling, and critical sampling of the atmosphere from our polar orbiting satellites and geostationary satellites, model forecasts for three days and beyond have improved substantially. For example, our forecasts for three days away are now as accurate as they were for two days away only 10 years ago. These improvements have allowed for advance lead times between first alert and the actual event.

For example, leading up to the "Snowmageddon" event of February 2010, NOAA was able to detect the storm threat seven-plus days in advance and begin alerting the East Coast up to five days in advance of the storm. This allowed states to implement contingency and continuity of operations plans, airlines to rearrange flights, and the retail industry to pre-stock their shelves. As a result, there was minimal impact to national and local airline and highway transportation. This long lead time was made possible in large part by observations obtained by NOAA's polar-orbiting satellite and numerical weather prediction models. Polar-orbiting satellites are the backbone of *all model* forecasts at three days and beyond; however, the launch of the next generation of NOAA's polar-orbiting satellites, the Joint Polar Satellite System (JPSS), has been delayed by the FY 2011 appropriations process. As a result, NOAA is faced with a nearly 100% chance of a data gap in the U.S. civilian polar orbit, on which both civilian and military users rely, by late 2016 to early 2017 when the current polar satellites reach the end of their life expectancy. JPSS is a critical part of NOAA's future infrastructure needed to continue our path of forecast improvement – and to maintain what we have built over the last 30 years.

NOAA was also able to highlight the likelihood for severe weather in southwest Missouri several days in advance of the May 22 Joplin tornado. Even our lead times for imminent hazards have increased: the tornado warning for the Joplin area was issued 24 minutes before the tornado struck, a substantial improvement over the 5-minute advance warnings that were typical just two decades ago. We have achieved similar forecast improvements for hurricanes. NOAA's hurricane forecast track error has decreased 60 percent since 1990. All these advances have come about through the close coupling of research and operations in NOAA's weather enterprise. All of these advances have helped save lives and reduce the economic impacts of severe weather.

With the high death toll and impacts we've seen this year, we take little solace in knowing that outcomes could have been worse without the extensive work of NOAA and our federal, non-federal, state and local partners. There is much more that needs to be done to improve the Nation's resilience for these events. Research, education, and outreach are the essential ingredients to improving preparedness and via improved forecast and warning accuracy and lead times. Realizing a Weather-Ready Nation, where society is prepared for and responds to weather dependent events, is vital.

Weather-related catastrophes with high economic and social costs are not just acute events like tornado outbreaks or hurricanes, but also longer-term events such as seasonal or prolonged flooding, droughts, wildfire outbreaks and other phenomenon brought on or enhanced by environmental change. These forces of nature can sometimes exact an even higher cost, since they occur over longer periods of time, impact greater areas, and require longer term planning to mitigate. NOAA has significant expertise in this area, and our products, services, information and planning are being used more broadly and sought out more fervently than ever before. One example is NOAA's work with our partners as part of the Devils Lake Task Force. Devils Lake is an enclosed basin in north-central North Dakota with no natural outlet. The water level in the lake has risen over fifty feet in the last fifty years. Flood damages in the Devils Lake Basin have exceeded $300 million and inundated over 138,000 acres since 1993 (Wiche, et al 2010), and increased in volume by six times. The community's concerns continue to grow regarding how much more of their land and homes, their businesses and infrastructure, the lake will consume, and how much more damage it may cause. NOAA is using our weather and climate information – spanning from daily weather forecasts to seasonal outlooks and local and regional climate trends and analysis – to provide decision support services to the local community, as well as resource management and disaster-response partners at FEMA, USGS, USACE, USDA and others. It is this type of science-based support that these decision-makers demand and need as they plan current and future actions to better prepare for both the continued flooding, and the potential impacts of a spill catastrophe should the lake reach critical spill elevation.

As noted earlier, demographic trends and population growth, plus our increased reliance on technology, have made our society more vulnerable to extreme weather. NOAA has started a national dialog with the Nation's top experts in broadcast meteorology, emergency management, and the weather industry to examine what is happening with severe weather and what can be done in the short- and long-term to improve the Nation's severe weather forecasts and warnings, and community preparedness. Included in this effort are social sciences, innovative technologies, and social media to improve our effectiveness in reaching those in harm's way and provoking appropriate response, whether to the urgency of a tornado or tsunami warning, or to the longer-term likelihoods of flooding or drought. For example, most NWS offices have established Facebook pages, providing an additional medium for conducting outreach and education, as well as highlighting information about ongoing or upcoming weather events. Additionally, NOAA uses NWSChat to give private sector partners an invaluable opportunity to interact with NWS experts, and to refine and enrich their communications to the public.

Moreover, more private companies are carrying weather warnings on wireless networks, providing real-time alerts to your cell phone or e-mail.

Sea level rise, the increased number and intensity of heavy rainfall events and strong coastal storms, and other natural and human hazards are putting more people and property at risk, with major implications for human safety, economic vitality, and environmental health, especially in coastal areas. A new study by NOAA indicates that coastal communities along the U.S. East Coast may now be at greater risk of inundation during El Niño years due to higher sea levels, accompanied by more destructive storm surges. To achieve a Weather-Ready Nation, it is essential that residents of communities understand these risks and learn what they can do to reduce their vulnerability and respond quickly and effectively when events occur.

NOAA is working on a number of efforts to increase the resilience of coastal communities. NOAA's multi-mission National Water Level Observation Network provides water level data that supports near term warnings conducted by the NWS for storm surge and tsunamis, and provides long term climatic records for sea level trends. NOAA has worked with many entities to help them incorporate sea level trend guidance into their policy and planning documents. NOAA also maintains the National Spatial Reference System (NSRS), which is the national coordinate system that defines position (latitude, longitude, and elevation), distances and directions between points, strength of gravitational pull, and how these change over time. NSRS is a network of precisely located, permanently marked, in-ground geodetic reference points critical for accurate GPS use, and is critical to determine an accurate depiction of the shoreline. Both systems are needed to accurately model coastal inundation ranging from short term extreme events to long term sea level changes.

A key component of achieving a weather ready Nation is community preparedness. NOAA's StormReady program works at the local level to ensure communities, both inland and coastal, have the warning capabilities and plans in place to help safeguard them against all types of disasters. This effort is complemented by NOAA's Coastal Storms Program (CSP), which is a nationwide effort to reduce loss of life and mitigate impacts of storms on coastal communities and the environment. CSP provides dedicated resources and expertise from across NOAA to deliver capacity-building tools, training, data, and other products and services to enhance hazard resilience in coastal communities in particular. For example, NOAA is working with communities along the Gulf of Mexico to provide a simple, inexpensive method for leaders to perform a self-assessment of their community's resilience to coastal hazards. The results help communities prioritize what needs to be addressed before the next extreme event. Through these various community resilience efforts, NOAA is placing an increased focus on social science to better understand how and why decisions are made at the state and local levels and how NOAA can improve its efforts to communicate risk and uncertainty to the public at large.

Sustaining our commitment to existing services, while continuing to improve our capacity to meet the Nation's weather and water needs, requires targeted investments to

shore up aging infrastructure, improve scientific understanding, and implement enhanced services to reduce risk to the Nation caused by weather and water. Today's services are built upon earlier investments in innovative science and technology as well as our highly-skilled workforce. Our capacity to collect and assimilate increasing amounts of data to improve model performance must increase to realize their potential. This is achieved through making critical improvements to science and technology. Future technology improvements include continued polar and geostationary satellites, more sophisticated radar coverage, observing systems, and improved computing capabilities. These technology assets are crucial pieces of our national infrastructure. The gap in data from NOAA's Joint Polar Satellite System will significantly impact our ability to achieve a Weather Ready Nation, because it will degrade our ability to accurately forecast severe weather events three days and beyond.

Water management decision makers also require a new generation of water information, forecasts and decision support. NOAA is working with its federal partners USGS, USACE and others to implement Integrated Water Resources Science and Services, creating an integrated, high-resolution common operating picture for water information, supporting timely and critical water management decision in full coordination and collaboration with forecasting and decision support services.

We know that NOAA forecasts, warnings, and community-based preparedness programs are vital in enhancing the economy and saving lives. It all starts with a commitment on improved forecasting and ends with a Weather-Ready Nation in which businesses, governments, and people are prepared to use those forecasts to mitigate impacts.

SUMMARY

To achieve an increase in community resilience and reduce the Nation's vulnerability to weather and water related extreme events, we must continue to improve predictions. Again, our Nation's environmental predictive capabilities are supported by four foundational pillars: observations, computer models, research, and our people. By strengthening the pillars – through improved satellite and in-situ observations, computing capacity, coupled atmosphere, ocean, land models, and necessary research and science improvement – we can revolutionize the forecast process across the entire spectrum from relatively small-scale, short range applications to long range weather and climate predictions.

The dual goals of preparing for and mitigating natural hazards require the continuous commitment and partnership of many individuals and sectors – from Federal, state, tribal, and local to public, private, and academic. The investments made by Congress and the Administration in NOAA's weather prediction and warning capabilities *directly* save lives in the United States during these weather disasters. NOAA remains committed to leading U.S. efforts to save lives and property through preparedness, detection, modeling, and forecasting efforts necessary for improved decision making. Although nothing can eliminate the physical threat that severe weather and natural hazards pose, NOAA has demonstrated success in better predicting them, reducing their impact, and helping

vulnerable communities become more resilient to their devastating effects – and will work to continuously improve its natural hazards products and services to the Nation.