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DROUGHT

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED THIRTEENTH CONGRESS

FIRST SESSION

ON

EXPLORING THE EFFECTS OF DROUGHT ON ENERGY AND WATER MANAGEMENT

APRIL 25, 2013

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DROUGHT

THURSDAY, APRIL 25, 2013

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

The committee met, pursuant to notice, at 10:08 a.m. in room SD–366, Dirksen Senate Office Building, Hon. Ron Wyden, chairman, presiding.

OPENING STATEMENT OF HON. RON WYDEN, U.S. SENATOR FROM OREGON

The CHAIRMAN. The committee will come to order. Senator Murkowski is trying to juggle. This is particularly a hectic day, as you know, with activity on the floor and lots of committees. She urged that we start. We'll have her opening statement when she gets here.

My friend from Nevada is going to introduce a witness who is especially important to him after the opening statements, and we'll proceed at this time.

This morning, we're going to look at drought and the impacts to the energy and water sectors. Water is life, and without access to water, the world as we know it ceases to exist, or at least to run effectively.

Last year was the warmest on record and combined with the exceptionally dry conditions, severe drought affected over 60 percent of our country. Again, that was 60 percent of the country. The cost of the damages associated with last year's drought exceeded $35 billion. That is a very substantial hit for our economy to take at a time when we have huge economic challenges ahead.

In addition to last year's drought, the country is seeing increasing numbers of extreme weather events, and, unfortunately, it seems that drought has become almost part of the norm. One reason the committee is focusing on this topic today is to better understand how the recent drought conditions fit into the overall picture of climate change, and if there are lessons to be learned to minimize the impact in the current climate and for the future.

Drought impacts everything from farmers to power plant operations and everything in between. Water is a critical resource, and yet so often it seems to almost be treated as an afterthought.

In my home State of Oregon, Oregonians are seeing severe drought in the Klamath region. The Bureau of Reclamation has told me that the Klamath basin has experienced the second driest January through March on record. This is a dire situation. This area is one of our thorniest watersheds. It has caused the Governor

of my State and Klamath County to issue drought declarations last week.

In effect, this has become a symbol of the debate over how to deal with droughts, and you saw the important Wall Street Journal article that recently ran on drought spotlighting what was going on in the Klamath basin. The Bureau of Reclamation will be a key player in the work to address drought conditions and solve the long-term resource disputes in the Klamath and other such places across the West, and we have always worked with the Bureau in a bipartisan way, and we are going to continue to work with them in that fashion to meet our goals.

Water is also a critical resource for generating electricity. It is obviously needed for generating hydropower, but it's also critical for cooling in many other types of thermoelectric generation, like nuclear, biomass, and coal. For those applications, water must not only be sufficiently available in quantities, but also be cool enough to allow the plants to run safely and efficiently. That means that climate change poses a double threat to some of these facilities, potentially threatening both water availability and sufficiently cool intake water.

Recent history has demonstrated the vulnerability of the power sector to both drought and high temperatures. In 2001, for example, severe drought in California and the Pacific Northwest resulted in significantly reduced hydroelectric generation, causing tight electricity supplies and high prices throughout the West. That drought was estimated to have an economic impact of between $2.5 billion and $6 billion.

High temperatures have also curtailed generation. In 2007, the Tennessee Valley Authority had to temporarily shut down its Brown's Ferry nuclear plant because the intake water temperatures were too high. In 2012, the Millstone nuclear plant that powers half of Connecticut had to take 40 percent of its capacity offline for almost 2 weeks because the cooling water it was getting from Long Island Sound was too warm.

In that same year, the Braidwood nuclear plant in Illinois had to get an exemption to use intake water that was 102 degrees instead of shutting down during a heat wave. The situation in Texas may demonstrate both the concerns and some of the solutions. During the extreme drought conditions of the summer of 2011, Texas made it through with only one power plant curtailing.

They did it because of extraordinary conservation efforts by customers, and they were also helped by having a lot of wind energy on their system that doesn't require any water at all. They also bought power on the spot market, with prices hitting an incredible $3,000 per megawatt hour, so consumers definitely felt the impact in their power bills.

The following summer was also hot and dry in Texas, but caused less disruption thanks to the steps that I have mentioned that their utilities had chosen to adopt. An important goal of this hearing is to understand both the risks to the power sector and the strategies for mitigating those risks.

Senator Murkowski, we're glad that you have navigated traffic and the logistics so you could be with us. Let's have your opening statement, and then Senator Heller will introduce a witness that

is important to him. Also, after Senator Heller has done that introduction, Senator Franken and Senator Manchin have also asked to make opening statements, and, given the importance of this topic, I think we should just waive our rules and we're going to allow that.

Senator MURKOWSKI. Good.

The CHAIRMAN. We'll go in the order of Senator Murkowski, Senator Heller for the introduction, Senator Franken, and Senator Manchin.

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

Senator MURKOWSKI. Mr. Chairman, thank you, and I appreciate the opportunity for us as a committee to focus on water. We talk a lot about energy and energy technologies and all the great things that are going to move us to our new energy future.

But I think at the end of the day, we have to remember that everything begins with water. So how we address our water issues is key, and if we fail to appreciate the nexus between energy and water, that's really to our detriment.

In my Energy 20/20 proposal that I've made available to all of my colleagues, we've got one little chapter on the energy-water nexus. I think that this is critical for us to review, and I appreciate the opportunity to do so.

I think we acknowledge that energy and water resources are the foundation of our Nation's economy. They are essential to our Nation's future and international security. All forms of energy production, energy distribution, fuel extraction, and fuel refinement require water or affect water resources in some way.

Every aspect of extraction, treatment, conveyance, and use of water, as well as the treatment of wastewater, is dependent on sufficient and reliable energy. So it goes both ways. Moreover, energy use by these systems is significant regionally, which is important to understand as we look at the impacts of drought on a regional and local level.

To improve the fundamental relationship between energy use and water use, we need a lot more information, both regarding water and energy. Specifically, what I would like to do—and I outlined some of this in my Energy 20/20—is to identify all existing Federal research authorities and activities that are currently authorized to address the interdependency of energy and water systems but that, perhaps at this time, are not actively doing so.

Also, ensure that DOE and the DOI have the authority to facilitate multi.agency efforts to develop energy and water interdependency R&D, and, further, ensure that the DOE and DOI develop planning tools to avoid multi.use water conflicts and to ensure that energy and water interdependencies are coordinated.

Then, finally, to authorize a coordinated research investment by multiple Federal agencies in the development and implementation of certain energy-water technologies. These technologies should address the interdependency of energy and water systems and multipurpose water and energy system planning.

So, again, Mr. Chairman, I appreciate the focus that the committee is giving this. I thank the government witnesses for appear-

ing before us today. I hope that we can proceed in the near future with legislation to address the issues associated with water management and energy and fuel production. I look forward to hearing from the panel this morning.

The CHAIRMAN. Thank you, Senator Murkowski. Let me just say, having looked at your report a number of times, I think, particularly, your R&D recommendations in this area really hold out a lot of promise for bipartisan cooperation. We're going to work together on that.

Senator Heller is going to do an introduction, and then my colleagues will make opening statements.

Senator HELLER. Mr. Chairman, thank you, and thanks for allowing a topic that I agree with the ranking member to be critically important, water and energy. I can't think of two more important issues facing us.

It's my pleasure to welcome and introduce to you Nevada's Pat Mulroy. I want to note, Mr. Chairman, that I didn't say Pat Mulroy from Nevada. She is Nevada's Pat Mulroy. We're very possessive——

The CHAIRMAN. I got the drift.

Senator HELLER [continuing]. Because of her efforts and hard work. We're grateful for the work she has done over the last couple of decades on behalf of the Southern Nevada Water Authority. Senator Reid and myself both share a very warm friendships, and we both appreciate the relationships we've had over the last couple of decades.

Pat is the General Manager of the Southern Nevada Water Authority and the Las Vegas Valley Water District. Let me assure you she has a stellar reputation that precedes her. For over two decades, Pat has had the incredibly challenging job of managing the water resources in southern Nevada. She has been at the helm during the incredible land boom that ushered in the turn of the last century and shepherded the water authority during these challenging economic times.

The gravity of her job has been compounded by the scarcity of water in southern Nevada. As Pat will explain in her testimony, the over-appropriated and drought-stricken Colorado River is the primary source of water for southern Nevadans.

Pat has implemented innovative water efficiencies and conservation measures, struck agreements with neighboring states to maximize the availability and flexibility of Nevada's share of the Colorado River, and deftly negotiated treaties with Mexico. All the while, the taps have kept flowing in the Las Vegas Valley.

Pat is a leader in her field and well respected by her peers. She is the first woman President of the Association of Metropolitan Water Agencies and serves on the board of directors for the National Water Resources Association and the Water Resource Foundation. I know she'll share with you some of the work she has been involved in and her perspectives, and I want to thank her again for being here today. I look forward to her testimony.

Of course, to all that are here today, thank you very much for taking time, as well as those that are in the audience listening to the testimony.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Heller. We know Ms. Mulroy is important to you and Senator Reid, and we're glad she's here.

Senator Franken.

STATEMENT OF HON. AL FRANKEN, U.S. SENATOR FROM MINNESOTA

Senator FRANKEN. Chairman Wyden, Ranking Member Murkowski, thank you for holding this hearing. I think it's an extremely important topic that affects so many sectors of our economy, and I want to commend you for giving it the attention that it deserves.

As we talk about drought, I think it's important that we talk about climate change, which we know is going to result in our Nation facing more extreme weather conditions. Last year was a remarkable year. The year 2012 was the hottest year on record in the continental United States, beating the previous record by a full degree, which is actually alarming and amazing.

The impacts of the 2012 drought were felt throughout the country. In fact, more than 70 percent of counties in our country were considered disaster areas. We are going to hear today about the effects of drought and water shortages on the energy sector. Last year, we saw serious effects on the ag sector. Secretary Vilsack estimated the impact to be around $50 billion to $60 billion.

Shipping on the Mississippi River was also seriously impacted. In fact, water levels dropped to the point that it seriously interfered with our ability to transport agricultural goods to market. The waters got so low that shippers had to send barges down the Mississippi half full with soybeans, for example, which makes our beans less competitive with Brazilian beans. In Minnesota, we export about a third of our soybean crop, and so this is a serious issue for us.

Then there's the issue of wildfires. We've heard testimony here. When Chief Tidwell testified before the committee last year, I asked him about the link between forest fires and climate change. He told us that we're seeing longer fire seasons on average by more than 30 days.

Wildfires are larger and cover more area and are more intense. Chief Tidwell also told us that scientists at the Forest Service thought that climate change was increasing the size and intensity of wildfires and extending their season.

These are very serious issues, and so I would again like to thank the chairman and the ranking member for holding this hearing. I really do believe that we need to come together, Democrats and Republicans, to hold a serious conversation about climate change and its effects. I think the droughts are clearly one of those effects. This hearing goes a long way to begin that conversation.

Thank you.

The CHAIRMAN. Thank you, Senator Franken. As I've indicated before, nobody on this committee has put in more time on this climate change issue than you and Senator Sanders. So we are really happy to have two consistent champions on this topic.

Senator Manchin, welcome.

STATEMENT OF HON. JOE MANCHIN, III, U.S. SENATOR FROM WEST VIRGINIA

Senator MANCHIN. Thank you, Mr. Chairman, Madam Vice Chairman.

I'm not a scientist, but I do think that climate change is a world phenomenon, not just in the United States. I know we try to beat ourselves up quite a bit that we're totally responsible. But it is a world contributor, if you will.

I'd like to start by acknowledging how lucky that we have been in our country to have a relative abundance of fresh and clean drinking water. It is one of those things that I think all of us can take for granted until it's taken away from us. Some of the good people of my State of West Virginia had that happen to them last summer. We do have an abundance of good water.

But when we were without water for weeks due to the derecho storm—and you would not think about that, and none of us thought about that. But it knocked out all of our power, and we could not have our plants up and running. So people went for weeks without water, and it had a tremendous effect on them. It surely brings issues like the availability of water to the forefront, and it has in my State unlike ever before.

There are two types of water usage that are often discussed. We have water withdrawal, and then we have water consumption. It's important to understand the difference, because a lot of our power plants—and West Virginia has an awful lot of power plants—our energy users withdraw a lot of water, but they don't consume that much.

What I mean by that—people think, "Well, my goodness, if we shut the power plant down, we wouldn't use all this water." We don't consume that much water. We withdraw it, but we only consume about 3 percent of what we withdraw.

Our biggest consumer of water is irrigation for agriculture. Agriculture, historically, has consumed about 81 percent of the water we use every day, somewhere around 3 billion to 4 billion gallons of water a day, and that's 27 times the water consumption of any power plants, 27 times. I just wanted to point that out, to keep it in perspective, because it seems to me that we have to look at all the options which are on the table here. Maybe there are some options in improving the ways we irrigate land.

But saving water is important, and we need to figure out how to do that, and electric power is at the center of that question. We're looking right now at using mine water, recycled mine water, which we think is a very good use of a resource without withdrawing.

We also know that when we save water, we save energy, and when you save water, you save energy because you don't have to pump it, move it, or do all those things. That's another energy-water nexus that I think we have to look into. So I think there's many things that go into all of this, and I just hope that we're broad enough to look at everything.

Thank you.

The CHAIRMAN. Thank you, Senator Manchin. We, in fact, are going to do exactly what you said in conclusion, which is to look at everything. Your subcommittee, in fact, kind of touches almost everything you have for us, and, of course, they are dramatically

affected by droughts. Senator Merkley and I know this so well because of the devastating effects of some of the droughts we saw in eastern Oregon and the implication for fires.

Then, of course, you have industry with jurisdiction over mining. So you have both ends of it, and we're going to work with you.

Senator Sanders.

STATEMENT OF HON. BERNIE SANDERS, U.S. SENATOR FROM VERMONT

Senator SANDERS. Thank you, Mr. Chairman. I want to apologize to our panelists. I'm going to have to run soon. There's a national security meeting.

The CHAIRMAN. I understand.

Senator SANDERS. I just want to concur with what Senator Franken said. Drought is one of the manifestations that we are seeing in terms of climate change. We're seeing flooding. We're seeing extreme weather disturbances. We're seeing heat waves that are taking people's lives all over the world.

I have to say, Mr. Chairman, I think when history looks back at this particular moment, our kids and our grandchildren and our great grandchildren are going to ask us where we were. Why were we not moving aggressively to prevent the problems that exist today and that we know only are going to get worse in the future?

So this is one of those very important issues that has not gotten the attention that it deserves, and I look forward to working with you and Senator Murkowski on addressing it. So I thank you.

The CHAIRMAN. We're sure going to try and change that, Senator Sanders. Thank you for all your leadership.

We're going to go to our witnesses now. You can see the enormous interest here in the panel. We also have the good fortune of having Senator Merkley, who is not a member of the committee, but a member of the Environment and Public Works Committee and has great expertise and experience in this area, also be part of this.

So we're going to look forward to all of the views that are going to be expressed this morning. Let's begin with Michael L. Connor.

Mr. Connor, welcome.

STATEMENT OF MICHAEL L. CONNOR, COMMISSIONER, BUREAU OF RECLAMATION, DEPARTMENT OF THE INTERIOR

Mr. CONNOR. Thank you, Mr. Chairman. Mr. Chairman, members of the committee, I'm Mike Connor, Commissioner of the Bureau of Reclamation. I'm pleased to provide testimony regarding the effects of drought on energy and water management. On a personal level, it's always a pleasure as well as a privilege to appear before this committee and work with my former colleagues on the committee staff. It's also an honor to be here with my esteemed colleagues and experts in the field of water resources.

This spring, as highlighted in NOAA's testimony, much of the West, California, the Rocky Mountains, the Southwest, and the Great Plains remain in a state of moderate to extreme drought. Reclamation's infrastructure anticipates the reality of an arid western climate. It is why Reclamation was created, and it's why our projects were built.

Recognizing that drought can never be eliminated and may become more common in the future, Reclamation now leverages its existing projects alongside new initiatives and enhanced water management that helps guard against and mitigate the devastating effects of drought. My statement today will summarize the activities and the results that we're achieving.

First, in the area of water operations, Reclamation must constantly work with our contractors to adjust operation plans to mitigate the impacts of water shortages. In California's Central Valley, January through March was the driest on record, and April is providing no relief.

We are currently taking a number of actions within the CVP to supplement low contract allocations in certain areas of the project. These actions include rescheduling available storage, acquiring supplies from willing sellers, diversifying supplies to wildlife refuges, and constructing a new intertie between the CVP and the State Water Project, providing tens of thousands of acre-feet of additional water supply to the project.

A second example concerns the Colorado River. Drought has been the norm over much of the past 10 to 12 years. Accordingly, a number of operational agreements have been executed during this time to incentivize conservation and increase the amount of water stored in Lake Mead to avoid or at least delay shortages in the lower Colorado River basin. The most recent operational agreement is Minute 319 to the 1944 Colorado River Treaty, an historic arrangement between the United States and Mexico that was signed last November.

Another example includes the Klamath River basin in Oregon. Once again, serious drought conditions are plaguing this basin in 2013. The low water year pits endangered fish versus endangered fish, as one species needs more water in Upper Klamath Lake, whereas the other species needs sufficient river flows based on releases from that same lake.

The situation also pits the needs of both sets of fish species against the agricultural community in the basin. Reclamation has worked with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to develop a new operational plan this year intended to maintain protections for fish while allowing irrigation operations to proceed during this year.

A second area I want to talk about is WaterSMART. The WaterSMART program provides the foundation for Reclamation's efforts to achieve a sustainable water supply. Completed WaterSMART grant projects along with other conservation activities are saving an estimated 616,000 acre-feet per year, enough water for more than 2.4 million people. Our current goal is to save 790,000 acre-feet per year by the end of 2014.

About $230 million in Federal funding has also been provided for the Title XVI Water Reuse Projects since 2009. Eight projects have finished construction since that time, and 8 others are expected to be completed this year. Project sponsors delivered about 295,000 acre-feet of recycled water in 2012, providing a durable, drought-resistant supply.

WaterSMART also acknowledges the nexus between energy and water use. In addition to saving water over the last 3 years,

WaterSMART projects across the West have conserved 40 million kilowatt hours of electricity annually.

Third, storage opportunities. It's reasonable to ask what role new water storage can play in insulating our country from drought in the short or long-term. Reclamation still studies, constructs, and maintains large surface storage or other water supply projects when authorized by Congress.

As mentioned in my written statement, under the WaterSMART program, there are 17 basin studies complete or underway across Reclamation on major river basins in the West. As part of a comprehensive assessment of water supply and demand, all of these major basin studies will consider potential new storage needs.

Additionally, within the last few years, Reclamation has completed or helped facilitate several new storage projects that added additional water supplies in critical water short basins, Ridges Basin Dam in the Animas River System; Brock Reservoir on the Lower Colorado River, water which regulates flows and conserves water in Lake Mead; and expansion of the Los Vaqueros Reservoir in California's Bay-Delta Region, which is perennially water short.

Fourth, hydropower impacts. Drought impacts hydropower production just as much as it affects water supply. Put in simple terms, reduced storage equates to less energy. Since 2001, reduced water availability West-wide has resulted in 11 percent less average energy production from Reclamation's facilities. In the Colorado River System, it's a 16 percent reduction.

Reclamation has responded to these issues by installing more efficient turbines, initiating an optimization program, and promoting new units on existing facilities. Overall, in the last 4 years, Reclamation has worked collaboratively to increase generating capacity at our facilities by over 110 megawatts through turbine upgrades and new units.

Fifth and finally, Reclamation's legislative authority for drought relief. As stated in our testimony before the committee last week, the Reclamation Emergency Drought Relief Act is an important tool within a comprehensive strategy to prepare for and respond to drought. As the committee is aware, the authority for Titles I and III of the act expired at the end of fiscal year 2012. Our 2014 budget seeks an extension of this authority through 2017.

In conclusion, I would simply note that the problem of drought is best addressed proactively through collaborative planning, flexible operating agreements, and targeted investments that promote more efficient water management and sustainable hydropower production.

Mr. Chairman, I'm ready for questions at the appropriate time.

[The prepared statement of Mr. Connor follows:]

PREPARED STATEMENT OF MICHAEL L. CONNOR, COMMISSIONER, BUREAU OF RECLAMATION, DEPARTMENT OF THE INTERIOR

Chairman Wyden and members of the Committee, I am Mike Connor, Commissioner of the Bureau of Reclamation (Reclamation) at the U.S. Department of the Interior. Thank you for the opportunity to testify before the Committee today regarding the effects of drought on energy and water management.

As most of us observed, 2012 marked an alarming increase of drought conditions in the United States. Under the U.S. Department of Agriculture's disaster designation process, 2,254 counties were declared primary drought disaster areas in cal-

endar year 2012. This month, much of the West remains in a state of moderate to extreme drought conditions, one of the most severe in recent decades. As of April 17, 2013[1], 891 counties were designated as primary drought disaster areas, but the continuous nature of the drought, coupled with the approach of this year's summer season, are obviously of great concern to the affected areas. While storms this month have helped ease conditions in the Rocky Mountains, the Reclamation states still experiencing severe to exceptional drought[2] are Nebraska, Kansas, South Dakota, Texas, New Mexico, Colorado, Wyoming, Arizona, Nevada, Oklahoma and California.

Almost all Reclamation regions experienced low precipitation and runoff during 2012, raising the critical need for precipitation in 2013. Significant impacts were avoided in most regions last year mainly due to carryover storage, but it has become clear that the remaining winter snow pack will provide very little carryover to mitigate conditions in 2013. As of early April, runoff from the Colorado River and its tributaries into Lake Powell was at only 38 percent of average, and the reservoir itself held just 47.4 percent of capacity. Downstream on the Colorado at Lake Mead, Reclamation's other major facility on the Colorado, storage is at 50 percent capacity. Power production is also reduced in the face of reduced reservoir storage.

To be clear from the outset, Reclamation addresses drought as part of its core mission, operating its core infrastructure, as an entity established at the turn of the last century to provide water in the arid West. Reclamation was established as a water management agency, with its statutory framework gradually built upon individual project authorizations and financial partnerships with water users to insulate communities and rural economies against disruption in their water supplies. Dealing with drought conditions was then and continues to be a significant part of Reclamation's mission. Today, many of Reclamation's activities address drought through the use of enhanced water management that helps guard against and to a certain extent mitigate the devastating effects of drought, for example, through conservation. My statement today will summarize those activities and the results we are achieving.

WATER OPERATIONS AND OTHER TOOLS

Reclamation continues to operate its infrastructure within the inherently wide framework of hydrologic variability that defines the western United States year-after-year. Given this dynamic, Reclamation must constantly be prepared to work with our contractors to adjust annual operation plans in an attempt to mitigate the impacts of water shortages. As an example, given the ongoing drought in California, we are currently taking a number of actions associated with the Central Valley Project (CVP) to provide additional supplies to supplement low contractual allocations. These actions include rescheduling available storage, acquiring supplies from willing sellers; diversifying supplies to wildlife refuges that are served by project water; and constructing a new intertie between the CVP with the State Water Project that has provided more flexibility to pump water when it's available, adding tens of thousands of acre-feet of additional water supply to the project on an annual basis.

A second example concerns the Colorado River basin which has suffered through drought conditions for much of the last decade. Reservoir levels have plummeted and there were strong concerns during the early part of 2011, that the lower Colorado River basin would suffer shortages for the first time ever. A number of operational agreements have been executed over the last 10-15 years to incentivize conservation and increase the amount of water stored in Lake Mead—all with the idea of mitigating the impacts of long-term drought. The most recent agreement is Minute 319 to the 1944 Colorado River treaty, a historic arrangement between the United States and Mexico that was signed last November, providing a range of binational benefits including (1) allowing Mexico to make use of storage capacity in Lake Mead at its discretion; and (2) ensuring the availability of additional water supplies to U.S. entities through conservation and efficiency improvements in Mexico.

A final example includes the Klamath River basin in Oregon. According to the State's Governor, drought conditions are plaguing this basin in 2013. The low water year pits endangered fish versus endangered fish as one species needs more water in Upper Klamath Lake, whereas the other species needs sufficient river flows based on release from the Lake. This situation also pits the needs of both sets of fish species against the water supply needs of the agricultural community in the basin. Reclamation has worked with biologists in the U.S. Fish & Wildlife Service

[1] http://www.fsa.usda.gov/FSA/webapp?area=home&subject=diap&topic=landing.
[2] http://droughtmonitor.unl.edu

and the National Marine Fisheries Service to develop a new operational plan this year, intended to maintain protections for the fish while allowing irrigation operations to proceed during this year.

Overall, Reclamation and its customer community continue to experience impacts from ongoing drought and are using as many operational tools as are available to respond. These tools include:

- using excess capacity of project facilities for storage and conveyance of project and non-project water for use both within and outside of project boundaries (consistent with applicable authorities)
- purchase of water (from willing sellers) for ESA purposes and to mitigate losses and damages to communities from drought
- regulating the quantity and timing of reservoir releases (consistent with agreements), and
- educating producers confronted with reduced water supplies on research-based irrigation scheduling and management strategies.

WATERSMART

The wise use of water enables water users to optimize and stretch their finite supplies in every year. The Department's WaterSMART (Sustain and Manage America's Resources for Tomorrow) program provides the foundation for Reclamation's efforts, in partnership with those water users, to achieve a sustainable water supply. It includes efforts of Reclamation and the U.S. Geological Survey (USGS) to improve water conservation and help resource managers make sound decisions about water use. It is a prominent feature in the Department's Fiscal Year 2014 budget request, and functions as the Department's implementation of the SECURE Water Act, Title IX Subtitle F of Public Law 111-11.

Consistent with Secretarial Order 3297, the Department's implementation of WaterSMART includes funding locally cost-shared water management improvements that today are saving significant amounts of water. Completed WaterSMART grant projects, along with other conservation activities, are saving an estimated 616,000 acre-feet per year—enough water for more than 2.4 million people—and our current goal is to save 790,000 acre-feet per year by the end of 2014. Since 2009, about $94 million worth of WaterSMART grants has enabled 158 projects to proceed, leveraging federal funding to implement more than $280 million in water management improvements across the West. About $231 million in federal funding has also been provided for Title XVI Water Reclamation and Reuse Projects since 2009[2]. Eight projects have finished construction since that time, and eight others are expected to be completed in 2013. Project sponsors delivered about 295,000 acre-feet of recycled water in 2012, providing a drought-resistant supply and new flexibility for water managers.

The assessment of water supply challenges and impacts at the local level is the subject of ongoing activities within the WaterSMART Basin Studies Program and West-Wide Climate Risk Assessments (WWCRAs). The WWCRAs will continue Reclamation's development of consistent and comprehensive baseline projections of risks and impacts to Reclamation operations due to the impacts of climate change and other water resource challenges. WaterSMART Basin Studies are complete or underway today on 17 river basins[3], all of them looking 50 years or more into the future. They are funded through a 50-50 Federal/non-Federal cost share and, when completed, each study will identify adaptation strategies that can alleviate imbalances between water supply and demand. All of this is geared toward providing real-world, practical results: preparing our facilities and the customers that help us operate them to continue delivering benefits in the future. Reclamation's customers, including farms, cities, power users, recreationalists, and our ecosystem programs that support the country's fish and wildlife species all rely on the stability provided by the existing water infrastructure in the West. We are looking ahead, through inevitable periods of drought, to maximize the benefits of these projects for decades into the future.

WaterSMART also acknowledges the nexus between energy and water use. In addition to saving water, WaterSMART projects across the West have conserved 40 million kilowatt-hours of electricity annually—enough power for 3,400 households—and additional savings are targeted for the future. Additional milestones are de-

[2] Includes regular annual appropriations and ARRA (PL 111-5).

[3] Los Angeles Basin, Pecos River, Republican River, Sacramento-San Joaquin River, Upper Washita River, Hood River, Klamath River, Lower Rio Grande, Santa Fe Basin, Henry's Fork of the Snake River, Niobrara River, Santa Ana River, Southeast California Region, Truckee River, Colorado River, St. Mary and Milk Rivers, Yakima River.

scribed in the program's three-year progress report, online at http://www.usbr.gov/WaterSMART.

Reclamation is committed to continuing WaterSMART, and it is anticipated that the program will exhaust its authorized appropriations for WaterSMART's water and energy efficiency grants in the next year. Therefore, in order to continue use of this highly valuable program which is significantly contributing to drought resiliency in the West, an increase in the authorization ceiling will be needed. A requested amendment to Section 9504(e) of the Secure Water Act of 2009 (42 USC 10364(e)), raising the ceiling from $200 million to $250 million, is part of the Appropriations language section of Reclamation's FY 2014 budget request.

STORAGE

The ability to use storage and conveyance resources to mitigate future hydrologic variability, changing water demands, constraints on operations, and changes in runoff seasonality are key determinants of whether these natural runoff changes will translate into significant management impacts. It is reasonable to ask what role new water storage can play in insulating our country from drought, in the short or long term. Reclamation still studies, constructs and maintains large surface storage or other supply projects, when authorized by Congress, and in fiscal year 2014, Reclamation has a construction budget of more than $140 million for a variety of projects.

As mentioned above, there are 17 Basin Studies complete or underway across Reclamation on major river basins in the West under the WaterSMART Program, authorized by the SECURE Water Act. All of these major Basin Studies will consider potential new surface storage needs, as directed in the Act at Section 9503(b)(4)(e). Reclamation is also at work studying four major surface storage proposals in California, which if constructed, would be integrated with the existing Central Valley Project. But while important, surface storage in the Reclamation study and construction budgets has been joined by significant obligations for dam safety, and the modernization or repair of infrastructure built generations ago. For many reasons—political, economic, and social—the construction of new surface storage projects is being undertaken on a much more limited basis than in decades past. New societal priorities and advancements in scientific knowledge support increased focus on ecosystem restoration, adverse impact mitigation, efficient management, wastewater reclamation, and conservation as cost-effective ways to maximize existing surface water storage. These priorities have become central parts of the Reclamation vision today, and can provide significant quantities of new water supply in a very cost efficient manner.

There are roughly three dozen Reclamation dam projects, project features or other storage facilities across the West that were authorized by Congress but, for one reason or another, were never funded or constructed. The stories vary, but the most frequent reasons center around economics or an inadequate potential water market associated with the given facilities. In other cases, environmental, safety or geologic challenges came to light during projects' development and rendered their construction, completion or operation infeasible. Political opposition often contributed, leaving the proposals "on the books" awaiting further action, but with external events and new priorities passing them by.

Nonetheless, within the last few years, Reclamation has completed or helped facilitate several new storage projects that added additional water supplies in critical basins. These recent projects include (1) the completion of Ridges Basin Dam as part of the Animas-La Plata project and Colorado Ute Tribes Settlement; (2) Brock Reservoir on the Lower Colorado River, which helps regulate flows and conserve storage in Lake Mead; and (3) Los Vaqueros Reservoir expansion in California's Bay-Delta Region, a perennially water short area. Reclamation will continue to look at storage opportunities, both surface and subsurface, that make technical and financial sense and can help improve overall water management.

COOPERATION

Last year, the Department of the Interior joined the National Integrated Drought Information System Office (NIDIS), the Western Governors Association and several other groups and agencies in hosting the National Drought Forum (NDF) in December 2012. The NDF included a series of plenary and breakout sessions to discuss the extent of the 2012 drought and outline actions that could help with drought response going forward. A draft NDF Report was released in February and highlights have been provided to local entities to provide strong examples of steps that can be taken to prepare for ongoing drought conditions.

The President triggered development of another initiative through his directive to "help the Midwest and states, like Colorado, move faster on projects that help farmers deal with worsening drought." Building on regional meetings held in the summer and fall of 2012 to hear concerns from affected communities, a Central U.S. Drought Mitigation Regional Team (DMRT) was formed in February to facilitate collaboration among Federal agencies (and their respective stakeholders) with ongoing and/or planned programs or projects. This effort will be focused on the States of Colorado, Kansas, Nebraska and Iowa. Reclamation is among the cooperating agencies in this effort which is being led by the U.S. Department of Agriculture (USDA), with participation from the Army Corps of Engineers and the National Oceanic and Atmospheric Administration.

LEGISLATIVE AUTHORITY ON DROUGHT

Reclamation's primary approach to drought is to continue working with our stakeholders on a proactive basis to assess the implications of water shortages, develop flexible operational plans that account for expected periods of drought, and support projects that conserve water and improve the efficiency of water delivery infrastructure. Federal Drought relief is a "last resort" to be employed only in the most extreme of cases. However, given the extreme weather conditions currently facing many parts of the nation, we will continue to consider ideas to make drought relief even more effective through improved interagency cooperation and other changes.

Since 1991, Reclamation has had authority under the Reclamation States Emergency Drought Relief Act of 1991, Public Law 102-250 (Drought Act), to provide drought assistance to states and tribes. However, Titles I and III of that authority expired on September 30, 2012, and have not been reinstated. Under Title I of the Drought Act, Reclamation has provided emergency drought relief assistance most often through the emergency deepening and drilling of new private wells. Reclamation has also provided relief assistance through executing temporary leases and water service contracts, hauling water for domestic use, installing water measurement equipment, furnishing removable pipe for irrigation, issuing loans for acquisition and transportation of water, and providing water on a temporary basis to meet requirements under the ESA. Title II of the Drought Act authorizes Reclamation to provide planning and technical assistance related to drought planning, preparation, and adaptation strategies to all states, tribes and territories. This permanent authority allows Reclamation to assist non-Federal entities to prepare for drought so that they are less vulnerable when drought inevitably happens. However, that assistance is dependent upon funding as authorized under Title III of the Act.

While the Drought Act is in some measure an inherently reactive authority, and not the primary focus of Reclamation's drought-related strategies, it nonetheless is an important tool and for that reason, Reclamation's 2014 Budget seeks an extension of the authority through 2017.

CONCLUSION

The problem of drought is best addressed proactively through collaborative planning, targeted investments and an emphasis on water conservation, all of which we are focusing on through WaterSMART and other initiatives. Droughts and dry weather are not new to the arid West. The water infrastructure constructed by Reclamation and our partners in the West was built to mitigate for that reality. As the region continues to grow and experience changes in climate and the economy, we will continue to evaluate and plan for the impacts of drought. This year, we will continue to seek efficiencies in our infrastructure, continue to operate to that reality, and through programs like WaterSMART, continue to fund proposals by our customers to accomplish water-saving efficiencies of their own.

In the longer term, the Department is working every day to equip our agencies, partners and other resource managers with the data they need to answer the questions they face about water supply and use and to continue delivering water and power in the face of drought and our changing global climate. We value our partnership with Congress to bring the best thinking to the challenge of drought and climate change. These challenges will impact nearly every facet of Reclamation's operations, so as new solutions to these complex problems arise, we will pursue those as well.

Chairman Wyden, thank you for the opportunity to discuss these important topics. I would be pleased to answer questions at the appropriate time.

The CHAIRMAN. Very good. Thank you.

Let's have our next witness, Dr. Roger Pulwarty.

STATEMENT OF ROGER S. PULWARTY, DIRECTOR, NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE

Mr. PULWARTY. Good morning, Chairman Wyden, Ranking Member Murkowski, and members of the committee. My name is Roger Pulwarty. I'm Director of the National Integrated Drought Information System at NOAA. Thank you for inviting me to speak with you today about drought and its impacts.

Drought is part of the American experience from the still vivid events of the 1930s and the 1950s to the present, with 2012 ending as one of the driest years on record with the most extensive conditions since 1934. Impacts crossed a broad spectrum, from energy and agriculture to recreation and wildfires, costing $35 billion in agriculture alone, not counting impacts to recreation and other sectors.

Low river levels threaten commerce on the Mississippi shipping lanes and reduced hydropower generation on the Missouri. Today, drought conditions persist for most of the West. Recent droughts demonstrate how dry conditions and high temperatures can affect the energy sector through its dependence on water resources and provide lessons as we go into the future.

Specific examples of impacts drawn from the NIDIS partners across the country follow. In 2007, during the Southeast drought, power plants from Atlanta to Raleigh cut back water use. North Carolina customers faced blackouts as water shortages forced Duke Energy to cut its output. This severe drought, lasting through 2009, threatened the cooling water supplies of 24 of the Nation's 104 nuclear power reactors, including the well known Browns Ferry nuclear plant.

The severe 2011 drought in Texas and across the South also reduced power plant cooling reservoirs to record low levels with the associated heat concurrently increasing peak electricity demand. The manager of the Aspen Petroleum Pipeline in south Texas placed several requests with NOAA for short and medium-range seasonal temperature updates to help inform his company's decisions about energy production.

Drought impacts can persist over multiple years. In California, over 2001 to 2011, the ratio of hydropower to total generation fluctuated between 12 and 22 percent, a 10 percent variation completely dependent on drought conditions.

The Colorado basin, as was just mentioned, is undergoing the second driest 12-year period on record. The Western Area Power Administration informed us that they have been forced to add a surcharge to customer bills to pay for hydropower losses and to make up for alternative power purchases.

These events also highlight the potential benefits of climate and weather information for managing risks at the water interface. NOAA and its partners are developing weather and climate information to support water and energy sectors in the Southwest, including how seasonal and year-to-year climate affects generation of power and the reliability of water supply.

As a look ahead, we know that the physical drivers of drought in the U.S. are linked to sea surface temperatures in the tropical

Pacific and Atlantic oceans, together with local land conditions and weather. Important features of the 2012 drought included the rapid expansion of dry conditions from 28 percent in the U.S. in May to over 60 percent by July, what we now term a flash drought.

The year 2012 was also the warmest year on record. High temperatures have been shown to exacerbate drought conditions in the past, and in some regions, droughts are expected to be more severe or prolonged with increasing temperatures. During the past 2 months, conditions have improved across some of last year's intense drought areas in the North Central Plains, the Upper Mississippi Valley, and the Southeast.

However, drought persistence, a new development, as well as above normal temperatures are forecast for west and south Texas. Several basins in the West are now below 50 percent of normal with some actually below 25 percent. California and Oregon are experiencing their driest and third driest springs respectively on record, and we are forecasting little or no prospects for improvement after April.

Recent snows in the mid Rockies have brought watersheds above 85 percent on the eastern section of the basin, but with snowpack still only above 60 percent in the San Juan and southern Rockies, including the Rio Grande head waters. Great Lake water levels are forecast to remain well below long-term average, while persistence and development of drought are anticipated for the Hawaiian Islands.

Some improvement is forecast for North Central Alaska, where mountain snowpack was 50 to 75 percent as of the first of March. The national drought outlook for the next 3 months, developed by NIDIS and its interagency and State partners, is provided as an appendix to this testimony.

In December 2012, NIDIS drew on its Federal partners and State collaborators, USDA, Interior, the Corps of Engineers, several Governors associations, to convene a National Drought Forum. The forum highlighted the need to increase public awareness of drought, to increase technical assistance for impacted communities, and also to ensure support for sustained monitoring and data collection critical for effective drought response, such as the NRCS Snowpack Telemetry sites, the USGS Stream Gauge and Water Census.

These activities will build on the Department of Commerce-USDA MOU signed in December 2012. They will also build upon existing successful partnerships, such as the Climate and Water Working Group led by the Bureau of Reclamation with NOAA, the Corps of Engineers, and other partners to bring together water managers and scientists. In addition, the Western Water Federal Support Team, representing 12 Federal agencies, was established in 2008 to support the Western States Water Council and the western Governors in coordinating Federal activities.

To help the Nation's energy resilience to drought, NOAA will work with its partners to improve the regional outlooks for weather and climate conditions and potential impacts on critical sectors, understand which energy sources and plants are in particular drought sensitive locations, and the links between regional climate varia-

bility and hydrologic processes, such as ground water recharge that can help support economic activities over the long term.

Engagement among Federal agencies and non-Federal partners is critical, and NIDIS has played a role in leading those. Information in this testimony is drawn from NIDIS and its many Federal, State, tribal, and private partners, including NOAA centers, such as the Physical Sciences Division, the River Forecast Centers, the National Drought Mitigation Center at the University of Nebraska in Lincoln, the U.S. Corps of Engineers, WaterSMART, the Water Census, the Western Governors Associations, and State climatologists.

Thank you for the opportunity to speak with you today.

[The prepared statement of Mr. Pulwarty follows:]

PREPARED STATEMENT OF ROGER S. PULWARTY, DIRECTOR, NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE

My name is Roger S. Pulwarty and I am the Director of the National Integrated Drought Information System (NIDIS) at the National Oceanic and Atmospheric Administration (NOAA). It is my honor to be here today. Thank you for inviting me to speak about our program, report on the information and data that have been made available to local, State, and regional water decision-makers, and how we can improve the information for anticipating and managing current and future drought conditions.

The NIDIS was established via the National Integrated Drought Information System Act of 2006 (Public Law 109-430, hereafter the NIDIS Act), which builds on longstanding efforts among agencies and institutions that have historically focused on drought risk assessment and response. The NIDIS Act prescribes an interagency approach, led by NOAA, to "Enable the Nation to move from a reactive to a more proactive approach to managing drought risks and impacts." Our goals are to (a) improve public awareness of drought and attendant impacts and (b) improve the coordination and capacity of counties, states and watershed to reduce drought risks proactively.

An important feature of the weather conditions in 2012 was the persistence of the areas of dryness and warm temperatures, the magnitude of the extremes, and the large area they encompassed. Broad sectors were affected and continue to be affected by the 2012 drought. Impacts include, but are not limited to, reduction in crop yields and commerce on major river systems.

In my testimony I will highlight what we know about the following questions and issues:

- How did we get here? Status and antecedent conditions.
- What are the impacts in the energy sector and where are they occurring?
- What information is being provided and by whom? Are information needs being met?
- How bad might it get and how long will it last?
- What can be done to improve the use of drought and other climate information to manage risks and opportunities in the energy sector?

Information for this testimony is drawn from NIDIS and its supporting partners including NOAA's Climate Prediction Center, NOAA's Earth System Research Laboratory's Physical Sciences Division, NOAA's National Climate Data Center, NOAA's River Forecast Centers, NOAA's Regional Integrated Sciences and Assessments, the National Drought Mitigation Center (NDMC) at the University of Nebraska Lincoln, the U.S. Army Corps of Engineers, the Department of the Interior (specifically the U.S. Geological Survey (USGS) and the Bureau of Reclamation), the U.S. Department of Agriculture's (USDA) Office of the Chief Economist and Natural Resources Conservation Services, the National Aeronautics and Space Administration (NASA), the National Interagency Fire Center, the Western Governors' Association, the Western States Water Council, Regional Climate Centers, State Climatologists, and State and Tribal Water Resources Departments, among others.

Drought is part of the American experience. Severe, long-lasting droughts have occurred in the Southwest during the 13th century, and in the central and lower Mississippi Valley in the 14th through 16th centuries. The great Civil War drought

of 1861-1864 led to the first water rights agreement in the West—in the San Luis Valley in the state of Colorado where I live. In the 20th century, droughts in the 1930s (Dust Bowl era) and 1950s were particularly severe and widespread. In 1934, 65 percent of the contiguous United States was affected by severe to extreme drought. These extreme events, including droughts of shorter duration but nevertheless severe, such as in 1977, have been felt throughout economies, ecosystems, and livelihoods, and certainly shaped much of the planning and practice surrounding modern water resources management and related decisions.

Since 2000, the total U.S. land area affected by drought of at least moderate intensity has varied from as little as 7 percent of the contiguous U.S. (August 3, 2010), to 46 percent (September 10, 2002) and over 60 percent of the Nation in the last year (July 3, 2012). Based on weekly estimates of the areal extent of drought conditions since 2000, the average amount of land area across the United States affected by at least moderate-intensity drought annually has been 25 percent.

As mentioned earlier, an important feature of the weather conditions in 2012 was the persistence of the areas of dryness and warm temperatures, the magnitude of the extremes, and the large area they encompassed.

Figure 1 (attached)* shows the progression of drought conditions since 2010 to the present. The year 2012 began with about 32 percent of the contiguous U.S. in moderate to exceptional drought with three areas of moderate to exceptional drought in the Southern Plains and moderate to extreme drought in the Southeast—with areas of moderate to severe drought in the Upper Mississippi Valley and moderate drought in the Far West. As the year progressed, the western drought expanded to link with the Southern Plains drought area and new drought areas developed along the East Coast, pushing the national drought area to 38.2 percent by May 1st.

Drought re-intensified suddenly in May and strengthened through July and August, which inhibited summertime convection/rainfall and some locations experienced exceptionally dry conditions with 30-60 days having no precipitation event. An interagency task force on drought that includes NOAA, NASA, and works with NIDIS, recently released a report on the cause of this re-intensification. One of the causes of this drought re-intensification was the unusual high pressure that reduced the southward push of cold fronts from the North that typically serves to organize rainfall during this time. Only 1934 had more months with more than 60 percent of the contiguous U.S. in moderate to severe drought.

Year	Month and '% Area under Moderate or stronger drought conditions over the U.S.'					
1934	May-73.1	Jun-74.1	Jul-79.9	Aug-77.5	Sep-70.2	Oct-67.7
1939	Dec-62.1					
1954	Jul-60.4	Dec-59.5				
2012	Jul-62.8	Aug-60.0	Nov-60.0	Dec-61.8		

The 10 driest years in the record since 1895, ranked in order of their summer (May-August) rainfall in the Midwest deficits are: 2012, 1934, 1936, 1901, 1976, 1913, 1988, 1953, 1911, and 1931. The deficit in rainfall over the Midwest in 2012 was -34.2 mm, which was about 53 percent of the region's long-term mean rainfall (73.5 mm). This deficit broke the record of -28.4 mm observed in 1934. In May and June (Figure 1, attached), a zonal ridge of high pressure anomalies inhibited the typical southward push of cold fronts from Canada that often serve to organize widespread rains.

Many local records were also set last year. For instance, on June 26, Red Willow, Nebraska set a temperature record of 115 degrees, eclipsing the 114-degree mark set in 1932. Twenty eight states east of the Rockies set temperature records for the six-month period, putting further pressure on agricultural irrigation requirements and direct plant crop stress, on energy demands for cooling and water storage management.

The following summarizes key features of the 2012 drought as experienced across different regions of the U.S. over the year (Figure 1, attached):

- Persistent and anomalous heat resulted in the warmest month ever in July 2012, and 2012 was ranked as the warmest year on record for the contiguous U.S.
- During the May—July growing season, dry weather dominated across the agricultural areas in the Central Plains to the Midwest.
- The anomalous warmth increased evaporation and intensified drought conditions during the growing season.

*Figure has been retained in committee files.

- As the year progressed, the western drought expanded to link with the Southern Plains drought area and new drought areas developed along the East Coast.
- Record heat and near-record dryness occurred in Colorado, contributing to numerous wildfires.
- Several states had record dry seasons: Arkansas (April-June and other seasons), Kansas (May-July), Nebraska (June-August and other seasons), and South Dakota (July-September).
- The prolonged dryness in parts of the Southeast gave Georgia the driest December-November 24-month period (December 2010-November 2012) on record.
- Several river basins have experienced unusually dry conditions during 2012, with the Upper Colorado having one of its driest years in the 1895-2012 period in the record.
- The spatial pattern of drought this year closely overlaid the agricultural area of the U.S. heartland, and the excessive temperatures and lack of rain during the critical growing season severely reduced corn and soybean crop yield.
- The extreme severity of the dryness and evapotranspiration demand over the growing season resulted in a rapid increase in the percent area of this agricultural belt experiencing moderate to extreme drought (as defined by the Palmer Drought Index) and moderate to exceptional drought (for the Midwest and High Plains as defined by the U.S. Drought Monitor (USDM)).

DROUGHT, WATER AND ENERGY: RECENT IMPACTS ACROSS THE NATION

Drought affects energy production in a variety of ways. For example, some regions are dependent on water supplies for hydropower and/or thermal power plant cooling; temperature increases during periods of drought reduce overall thermoelectric power generation efficiencies; and altered conditions can affect facility siting decisions. Recent significant droughts have demonstrated how dry conditions and high temperatures affect the energy sector due to their high dependence on water resources. But these events have also highlighted the potential benefits of reliable climate and weather information for improving energy-water strategies. The need for this type of information is increasing as the awareness of the central role of water for energy production, and industry's expanding understanding of the role of energy in water management, also increases.

In 2000, U.S. electricity production accounted for 41 percent of national freshwater withdrawals, roughly the same as for irrigated agriculture.[1] Much of this water is used for cooling purposes and discharged back to the source water body. Electricity production accounts for 3 percent of all water consumption in the U.S. By 2040, the Energy Information Administration expects U.S. primary electricity demand to grow by roughly 10 percent (to almost 43 percent of total withdrawals)—placing an additional burden on freshwater supplies[2] that in many parts of the country will already be stressed by increasing population pressures, climate change, and other factors.

A Summary of Impacts from the Colorado State Drought Plan Energy Sector Vulnerability Assessment of 2010[3] summarizes some of the possible impacts of drought on energy supply in both the short and long term:

- Decreased power generation due to inadequate water supply for evaporative cooling
- Increased costs for power providers to purchase additional water during drought
- Decreased hydropower generation due to lower water reservoir levels
- Change in power supply mix and operation costs can result in increased price for electricity
- Discharge temperature limits could result in prolonged plant shutdowns
- Severe power cutbacks could result in rolling blackouts
- Environmental impacts could result from shifts in power production depending for instance on changing peak times for hydropower demand
- Increased intake water temperatures can decrease plant efficiency and cooling ability
- Plant shut downs may occur due to water levels dropping below intake elevations

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[1] Averyt, K., J. Macknick, J. Rogers, N. Madden, J. Fisher, J. Meldrum, R. Newmark. 2012. Water use for electricity in the United States: an analysis of reported and calculated water use information for 2008. Environ. Res. Lett. 8 015001 doi: 10.1088/1748-9326/8/1/015001,

[2] EIA 2013 Annual Energy Outlook.

[3] Colorado Water Conservation Board (CWCB). (2010). Colorado Drought Mitigation and Response Plan. Annex B. Energy Sector Vulnerability Assessment pp. B119-158. Retrieved from http://cwcb.state.co.us.

- Increased costs for mining operations to obtain water rights
- Decreased power generation activity due to inability to obtain additional water rights
- The energy sector's ability to obtain more water rights may require transferring water rights from other sectors (e.g. agriculture) to the energy/power sector to meet the increased water demand

To illustrate the breadth and importance of these above potential impacts on the energy sector, a number of specific examples follow (drawn from NIDIS partners in Federal, state and tribal agencies including NOAA's Regional Integrated Sciences and Assessments (RISAs), National Weather Service Field Offices and River Forecast Centers, Regional Climate Centers, U.S. Army Corps of Engineers, USGS, and the Bureau of Reclamation, all of which contribute directly to the NIDIS early warning systems)[4]:

- The 2007-2009 severe drought in the Southeast threatened the cooling water supplies of more than 24 of the nation's 104 nuclear power reactors.
- When drought affected the Southeast US in 2007, power plants from Atlanta, GA to Raleigh, NC cut back their water use, resulting in North Carolina customers facing blackouts as water problems forced Duke Energy to cut output at its G.G. Allen and Riverbend coal plants on the Catawba River. In addition, Duke Energy was working hard to keep the water intake system for its McGuire nuclear plant underwater as water levels dropped.
- Also in the 2007 Southeast US drought, the Browns Ferry, AL nuclear plant had to drastically reduce its output to avoid exceeding the temperature limit on discharge water to the Tennessee River.
- A severe drought in Texas in 2011 affected many power plants' cooling water reservoirs, while associated heat increased peak electricity (air conditioning) demands:

  —11,000 megawatts (MW) of Texas power plants had cooling water reservoirs at record low levels and 3,000 MW of plants were considered "at risk" (of shutting down) if drought conditions persisted.

- In the end of 2011, the Barnett Shoals Dam, near Athens, GA had not been operating at capacity due to the combined low level of the Oconee River and increased levels of sedimentation.

  —According to one of the dam's owners, "We do not have an adequate source of water to operate at anywhere close to capacity, but we are very cognizant of the water levels. In fact, we do minimize the amount of water passing through our turbines." Neighbors downstream of the dam expressed some frustration at the fluctuation in the already low river level when the turbines ran.

  —However, as of April 2013, the U.S. Army Corps of Engineers has ended drought operations in this river basin (the Apalachicola-Chattahoochee-Flint River Basin) due to recent above-normal rainfall. Reservoir storage across the Basin is now at capacity.

- Hydropower generation is an important source of low-cost, clean electricity in California. Hydro units also provide electricity during peak demand periods. During the period. From 2001 to 2011, the contribution of hydropower to the total generation in California varied from 12 to 22 percent depending on drought conditions and other demands. A difference of 10 percent, driven by the availability of water, is a huge amount representing a substantial cost to California. For California, the 2009 winter season snow pack water content was 39 percent below normal impacting the state's ability to generate hydropower, with a 62 percent reduction in hydropower generation at Lake Oroville from October 1, 2008 to January 31, 2009. (Present conditions are discussed further below.)
- In late 2012, according to the U.S. Army Corps of Engineers, six hydropower plants on the Missouri River produced approximately 127 kWh less than average December production. Drought conditions resulted in diminished flow in the Missouri River, yielding less hydropower production. Power generation is ex-

[4] Synthesis of drought impacts reported in the Energy Sector. Reports based on NOAA-funded activities across the Regional Sciences and Assessments Program, Regional Climate Centers, NIDIS Early Warning System partners including the University of Nebraska National Drought Mitigation Center. California Drought Plan 2010, A Synthesis Report in preparation: J. Macknick, S. Satter, K. Averyt, S. Clemmer, J. Rogers, 2012: The water implications of generating electricity: water use across the United States based on different electricity pathways through 2050. Environ. Res. Lett. 7 045803 doi:10.1088/1748-9326/7/4/045803

pected to be 8 billion kWh in 2013, compared to average production of 10 billion kWh in previous years.

- Ethanol production in Iowa declined, through voluntarily adopted restrictions by ~ 20 percent since the beginning of 2012 as high corn prices, combined with reduced corn production from drought and heat, raised concerns over the amount of corn used in ethanol production.
- At some hydropower facilities, drought conditions may lead utility or power managers to purchase more expensive and/or carbon-intensive power from alternate sources. For example, the Western Area Power Administration (WAPA) saw declining hydroelectric generation starting in 1999, as reservoirs declined due to drought. In response to these conditions, WAPA had to purchase power (typically from thermoelectric power plants in the region) in order to meet energy contract obligations. The WAPA has been forced to add a surcharge to customers' bills to pay for losses incurred during the past decade of drought when hydropower generation was down and alternative power was purchased at a higher cost. The surcharge is intended to end by September 2017, when it is hoped that the agency will have recouped its losses, unless low flow conditions persist.
- Drought conditions may also cause extraordinary demand for electricity, which can lead to adverse effects to communities as power generation fails to meet demand. In July 2012, the Nebraska Public Power District (NPPD) had to turn to temporary electrical outages in north central Nebraska to deal with the extraordinary demand for electricity on the night of July 18-19. A spokesman for the NPPD stated that demand had exceeded previous daily records for peak utility use on 19 of the previous 22 days, due to heat and drought.

In addition to these specific and direct adverse impacts to the energy/power sector, drought can also lead to other negative impacts, including environmental effects, disruptions to navigation and shipping (that also affects transportation of coal and other fuel), facility siting decisions, impacts to farmers due to necessary transfer of water rights to the energy sector, and impacts to the outdoor recreation economy. A few specific examples include[5]:

In August 2012, the Illinois Environmental Protection Agency was allowing four coal-fired, and four nuclear, power plants to release hundreds of millions of gallons of hot water near 100 degrees Fahrenheit into state lakes and rivers, according to the Chicago Tribune. At the same time, a number of fish kills were reported in the area. None of the fish kills in the state that year, however, were linked directly to the hot water from the power plants.

- In the Mississippi river region, drought affected the area throughout the year and by November 2012, river water levels were severely diminished. This had impacts to power production along the river and its tributaries, as well as impacts to navigation and shipping.
- The manager of Aspen Pipeline placed several requests with NOAA for short- and medium-range (i.e., seasonal) temperature outlook information to help inform his company's decisions about energy production in south Texas.
- As one final example, Duke Energy operates many different types of power plants (nuclear, coal-fired, oil/gas-fired, pumped-storage hydro) in the Carolinas—all of which are dependent on water resources for some part of their operations. Drought affects how Duke Energy—and other companies like them—balance individual plant requirements, energy demand, and water availability within their entire system.
- Colorado Rafting declined 17 percent in 2012, the lowest since 2002

Energy companies are forced to use a variety of sources of information for their operations and planning, including in-house resources, private consultants, external drought management advisory group, and many of NOAA's existing products and services. In some instances, however, these existing forecasts and other products might not be accurate enough to be used to make specific operational and management decisions. This is one area where improvements (i.e., seasonal drought forecasts) would be valuable. In summary, many sectors face drought impacts across a

[5] Synthesis of drought impacts reported in the Energy Sector. Reports based on NOAA-funded activities across the Regional Sciences and Assessments Program, Regional Climate Centers, NIDIS Early Warning System partners including the University of Nebraska National Drought Mitigation Center. California Drought Plan 2010, A Synthesis Report in preparation: J. Macknick, S. Satter, K. Averyt, S. Clemmer, J. Rogers, 2012: The water implications of generating electricity: water use across the United States based on different electricity pathways through 2050. Environ. Res. Lett. 7 045803 doi:10.1088/1748-9326/7/4/045803

broad range, as described here, and they require reliable information to balance their operations and meet requirements.

Attached to this testimony is the interagency regional drought outlook from April 12, 2013, developed by NOAA/NIDIS in partnership with its partners in Federal, State, and tribal agencies.*

Some improvement is expected across the northeast quarter of Texas with forecasts indicating a wet pattern during early-to-mid April across this region. Persistence and development are forecast for west and south Texas where the CPC seasonal outlook favors below median precipitation and above normal temperatures.

Some improvement forecast for the northern and central Plains is based largely on the annual cycle of precipitation and the absence of a dry signal in the CPC monthly/seasonal precipitation outlooks. Forty to fifty percent of the annual precipitation occurs during April, May, and June (AMJ) across much of the northern and central Plains. However, this designation of improvement does not imply elimination of drought, just a possible easing of conditions. Adequate precipitation during May and June and a lack of early summer heat waves are critical for any improvement to occur.

According to the National Operational Hydrologic Remote Sensing Center on April 2, snow-water equivalent values range from 2 to 5 inches across the upper Mississippi Valley. It is unclear how much of the spring runoff can recharge the dry subsoils. AMJ is a relatively wet time of year for the upper Mississippi Valley. The 6-10/8-14 Day outlooks from April 3 favor above median precipitation in this region. Due to these factors, improvement is expected across the upper Mississippi Valley. Prospects for improvement are highest across southeast Minnesota and Wisconsin where drought levels are less intense and the seasonal outlook favors above median precipitation.

Persistence is expected for much of Colorado, New Mexico, Utah, Nevada, and Arizona due to low snow-water equivalent values (around 75 percent of normal) and below average streamflows forecast for the spring and early summer. Enhanced odds for below median precipitation and above normal temperatures during AMJ also favor persistence. Recent wetness, expected short-term precipitation, and the lack of a dry signal during AMJ lead to a forecast of some improvement across northeast Colorado. Recent snows last week has brought snowpack up to around 85 percent but with the Southwest Basins of the San Juan at around 60 percent of normal. Forecast confidence for Colorado, New Mexico, Utah, Nevada, and Arizona is high.

Similar to the interior Southwest, snow-water equivalent values are also below average across California and southern Oregon. Following a wet start to the winter, unseasonably dry conditions affected these areas during the past three months. According to the USDM on April 4, abnormal dryness (DO) covers northern California and parts of southern/eastern Oregon. Below median precipitation is favored during AMJ across these same areas. Therefore, persistence and development is forecast for this region. Precipitation typically decreases rapidly later in the spring with little to no prospects for improvement after April. Forecast confidence for California and southern Oregon is high.

Snow-water equivalent values are running slightly below average across the northern Rockies. Since tools on most time scales offer weak precipitation signals, persistence is forecast for the northern Rockies and adjacent Plains. However, forecast confidence is low since AMJ is relatively a wet time of year across most of Montana and Wyoming. Forecast confidence for the northern Rockies is low.

Recent above-normal snow (April, 2013) in the mid-Rockies has brought watersheds up to 85 percent but with snowpack still hovering above 60 percent in the San Juan and southern Rockies, including the Rio Grande headwaters.

Mountain snowpack was 50 to 75 percent of normal on March 1, 2013 across the drought area in north-central Alaska which is a slight increase from one month ago. Some improvement is forecast for this region.

Moderate to extreme drought covers western sections of the individual Hawaiian Islands from Oahu southeastward through the Big Island. Persistence is forecast for these leeward areas since odds for improvement decrease significantly during May and June. Individual basins in California, Oregon, Nevada, Arizona and New Mexico are at 25-49 percent of normal, with some in the Southwest at below 25 percent of normal. Only some basins in Washington have snow- water equivalent (SWE) in excess of 110 percent at this time. In sum, drought will persist or intensify in much of the western U.S. Improvement is anticipated in the center of the U.S. and in areas of the southeast, including much of Florida. In April and May significant fire potential will exist over most of Florida as lingering drought keeps fuels dry. Most

*Document has been retained in committee files.

of the rest of the eastern U.S. will have below-normal significant fire potential as active storm patterns keep conditions wet and cool. Cool and wet conditions will keep southern Alaska significant fire potential below normal. In June and July the wildland fire potential shifts from the red and gray hatched areas to the western U.S. Significant fire potential will be above -normal in the mountains and foothills of southern California. Significant fire potential will increase to above normal over northern California and the Northwest. Significant fire potential will decrease to normal in Florida, Minnesota, Iowa, New Mexico and Arizona. Water levels are recovering to some extent on the Mississippi River due to recent rain, and now easing transportation problems along the river. Great Lakes water levels are forecast to remain well below long-term averages.

WORKING TOGETHER TO INCREASE THE NATION'S RESILIENCE TO DROUGHT

The number of watershed, State, and local drought and water plans using NOAA-based information has significantly increased since NIDIS was initiated in 2007. Part of the support that NIDIS has generated and the ability of the program to meet the needs of the Nation are a result of the strong partnerships that the program has with other agencies, outreach organizations, and an enabling set of programs and observational capabilities.

Together with the U. S. Army Corps of Engineers, NOAA, and the USGS, the Bureau of Reclamation has formed the Climate Change and Water Working Group (C-CAWWG) to bring the water managers and climate scientists together to create efficient research and development (R&D) collaborations and information sharing across the federal agencies toward understanding and addressing climate change impacts on Western water supplies and water use.

In addition to joint reports, the Bureau of Reclamation, the U.S. Army Corps of Engineers, NOAA and the USGS, as part of C-CAWWG coordination, are developing detailed descriptions of information and tools that water managers need from the science agencies and other researchers. Furthermore, the Interagency group WESTFasT (with representatives from 12 Federal agencies) was established in 2008 to support the Western States Water Council (WSWC) and the Western Governors Association in coordinating Federal efforts regarding water resources.

Perspectives from both State and local water managers have been sought and the Bureau of Reclamation is providing input to NOAA as it plans for the next generation of Global Circulation Models (GCMs) to define the types of outputs that will be of most value to water managers. NOAA and the Bureau of Reclamation are participating in the Postdocs Applying Climate Expertise (PACE) Fellowship program to sponsor research activities focused on water management needs.

In December 2012 NIDIS and its partners convened a National Drought Forum (hereafter, "the Forum") hosted at the National Governors Association Hall of States here in Washington D.C. The Forum was co-chaired by Dr. Robert Detrick, the NOAA Assistant Administrator for Oceanic and Atmospheric Research and Dr. Donald Wilhite, founder of the NDMC. The Forum featured keynote addresses from Secretary Vilsack (USDA), Gov. Brownback of Kansas and the NOAA Deputy Administrator Dr. Kathryn Sullivan (currently NOAA Acting Administrator). The Forum was co-sponsored by the National, Mid-Western, Southern and Western Governors' Associations, the U.S. Army Corps of Engineers, and the Department of the Interior and saw significant participation at high levels by these agencies and by regional and local agriculture, health, and water managers. The goals of the Forum were: "To understand the extent of 2012 drought impacts and response in 2012, and help provide new information and coordination for improving the nation's drought readiness for 2013 and in the future."

Among other issues, discussions at the National Forum highlighted the need to:

- Increase public awareness of last year's drought and potential impacts for this year;
- Increase technical assistance for the communication and use of drought-related information in impacted communities including efforts through the NIDIS regional early warning systems in partnership with NDMC; and
- Ensure sustained support for monitoring programs and equipment critical to understand and respond to drought, e.g. the National Resources Conservation Service SNOwpack TELemetry (SNOTEL) sites; and the Water Census led by the USGS.

NOAA will be happy to provide a copy of the Forum Report to this Committee when it is final. Through the Economic Development Administration and NIDIS, the Department of Commerce (DOC) is working closely with USDA and other agencies within the National Disaster Recovery Framework for Drought, with a strong focus

on the recovery needs and sustainability of rural communities. Critical preliminary efforts will be built on the DOC-USDA Memorandum of Understanding (MOU) announced at the Forum and signed by the Secretary of Agriculture and the Acting Secretary of Commerce in December 2012. This MOU is aimed at improving cross-agency collaboration on drought risk reduction. The agreement is intended to (1) strengthen Commerce's and USDA's development and delivery of relevant local and regional drought information services to agricultural, forestry, rural economies, and related sectors; and (2) foster improved understanding by end-users in these sectors of the value and use of weather and climatological information and its integration with social and economic information, in planning and operational activities for farming and forestry communities.

For some regions actions in preparation for the upcoming season are being undertaken. In the Midwest, land dedicated to sorghum—which tolerates drought better than other grains—will rise by 22 percent, or 566,000 hectares (1.4 million acres) over last year. It is both the largest absolute and largest relative increase of any crop for the 2013 season. The USDA expects farmers to plant a total of 3.1 million hectares (7.6 million acres) of sorghum, which is the most since 2008. Sorghum acreage has climbed 40 percent in the last two years.[6]

NOAA-supported projects are examining potential climate change and variability adaptation strategies in the water and energy sectors in the Southwest, including how climate influences the market price of water. Researchers are developing tools, as well as guidelines for using these tools, to enhance water supply forecast reliability and management. Researchers are developing improved methods for predicting and adapting to climate impacts for the generation of electricity. Partners include NOAA/University of Colorado Western Water Assessment, U.S. Bureau of Reclamation, USDA, Arizona Dept. of Water Resources, Central Arizona Project, Salt River Project, Arizona Electric Power Cooperative, Arizona Public Service Corporation, Tucson Electric Power, Nature Conservancy-Western Regional Office, Environmental Defense, and the Sonoran Institute. NOAA is also working with California Energy Commission on climate forecasts and change for energy applications.

The following actions could be taken to improve the Nation's energy resilience to drought:

- Greater understanding of which energy plants and sources are susceptible to water shortages in particular drought-sensitive locations. For instance, the impact of increased biofuel production on water resources will depend on where the feedstock is grown and whether or not irrigation is required. Collaborative activities among NOAA and other agencies could include evaluating the likelihood and consequences of the shortages, and options that are available to prevent/mitigate the consequences in the short to long term.
- Improved understanding of links between climate and hydrological processes, including aquifer recharge rates and groundwater movement. In the absence of such data and research, developing and implementing effective policies could continue to be a challenge for Congress and federal agencies.
- Improved coordination among federal agencies and other stakeholders especially regarding the quality and use of climate and weather information at the energy-water interface. Some agencies, including NOAA, have taken steps to improve coordination.

To achieve a more comprehensive vision of a truly "national integrated drought information system" requires improvements that NIDIS has already begun to address. These include:

- Improving the understanding and predictability of droughts across a variety of timescales for seasonal, to interannual and decadal time scales including the role of precipitation events in reducing drought duration and intensity;
- Improving collaboration among scientists and managers to enhance the public awareness and effectiveness of observation networks, monitoring, prediction, information delivery, and applied research;
- Improving the national and regional drought information framework by transferring successful approaches (information development, products, capacity, and coordination) to areas covered by the drought portal, but not yet having active early warning systems;
- Improving coordination between institutions that provide different types of drought early warning;

[6] USDA, 2013: Prospective Plantings Report. National Agricultural Statistics Service (NASS), Agricultural Statistics Board, United States Department of Agriculture (USDA) www.usda.gov/nass/PUBS/TODAYRPT/pspl0313.pdf

- Developing impact indicators to form part of a comprehensive early warning system; and
- Working with the private sector and others on guidance and standards for developing value-added products to support drought preparedness plans.

Thank you for the opportunity to be with you today.

The CHAIRMAN. Thank you very much, Doctor.

Welcome, Ms. Mulroy. Welcome again, since Dean Heller has given you the first one.

STATEMENT OF PATRICIA MULROY, GENERAL MANAGER, SOUTHERN NEVADA WATER AUTHORITY, LAS VEGAS, NV

Ms. MULROY. Thank you, Senator. Chairman Wyden, Senator Murkowski, members of the committee, I appreciate this opportunity to testify on this very important topic. I'd like to take this opportunity to thank Senator Heller for his kind welcome and assure him that we in Nevada know how fortunate we are that he is representing our interests back here in Washington, DC.

My name is Patricia Mulroy, and I am the General Manager of the Southern Nevada Water Authority, lead negotiator for the State of Nevada in all interstate and international matters on the Colorado River. I'm here today on behalf of the water utilities throughout the United States, since I'm currently president of the Association of Metropolitan Water Agencies and a trustee of the Water Research Foundation.

Around the world, water utilities are finding themselves on the frontline of extreme weather events. The effects of a severe and prolonged drought have been particularly apparent in the desert Southwest, especially in southern Nevada. In 2002, after only 2 years of the now 1-year drought, we went from having a reliable 50-year water plan to facing the reality of immediate, severe, and debilitating shortages.

My experience reflects the challenges facing the American Southwest, where the flows of the Colorado River support more than 30 million people and irrigate about 15 percent of the Nation's crops. Since 2000, the 7 states that share the Colorado have witnessed cumulative flows drop 13 trillion gallons below average. The latest 2-month projection for the next year forewarns possibly the lowest releases into Lake Mead since the filling of Lake Powell.

The most critical consequence of such prolonged droughts is developing a quick and lasting adaptation strategy. The obvious first reaction is to reduce consumer consumption. In the new environment in which we find ourselves, however, this plan has to reflect a permanent change in water use habits, not a short-term drought response.

My agency adopted one of the Nation's most aggressive water conservation programs, having paid our customers to date nearly $200 million to remove grass and replace it with desert vegetation. This has resulted in reducing our annual water use by approximately 29 billion gallons, even as our population swelled by 400,000 inhabitants. Today, the residents of southern Nevada can proudly claim a net water use of 75 gallons per person per day, and that in the driest city of the United States.

Next, we immediately began to build a new intake deeper into Lake Mead at a cost of almost $1 billion, paid for entirely by our

customers. Finally, we are developing a water supply that is hydrologically independent of the Colorado River.

As a river community sharing a resource with 6 neighbors in the United States and the country of Mexico, the impacts are being felt by all of us. For all of us, the need to cooperate has never been greater. Therefore, the importance of the Interim Shortage Agreement, signed by the States in 2007, and Minute 319 that Mike referenced, signed with Mexico last November, cannot be ignored.

Seven states and one foreign country have agreed to set aside their differences and cooperatively work to protect all the users of this river and the environment as well. Further, regional wholesalers in the lower basin, meaning Metropolitan in Southern California, Central Arizona Water Conservation District, and ourselves, are banking water together and funding projects to extend the resources of this fragile river. Today, Lake Mead is 10 feet higher than it would normally be because of the efforts of these 3 agencies and Mexico.

Even the most thoughtful and prudent strategies won't work if they cannot be implemented. Adapting to challenges ranging from severe drought to heavy precipitation or rising sea levels requires investment in water infrastructure. As stated earlier, just our one intake project cost nearly $1 billion, and that's one project in one community. Considering all of the water agencies that will likely be affected by extreme weather events, the financial implications are staggering.

We know that local ratepayers in all of our communities will face significant rate increases even if all the various Federal infrastructure proposals are enacted. That burden becomes that much more onerous if municipal bonds lose their tax-exempt status. We urge you to resist any attempt to remove this exemption.

I cannot come before you today without addressing the critical need for research, focused, applied research. The development of adaptation strategies requires actionable research that explores the full range of impacts on water utilities, both in the water supply and water quality realms. To that end, we recommend the Federal Government partner with the Water Research Foundation to optimize the value of research investments.

Americans have a remarkable ability to overcome adversity. Southern Nevada and the larger community have proven that with courage, resilience, and tenacity. We in the water industry respectfully ask that you support our efforts to adapt to and surmount the challenges we are facing due to dramatically shifting climate conditions.

Thank you.

[The prepared statement of Ms. Mulroy follows:]

PREPARED STATEMENT OF PATRICIA MULROY, GENERAL MANAGER, SOUTHERN NEVADA WATER AUTHORITY, LAS VEGAS, NV

INTRODUCTION

Chairman Wyden, Senator Murkowski and members of the committee, I appreciate the opportunity to testify on this important topic. My name is Patricia Mulroy, and I am the General Manager of the Southern Nevada Water Authority, a regional agency that manages water resources for 2 million residents and nearly 40 million annual visitors. In addition to my role with the Water Authority, I serve as the lead negotiator for the State of Nevada in all interstate and international matters on the

Colorado River. I am here today on behalf of water utilities throughout the United States. I am currently the President of the Association of Metropolitan Water Agencies and a Trustee of the Water Research Foundation, as well as being an active member of the American Water Works Association and a founding member of the Water Utility Climate Alliance.

Around the world water utilities are finding themselves on the front line of extreme weather and climate events. Ours is not an abstract discussion of future impacts. Nowhere have the effects of a severe and prolonged drought been more apparent than in the desert southwest, particularly in Southern Nevada. Due to the arid nature of the Mojave Desert and our virtually exclusive reliance on the Colorado River, we yearly adopt a 50-year resource plan. In 2002, after only 2 years of this now-13-year drought, we went from having a reliable 50-year plan to facing a reality of immediate severe and debilitating shortages.

My experience reflects the challenges facing the American Southwest where the flows of the Colorado River support more than 30 million people and irrigate 15 percent of the nation's crops. Since 2000, the seven states that share the Colorado have witnessed cumulative flows drop 13 trillion gallons below average. The latest 24-month projection for the next year forewarns possibly the lowest releases into Lake Mead since the filling of Lake Powell. Other regions are also seeing effects of drought, particularly the farming communities along the Mississippi and Missouri System.

ADAPTATION

The most critical consequence of such prolonged droughts is developing a quick and lasting adaptation strategy. The obvious first reaction is to reduce customer consumption. In the new environment in which we find ourselves, however, this plan has to reflect a permanent change in water use habits, not a short-term drought response. My agency adopted one of the nation's most aggressive water conservation programs, having paid our customers nearly $200 million to remove grass and replace it with desert vegetation. This has resulted in reducing our annual water use by approximately 29 billion gallons even as our population swelled by 400,000 inhabitants. Today the residents of Southern Nevada can proudly claim a net water use of 75 gpcd in the driest city in America. Next, we immediately began to build a new intake deeper within Lake Mead at a cost of almost $1 billion, paid for entirely by our customers. Finally, not knowing how long or how severe this drought will be, we are developing a water supply that is hydrologically independent of the Colorado River.

As a river community sharing a resource with six neighbors in the United States and the country of Mexico, the impacts are being felt by all of us. In California, officials are not only grappling with these worsening Colorado River conditions, but a drought in the Sierra Nevada watershed and restricted use of in-state supplies. For all of us, the need to cooperate has never been greater. Therefore, the importance of the Interim Shortage Agreement, signed by the States in 2007, and Minute 319, signed with Mexico last November, cannot be ignored. Seven States and one foreign country have agreed to set aside their differences and cooperatively work to protect all the users of this river and the environment as well. Further, the Metropolitan Water District of Southern California, the Central Arizona Water Conservation District, and the SNWA are banking water together and funding projects to extend the resources of this fragile river. Today Lake Mead is ten feet higher than it would normally be because of the efforts of these three agencies and Mexico.

FINANCING WATER INFRASTRUCTURE

Even the most thoughtful and prudent strategies won't work if they cannot be implemented. Adapting to challenges ranging from severe drought to heavy precipitation or rising sea levels requires investment in water infrastructure. As stated earlier, our new Lake Mead intake, which will cost nearly $1 billion, is only one project in one community. Considering all of the water agencies that will likely be affected by extreme weather events, the financial implications are staggering.

Senator Merkley's "Water Infrastructure Finance and Innovation Act," which is based on the Transportation Infrastructure Finance and Innovation Act, is an avenue for financing water infrastructure that would provide municipal water agencies the necessary capital to enact adaptation strategies. This legislation would create a $500 million federal loan guarantee program to provide low-interest loans, loan guarantees, or other credit for larger projects that would be funded by the U.S. Treasury.

To be clear, I feel strongly that water agencies should be financially self-sufficient. These funds would be subject to repayment by municipal water agencies, which his-

torically are among the country's most secure borrowers. I urge the Senate to pass S. 335, which was also included as part of the Water Resources Development Act of 2013 (S. 601) that just passed the Senate Environment and Public Works Committee in March.

Similar legislation has also been introduced in the House by Congresswoman Lois Capps—the Water Infrastructure Resiliency and Sustainability Act of 2013 (H.R. 765). The principles encompassed in this legislation represent pragmatic solutions to a complex problem. The legislation would authorize a new Environmental Protection Agency program that prioritizes funding for those utilities facing immediate and significant negative impacts from extreme changes in hydrology. Also, it offers competitive matching funds to water, wastewater, and stormwater agencies for water conservation and efficiency projects, water quality improvement, and rebuilding or relocation of threatened infrastructure.

Having highlighted several pieces of legislation that would be helpful, I find I must point to measures being considered that will make funding critical projects even more difficult. We know that ratepayers in all of our communities will face significant rate increases even if the identified legislation passes. That burden becomes that much more onerous if municipal bonds lose their tax-exempt status. The impact on residents and small businesses will be staggering and cannot help but negatively impact job growth in this country. We urge you to resist any attempt to remove this exemption.

RESEARCH

I cannot come before you today without addressing the critical need for research—focused, applied research. The development of adaptation strategies requires actionable research that explores the full range of impacts to water utilities, both in the water supply and water quality realms. To that end, we recommend the federal government partner with the Water Research Foundation to optimize the value of research investments. For the past two years, Congress has funded an extramural research competitive grant program though the EPA, which is focused on applied drinking water and wastewater research. I ask that the Senate continue to fund the grant in FY 2014. This applied research will help provide information that water managers need to make sound policy decisions.

Americans have a remarkable ability to overcome adversity. Southern Nevada and the larger community have proven that with courage, resilience and tenacity. We in the water industry respectfully ask that you support our efforts to adapt to and surmount the challenges we are facing due to dramatically shifting climate conditions. Thank you for your time.

The CHAIRMAN. Thank you very much, Ms. Mulroy.

Dr. Webber.

STATEMENT OF MICHAEL E. WEBBER, PH.D., DEPUTY DIRECTOR, ENERGY INSTITUTE, ASSOCIATE PROFESSOR, DEPARTMENT OF MECHANICAL ENGINEERING, CO-DIRECTOR, AUSTIN TECHNOLOGY INCUBATOR'S CLEAN ENERGY INCUBATOR, THE UNIVERSITY OF TEXAS AT AUSTIN, AUSTIN, TX

Mr. WEBBER. Mr. Chairman and members of the committee, thank you very much for the invitation to speak before your committee on the effects of drought on the energy sector. My name is Michael Webber, and I'm the Deputy Director of the Energy Institute at the University of Texas at Austin, and I'm here to share my perspective.

This testimony will make a few key points. First, the energy sector is heavily dependent on water, as you noted in your opening remarks. Second, the water constraints from drought or heat waves can become energy constraints. Third, there are technical and policy solutions available.

So, with the first point, the energy sector's dependence on water introduces vulnerability to drought as a key concept. The energy sector uses a lot of water. Namely, water is needed for power generation and for fuels production. It's also used for refining in other

steps, but the production of the fuels and the generation is the most important.

For power generation, we use water directly to spin hydroelectric turbines at dams and indirectly as a coolant for thermoelectric power plants. For fuels production, we use water to grow energy crops and to extract oil and gas.

I'm going to start with the power sector. The thermoelectric power sector, comprised of power plants that use heat to generate power, including those that operate on nuclear, coal, natural gas, or biomass fuels, is the single largest user of water in the United States.

Cooling of power plants is responsible for 39 percent of non-consumptive fresh water use and is responsible for total withdrawals of 200 billion gallons of water every day. But because most of that water is returned to its source, the power sector is responsible for only 3 percent of national water consumption, as was noted by Senator Manchin.

The amount of water used by power plants depends on the type of fuel—coal, gas, nuclear, wind, et cetera—the type of power cycle—steam cycles versus combined cycles—and the cooling technology, as well as the prevailing climate. So there are many factors that determine how much water is used by the power plants, and a table is provided with those details for you. Nuclear is the most water intensive, and solar panels, wind, and natural gas combined cycle are water lean for power plants.

Referring to Senator Manchin's remarks earlier, there are two types of water use, the non-consumptive and the consumptive use. Consumptive water use is important because it has an impact on water availability for other users. Non-consumptive water use is also important—these are the withdrawals—because they affect the power sector's reliability and impact the environment through potential impingement of aquatic life and thermal loading of waterways. This is when the waterways get heated by the power plants.

If water is too scarce or too hot from droughts or heat waves, then the electric grid might be less reliable and power plants might need to turn off or dial back because of a need to comply with the thermal pollution limits. That could have cascading effects through other sectors, affecting refineries, the gas distribution grid, water systems, and so forth, and that introduces a significant risk to economic activity and human health.

For example, during the heat wave in France in 2003 that was responsible for nearly 10,000 deaths, nuclear power plants in France had to reduce their power output because of the high inlet temperatures of the water. Eventually, that caused a dial back of power, and that was a risk to human life there.

Then there's other heat waves that put U.S. power plants at risk as well, and then droughts also have this effect of lowering water levels behind dams and reducing the availability of cooling water for power plants. During the drought in the southeastern United States in 2008, nuclear power plants were within days of turning off. We had the drought in India last year that triggered the power outage that affected 600 million people.

So we know droughts can affect the reliability of the energy sector. Because thousands of power plants in the United States are lo-

cated in the region covered by last year's drought, we know that we are at risk for some of these same problems.

There are several ways to reduce the vulnerability of the power sector to droughts and heat waves. We can install or switch the fuel to water-lean forms, like solar, wind, natural gas combined cycle. We could switch the cooling technology to water-lean forms, like dry cooling or hybrid wet-dry cooling, because not all power plants need wet cooling all the time. We could also switch the water source to effluent or wastewater or saline or mine water, as mentioned earlier.

The fuel sector also needs water. Water is used for conventional oil and gas production, for techniques such as water flooding to get oil and gas out of the reservoirs. It's also used to grow biofuels. Biofuels need something like 1,000 gallons of water per gallon of fuel. Compare that with a couple of gallons of water per gallon of fuel for conventional oil and gas. So this means that biofuels are also at risk from drought, just as the power plants are.

Shale oil and shale gas production typically requires something like 1 to 9 million gallons of water per well, and they also return millions of gallons of wastewater. So that means they're also at risk from water constraints. In fact, there are some places in Texas that are considering prohibitions against using local ground water for shale oil and gas production.

There are several ways to reduce the risks of water scarcity and how they might constrain oil and gas production. One is to look at water re-use technologies from well to well for shale oil and gas production; looking at waterless fracking techniques; enhanced technologies at the drilling pad to speed up drilling times and reduce the amount of water that is needed; and using effluent, brackish water, or gray water instead of virgin fresh water for the hydraulic fracturing.

There are a variety of policy solutions available. Firstly, I think that this is a topic worthy of Federal policy engagement, because many rivers, watersheds, basins, and aquifers span several states. So some states cannot manage the entire water system themselves.

I recommend the following policy actions be considered. One is collect, maintain, and make available accurate, updated, and comprehensive water data, possibly through the U.S. Geological Survey or the Energy Information Administration. The EIA has an extensive data base of accurate, up to date, and comprehensive information on energy production, consumption, trade, and price. We do not have an equivalent for water, and that would be worthwhile.

Consequently, industry, investors, analysts, policymakers, and planners lack suitable water data for informed decisions. I think you can encourage fuel switching to save water, and you could encourage water switching to save energy. These go back and forth. We could switch to low water fuels, like wind, solar, and natural gas, or we can switch to other forms of water.

We could support the use of dry and hybrid cooling of power plants, invest heavily in water-lean energy R&D—this is biofuel feedstocks that need less water, new fracking techniques and other opportunities. We can encourage water-lean shale production and invest aggressively in conservation, because conserving water conserves energy, and conserving energy conserves water.

The vulnerability of the energy sector to droughts is important and not obvious. So I'm very pleased to know you're being attentive. That concludes my testimony.

Thank you very much.

[The prepared statement of Mr. Webber follows:]

PREPARED STATEMENT OF MICHAEL E. WEBBER, PH.D., DEPUTY DIRECTOR, ENERGY INSTITUTE, ASSOCIATE PROFESSOR, DEPARTMENT OF MECHANICAL ENGINEERING, CO-DIRECTOR, AUSTIN TECHNOLOGY INCUBATOR'S CLEAN ENERGY INCUBATOR, THE UNIVERSITY OF TEXAS AT AUSTIN, AUSTIN, TX

Mr. Chairman and Members of the Committee, thank you so much for the invitation to speak before your committee on the effects of drought on the energy sector. My name is Michael Webber, and I am the Deputy Director of the Energy Institute at the University of Texas at Austin. I am here to share my perspective on this issue.

This testimony will make a few key points:

1) The energy sector is heavily dependent on water,
2) Water constraints (from drought) can become energy constraints, and
3) There are technical and policy solutions available.

THE ENERGY SECTOR'S DEPENDENCE ON WATER INTRODUCES VULNERABILITY TO DROUGHT

The energy sector uses a lot of water. Namely, water is needed for power generation and for fuels production.

For power generation, we use water directly through hydroelectric turbines at dams and indirectly as a coolant for thermoelectric power plants.

For fuels production, we use water to grow energy crops and to extract oil and gas.

Power Sector

The thermoelectric power sector—comprised of power plants that use heat to generate power, including those that operate on nuclear, coal, natural gas or biomass fuels—is the single largest user of water in the United States.

Cooling of power plants is responsible for 39 percent of non-consumptive freshwater use and is responsible for total withdrawals of nearly 200 billion gallons of water per day. [Kenny, 2009]

Because most of that water is returned to its source, the power sector is responsible for only 3 percent of national water consumption. [Kenny, 2009]

The amount of water used by power plants depends on the fuel (coal, gas, nuclear, wind, etc.), the power cycle (steam cycle, combined cycle, etc.), and the cooling technology (open-loop cooling, cooling tower, etc.). Typical water needs for power plants are summarized in the table below. [Stillwell, 2011] Nuclear is the most water-intensive, while solar PV, wind, and some uses of natural gas are very water lean.

Table 1. The water withdrawals and consumption for cooling power plants depend on the fuel type, power generation technology, and cooling system. [Stillwell, 2011]

Table 1. The water withdrawals and consumption for cooling power plants depend on the fuel type, power generation technology, and cooling system. [Stillwell, 2011]

		Water Use and Cooling Technologies			
		Closed-Loop (cooling tower)		Open-Loop	
		Withdrawals [gal/kWh]	Consumption [gal/kWh]	Withdrawals [gal/kWh]	Consumption [gal/kWh]
Fuels & Technologies	Nuclear	1	0.7	42.5	0.4
	Solar CSP	0.8	0.8	---	---
	Coal	0.5	0.5	35	0.3
	Natural Gas (Combined Cycle)	0.23	0.18	13.8	0.1
	Natural Gas (Combustion Turbine)	Negligible	Negligible	Negligible	Negligible
	Solar PV	Negligible	Negligible	Negligible	Negligible
	Wind	Negligible	Negligible	Negligible	Negligible

Consumptive water use is important because it has an impact on water availability for other users. Non-consumptive water use (i.e., withdrawal) is important because it can affect the power sector's reliability and impacts the environment through potential impingement of aquatic life and thermal loading of waterways.

If water is too scarce or too hot (from droughts and/or heat waves), then the electric grid might be less reliable as power plants might need to turn off or dial back to ensure safe operation and to comply with thermal discharge limits. These outages can have cascading effects through other sectors, affecting refineries, the gas distribution grid, water systems, and so forth, with significant risk to economic activity and human health.

For example, during the heat wave in France in 2003 that was responsible for approximately 10,000 deaths, nuclear power plants in France had to reduce their power output because of the high inlet temperatures of the cooling water. Environmental regulations in France (and the United States) limit the rejection temperature of power plant cooling water to avoid ecosystem damage from thermal pollution (e.g. to avoid cooking the plants and animals in the waterway). When the heat wave raised river temperatures, the nuclear power plants could not achieve sufficient cooling within the environmental limits, and so they reduced their power output at a time when electricity demand was spiking by residents turning on their air conditioners. In this way, a water resource constraint became an energy constraint.

In addition to heat waves, droughts can also strain the energy-water relationship. During the drought in the southeastern United States in early 2008, nuclear power plants were within days of shutting down because of limited water supplies. Droughts also lower water levels behind dams, reducing output from their hydroelectric turbines. Droughts triggered the massive power outage in India in 2012 that affected 600 million people, cutting off power for several weeks.

Because thousands of power plants are located in the region covered by last year's drought, the United States is vulnerable to a similar kind of widespread outage event.

There are several ways to reduce the vulnerability of the power sector to droughts and heat waves:

1. Installing and/or switching the fuel and conversion technology to lower-consuming options (for example, natural gas combustion turbines, natural gas combined cycle, wind, and solar PV all require less water than steam cycle plants powered by natural gas, coal, or nuclear)
2. Installing and/or switching the cooling technology to lower-consuming options (for example, dry cooling and hybrid wet-dry cooling require less water than conventional cooling, though they can reduce power plant performance)
3. Switching the water source (for example, to effluent from wastewater facilities or saline water)

These technical solutions face some policy or cost hurdles today.

Fuels Sector

The fuels sector—namely oil, gas, and biofuels production—also requires significant volumes of water. Water is used for conventional production for techniques such as waterflooding, which can increase productivity from reservoirs. Biofuels use water during photosynthetic growth.

Shale oil and gas production typically requires approximately 0.7—9 million gallons of fluids per well. Those wells also return significant volumes of wastewater comprised of drilling muds, flowback water, and produced water. [Nicot and Scanlon, 2012]

Major Shale Play	Median Water Use per Well (Mgal)
Barnett	2.8
Tx-Haynesville	5.7
Eagle Ford	4.3

*From Nicot and Scanlon, 2012 Table 1.

The lifecycle water intensity (see Figure 1)* shows that conventional fossil fuels and unconventional natural gas are relatively water lean. However, unconventional petroleum and biofuels are relatively water intensive.

Because biofuels need so much water for their growth, they are particularly vulnerable to droughts. Just as traditional agricultural crops are hindered in times of drought, so are energy crops.

Droughts can also affect oil and gas production. This risk is important because the growth in production from shale formations has triggered an increase in water use from nearby basins and aquifers. [Nicot and Scanlon 2012]

It is important to note that despite the water used with hydraulic fracturing to produce natural gas from shale formations, natural gas use saves water because natural gas combined cycle power plants have less than half the water intensity of coal plants (See Figure 2)*. [Grubert, 2012]

Though shale gas is water lean over its entire lifecycle, water scarcity from drought can constrain shale gas production. For example, the current drought that began in 2011 has led some groundwater conservation districts in Texas "to consider enacting specific water use restrictions against" hydraulic fracturing. [Allen 2013] Furthermore, droughts sometimes position the agricultural sector against the energy sector in a competition for limited water supplies.

There are several ways to reduce the risks that water scarcity will constrain oil and gas production from shale formations:

1. Water re-use from well-to-well to reduce the amount of freshwater that is needed
2. Waterless fracking
3. Enhanced technologies at the drilling pad to speed up drilling times and reduce the amount of water that is needed
4. Using effluent, brackish water, or greywater

THERE ARE POLICY SOLUTIONS AVAILABLE

In addition to the technical solutions noted above, there are different policy actions that can help.

Because there are many rivers, watersheds, basins and aquifers that span several states and/or countries, there is a role for federal engagement on these issues. I recommend the following policy actions:

1. Collect, maintain and make available accurate, updated and comprehensive water data, possibly through the USGS and EIA. The Department of Energy's Energy Information Administration maintains an extensive database of accurate, up-to-date and comprehensive information on energy production, consumption, trade, and price available with temporal and geographic resolution and standardized units. Unfortunately, there is no equivalent set of data for water. Consequently, industry, investors, analysts, policymakers and planners lack suitable data to make informed decisions.
2. Encourage fuel-switching to save water. Some fuel sources such as natural gas, wind, and solar PV are domestic, need much less water, and reduce emissions of pollutants and carbon.
3. Encourage water-switching to improve the energy sector's reliability. Using reclaimed water for powerplants, industry, and agriculture can spare a signifi-

*Figures 1 and 2 have been retained in committee files.

cant amount of energy and cost. However there are financing, regulatory and permitting hurdles in place that restrict this option.

4. Support the use of dry and hybrid wet-dry cooling at powerplants. Not all powerplants need wet cooling all the time. Finding ways to help plants upgrade their cooling to less water-intensive versions can spare significant volumes of water to meet public supply or in-stream flow requirements.

5. Invest heavily in water-lean energy R&D. R&D investments are an excellent policy option for the federal government because state/local governments and industry usually are not in a position to adequately invest in research. DoE's R&D program for biofuels should emphasize water-lean power plant cooling technologies, feedstocks such as cellulosic sources or algae that do not require freshwater irrigation, and advanced techniques for hydraulic fracturing. At the same time, the amount of R&D in the water sector is much lower than for other sectors such as pharmaceuticals, technology, or energy, so water R&D should be increased. [Kirshenbaum, 2012]

6. Encourage water-lean shale production. Supporting R&D for water-lean shale production techniques would also be valuable. Encouraging producers to reuse water and to perform on-site treatment of produced water would spare significant volumes of freshwater.

7. Invest aggressively in conservation. Water conservation can be a cost-effective way to save energy, and energy conservation can be a cost-effective way to save water. Therefore, conservation has cross-cutting benefits.

The vulnerability of the energy sector to droughts is important and not obvious, and so I am very pleased to know that you are being attentive to the matter.

Mr. Chairman, that concludes my testimony. I'll be pleased to answer questions at the appropriate time.

The CHAIRMAN. Thank you. I heard you repeatedly talk about switching and conserving. I think those are pretty good principles. It almost sounds like a law firm—Switch and Conserve, Attorneys at Law.

[Laughter.]

The CHAIRMAN. Thank you very much.

Our last witness will be Dr. Nicole T. Carter, Specialist in Natural Resources Policy for the CRS.

STATEMENT OF NICOLE T. CARTER, SPECIALIST IN NATURAL RESOURCES POLICY, CONGRESSIONAL RESEARCH SERVICE

Ms. CARTER. Chairman Wyden, Ranking Member Murkowski, and other members of the committee, thank you for this invitation to appear before you on behalf of the Congressional Research Service. I am Nicole Carter, and I'm a Specialist in Natural Resources Policy. My testimony today will cover some of the other non-agricultural impacts of the drought, including navigation, and touching on electric power generation as well.

Today, there are fears of flooding on some of the same rivers where we were worried about drought not very long ago. That drought destroyed or damaged a significant portion of the U.S. corn and soybean crops, with impacts on U.S. livestock as feed costs reached record levels. Drought reduced corn yields which lowered ethanol production.

The 2012 drought, though, also had impacts on our navigation system. For those moving agricultural and energy products on waterways, the 2012 drought raised fears of a repeat of what happened in 1988, when we saw extensive closures and significant barge backups. In 2012, commercial navigation did suffer short-term closures and disruptions, but it did not see those same extended closures.

By most accounts, the U.S. Army Corps of Engineers maintained the congressionally authorized navigation channel on the Mississippi River. The authorized channel, however, is significantly narrower and significantly shallower than what we're accustomed to. As a result, tows moved only 15 barges rather than 30 barges at a time, and barges had to be light-loaded. While these conditions were difficult, the extended closures of 1988 were avoided.

The impaired navigation conditions in 2012 renewed discussions about the relationship between the Missouri River and the Mississippi River. The Federal reservoirs in the Missouri River system provide multi-year and multi-purpose storage to assist in managing the basin's droughts and floods. The U.S. Army Corps of Engineers operates these reservoirs according to a master manual adopted in 2006.

The basin's water history includes instances of dry conditions lasting 1 year or 2 years, but also multiple examples of dry conditions lasting 6 years or 12 years. After record runoff in the Missouri basin in 2011, Federal reservoirs were full in early 2012. During the dry summer and fall of 2012, the Corps released stored water to support Missouri River navigation. These flows incidentally but critically supported Mississippi River navigation.

Recently, the Assistant Secretary of the Army has reaffirmed that the Corps lacks the authority to modify Missouri River operations to benefit downstream Mississippi River navigation. Based on declining reservoir levels in 2013 runoff forecasts, the Corps implemented minimum Missouri River water releases for the winter, thus reducing contributions from the Missouri to the Mississippi beginning late December.

How recent storms may affect spring and summer runoff forecasts remain unclear. What is known is that managing reservoirs in times of drought embody difficult tradeoffs, such as whether to release stored water in the near term to offset near-term impacts, or to store water for future use in case of continued dryness.

The 2012 drought also affected electric generation in a variety of ways. Impacts were largely at the power plant level. Individual coal and nuclear power plants curtailed operations due to water access problems and water temperature issues. Others pursued regulatory waivers to continue operations at higher water intake temperatures.

Lost generation at drought-impaired facilities was offset by other generation. The mid-continent electric grid avoided major drought-related disruption in 2012. This experience contrasts with the power grid serving most of Texas, which did have to ask customers to conserve during the drought conditions in 2011.

In 2012, hydropower production nationally was above average. Hydropower generation in the Pacific Northwest, although drought susceptible, was unaffected by the 2012 drought. The Missouri River basin's strong hydropower generation in 2012 during the drought can be attributed to the full reservoirs at the beginning of the year.

The most recent Missouri River hydropower forecast, which was performed prior to the current storms, anticipated a 20 percent reduction in hydropower generation for 2013. What this shows is that for large reservoirs and reservoir systems, it is often the multi-year

droughts that most significantly reduce hydropower generation, and that's also illustrated by the Colorado River basin.

The 2012 drought provides us a single year of data at this point on drought vulnerability and resilience for a significant portion of the United States. It's up to Congress and the administration to decide what are the lessons to draw from 2012, both to improve single and multi-year drought resilience.

Thank you, and I am available for questions.

[The prepared statement of Ms. Carter follows:]

PREPARED STATEMENT OF NICOLE T. CARTER, PH.D., SPECIALIST IN NATURAL RESOURCES POLICY, CONGRESSIONAL RESEARCH SERVICE

Chairman Wyden, Ranking Member Murkowski, and Members of the Committee, on behalf of the Congressional Research Service, thank you for this opportunity to appear before you. I am Nicole Carter, Specialist in Natural Resources Policy. The Committee requested that CRS discuss how the 2012 drought affected navigation and electric generation.

DROUGHTS FORCE DIFFICULT TRADEOFFS IN THE FACE OF UNCERTAINTY

Droughts and floods force difficult tradeoffs and draw attention to the management of the nation's rivers, lakes, and reservoirs. Today, there are fears of flooding along some of the nation's rivers. Only recently some of the same rivers were experiencing low flows from drought.

Like floods, droughts focus attention on water resources management and the role of storage reservoirs. Droughts also bring attention to the role of groundwater, its use, and long-term management. Aquifers store and supply water for irrigation, rural communities, energy production, and some urban areas.

The 2012 drought destroyed or damaged a significant portion of the U.S. corn and soybean crops, with impacts on U.S.livestock sectors as feed costs reached record levels. Drought-reduced corn yields also lowered ethanol production and brought attention to the drought vulnerability of domestic fuel production. The 2012 drought also tested the resilience of the navigation and electric power sectors.

2012 DROUGHT: NAVIGATION IMPAIRED BUT MAINTAINED

For those moving mid-continent agricultural, energy, and other products by watetway, the 2012 drought raised fears of repeating the navigation experience of 1988. During that drought, the Mississippi River and its tributaries experienced extensive navigation closures and barge backups.

In 2012, commercial navigation suffered short-term closures and restrictions, but no extended closures. By most accounts, the U.S. Army Corps of Engineers maintained the congressionally authorized navigation channel on the Mississippi River. The authorized channel is notably narrower and shallower than what is typically available on the Mississippi for commercial navigation in a normal water year. For example, in the Middle Mississippi River between St. Louis, Missouri and Cairo, Illinois, the authorized channel is 300 feet wide and 9 feet deep.

The more limited channel dimensions on the Mississippi and its tributaries in 2012 reduced waterway transportation efficiencies and increased transportation costs for shippers and carriers. Tows moved 15 rather than 30 or more barges at a time. Barges were light-loaded to meet the shallower draft. Tow operators had to account and schedule for segments where traffic was limited to one-way. While these conditions were difficult, the extreme disruptions and extended closures of 1988 were avoided.

The Corps maintained the Mississippi River navigation channel through a combination of measures previously put into place and actions taken during the drought. For example, additional structures to concentrate the river's flow into the navigation channel were constructed after the 1988 drought. These structures improved flow and reduced the need for emergency dredging. During 2012, the Corps also removed rock pinnacles in the authorized channel and dredged critical locations.

The Coast Guard, the Corps, navigation industry representatives, and others communicated through regular standing forums established since 1988. During 2012, improved information and technologies also helped avoid groundings, allowing commercial navigation to continue, albeit at reduced efficiencies.

The Corps during the 2012 drought monitored 17 reservoirs that influence navigation conditions on the Mississippi River and its tributaries below the Corps' locks and dams. At times the Corps altered reservoir releases to benefit Mississippi River navigation while attempting not to interfere with the congressionally authorized purposes of those facilities.

The impaired navigation conditions in 2012 renewed discussions about the relationship between water management activities in the Missouri River basin and navigation conditions in the Mississippi River. Missouri River flows can and do influence navigation conditions during drought on the Middle Mississippi River.

The Missouri River's system of federal reservoirs was designed to provide multi-year and multi-purpose storage to assist the basin in managing both droughts and floods. The Corps operates its Missouri River reservoirs according to a Master Manual adopted in 2006. The Missouri River basin provides instances of dry conditions lasting one or two years, as well as droughts lasting six to twelve years.

After record runoff in the upper Missouri River basin in 2011, federal reservoirs were full in early 2012. During the basin's dry summer and fall of 2012, the Corps released stored water in accordance with the Master Manual to fully support Missouri River navigation. These flows incidentally, but critically, supported Mississippi River navigation. The Assistant Secretary of the Army recently reaffirmed that the Corps lacks authority to modify Missouri River system operations for the express purpose of benefiting downstream Mississippi River navigation.

Based on declining Missouri River reservoir levels and 2013 runoffforecasts, the Corps implemented minimum water releases for the 2012-2013 winter, thus reducing contributions from the Missouri River to the Mississippi River beginning last December. This reduction occurred while the drought continued to impair navigation on the Middle Mississippi River.

Dry conditions persisted in the Missouri River basin until recently. How recent and ongoing storms may affect spring and early summer runoff forecasts, especially for the reservoirs in the upper basin, remains unclear. What is known is that managing reservoirs in times of droughts embody difficult tradeoffs, such as whether to release stored water to offset near-term harm or store water for future use in case of continued dryness.

2012 DROUGHT: MIXED EFFECTS ON ELECTRIC GENERATION

The 2012 drought also affected electric generation in a variety of ways.

Some individual power plants curtailed operations due to water access problems or water temperature issues; others pursued regulatmy waivers to continue operations at higher water temperatures or made cooling system investments. Lost generation at drought-impaired facilities was offset by other generation. The mid-continent electric grid as a whole appears to have avoided major drought-related disruption in 2012. This experience contrasts with the experience of the power grid serving most of Texas, which asked customers in 2011 during a period of intense regional drought to voluntarily conserve to avoid rolling blackouts.

In 2012, hydropower production nationally was above average. Hydropower generation in the Pacific Northwest, although drought-susceptible, was unaffected by the 2012 drought. The Missouri River basin's strong hydropower generation in 2012 can be attributed to full reservoirs at the beginning of the year and the generation associated with releases of stored water to augment low river flows. The most recent hydropower forecast for the Missouri River, which was produced prior to recent storms, anticipated a 20 percent drop in generation in 2013. For large reservoirs and reservoir systems, it is often the multi-year droughts that most significantly reduce generation, as illustrated in the Colorado River Basin.

The drought's impact on navigation did not appear to materially affect regional power plant operations. Base-load coal plants that are dependent on waterways for fuel delivery generally have coal stockpiles located at the power plants to reduce their vulnerability to short-term delivery disruptions.

In addition to coal, other energy products are transported on the inland navigation system. There was a dramatic decline in the movement of crude product by barge down the Mississippi River in December 2012 and January 2013, relative to the previous year. Whether this decline can be attributed to the drought's effect on navigation costs and reliability is unclear.

DROUGHT RESILIENCE

The 2012 drought provided a single year of data on the drought vulnerability and resilience of a significant portion of the United States. It reinvigorated debates about water management; who should bear the costs of droughts, and the most cost-effective drought preparations and responses. Congress and the Administration are

faced with deciding what lessons to draw from 2012 to improve single and multi-year drought resiliency.

Thank you and I welcome your questions.

The CHAIRMAN. Dr. Carter, thank you. As perhaps the all-time leading consumer of CRS products, I can tell you even by CRS's high standards, you're doing good work, and I appreciate it. Thank you very much.

Mr. Connor, let me go to you first, and I've got to do some Oregon business with you right here at the outset. You know, severe drought is just pounding the Klamath basin region of my home State. The Bureau of Reclamation is telling us that the basin has experienced the second driest January through March on record.

Now, Senator Merkley, and Congressman Walden, and I worked with the Bureau to secure drought relief for the basin during the really devastating drought that we saw back in 2010. Oregonians are now concerned that we could be looking at the same thing.

Let me start with this. Oregonians want an assurance that the water won't be cutoff to the Klamath project this summer. Can you give us that assurance this morning?

Mr. CONNOR. At this point in time, I can give you my very high expectation that water will not be shut off to the Klamath project this year. It certainly won't be shut off in its totality.

Two aspects of what we're doing in the Klamath basin—based on the resources provided in 2010 and the Water Use Mitigation Program that we really set up and got going with the folks locally at that point in time, we've got mitigation measures in place. We've got other water supplies that are being accessed in the Klamath basin, which will provide, I think, somewhere in the neighborhood of 40,000 to 50,000 acre feet this year to add to the project water supply.

In addition, with our Corps operations, what Reclamation has done is we have gone back and redone our operations plan; submitted a new biological assessment to the resource agencies, U.S. Fish and Wildlife Service and NOAA Fisheries; and are seeking a new consolidated biological opinion from those two agencies to approve those operations for this year, which I anticipate will yield about a 75 percent water supply to the project. That, coupled with the mitigation program, should allow the project to operate this year.

The CHAIRMAN. That sounds constructive. Just have as a takeaway that the Oregon congressional delegation, myself, Senator Merkley, and Congressman Walden, is going to push very, very hard to make sure that the high expectation that water won't be cutoff to the Klamath project this summer actually becomes a reality, because as you know, this area has just been pounded.

I think you know we want to work closely with you. We appreciate the fact that you're taking these extra steps. But given what has gone on and that this is really emblematic of the government's desire to work through some fresh approaches to solving our problems, we just have to make sure that water is not cutoff to the project this summer.

Now, you touched on it, but let me just ask it this way. When will the new biological opinion be completed? You gave several

dates. Just unpack that a little bit more for me so that we know when the next biological opinion will be completed.

Mr. CONNOR. The expectation right now is that we will have the new biological opinion either the second or third week of May. That's the timeframe, so we're about two or 3 weeks out. Actually, that's the only reason I hedged even a little bit. We've been working very closely with the fisheries agencies. We have good expectations that we will receive the biological opinion at that point in time. But it's now in their hands, and we're just waiting for the actual receipt of the document.

The CHAIRMAN. I appreciate that. I know that you all are pushing ahead and trying to work with the fisheries agencies, and I was just trying to make sure I could sort through an awful lot of biological opinions—Senator Murkowski knows this—that are circulating through the West, and I appreciate that. I think we've already gotten your pledge previously to continue to work with our delegation to secure drought relief and the administration's willingness. Let me just move on here quickly.

I'd like to start, and since we brought you into the discussion already, maybe we could start with your colleague, Dr. Pulwarty. Each of you get to name one specific thing that you would like to see Senator Murkowski and I pursue on a Federal level to deal with this drought issue. Obviously, my time is almost out, so each of you get one, your No. 1 priority bipartisan action in this committee to deal with the drought now.

Dr. Pulwarty.

Mr. PULWARTY. The major issue related to drought has to do with how effectively we're using information for planning. I would suggest that an effort to do the research on linking climate variability and hydrologic processes and communicating that information most carefully to reservoir energy managers and the agricultural sector is critical. The coordination of information into planning and operations is the most critical aspect.

The CHAIRMAN. Good information quickly shared.

Mr. PULWARTY. Precisely.

The CHAIRMAN. We'll call that Dr. Pulwarty's.

Ms. Mulroy.

Ms. MULROY. Yes, Mr. Chairman. From the city's perspective, since he already addressed better climate research and more direct climate research, I think for purposes of those of us that are on the ground, finding ways to make what is becoming an ever-increasing financial burden more tolerable is really first and foremost in our minds.

You're looking at billions and billions of dollars that are going to have to be invested—communities that have to build projects that aren't growth driven, that aren't decaying infrastructure driven, that are coming out of nowhere in order for whole communities to survive. There needs to be a greater dialog about how we do that and how we fund those kinds of efforts.

The CHAIRMAN. We'll call that innovative financing.

Ms. MULROY. Absolutely.

The CHAIRMAN. Very good.

Dr. Webber.

Mr. WEBBER. I recommend a comprehensive, thoughtful, well-funded R&D program so we are prepared to deal with the challenges. I think right now the energy-water nexus is not fully tackled from an R&D perspective, and there's opportunity there.

The CHAIRMAN. R&D.

Dr. Carter.

Ms. CARTER. CRS does not make recommendations, but what we can do is pull together recommendations——

The CHAIRMAN. Let me ask it this way. I appreciate that, and I should have revised the way I asked the question. Based on the literature—because that is something that you all are very knowledgeable about—is there consensus that there might be one area? I'm not asking your opinion. But essentially, in the body of the evidence that you all review on an ongoing basis, is there one approach that may seem to have a consensus in terms of support for purposes of answering this question?

Ms. CARTER. There was a document produced that was delivered to Congress in 2000. It was produced by the National Drought Policy Commission, and in there they identified a number of recommendations, one of which, basically, helped produce NIDIS, and there are still a number of other recommendations.

But that document is from 2000, so it would be helpful to have information about what happened in 2012, like what you've collected today with this committee. But right now, we don't have that information regarding what happened from 2012. We do know that there are some efforts underway, but they seem fairly limited in scope at this time.

The CHAIRMAN. So based on the literature, you might say that there would be interest—not, again, CRS's opinion—but looking at what happened in 2012 and getting more detail about that.

Ms. CARTER. A number of people I spoke to said I was the first person sort of asking to do a comprehensive look at what happened in their area.

The CHAIRMAN. I got the drift. I got it.

Senator Murkowski.

Senator MURKOWSKI. I am starting to feel a little bit like an energy geek, because this has just been fascinating here this morning. I so wish, Mr. Chairman, that more of our colleagues were here with us today.

We talk so much in this committee about the energy potential and where we're going, and we heard a hydropower bill earlier this week. You and I are working nuclear issues. We've got interest in geothermal, and we talk about fracking. Everything that we do, though, in the energy sector comes back to water.

You know, when I first got on this committee 10 years ago, I was the chairman of the Water and Power Subcommittee. Coming from Alaska, where we have an abundance of water, I had no real appreciation for some of the water fights. It was in that committee that I learned that whiskey is for drinking and water is for fighting. I learn that a little bit more all the time.

When I appreciate what it is that we have in front of us in terms of the challenge of how we balance this—because we keep using the word, nexus, but these are just inextricably tied. I've mentioned to you, Mr. Chairman, the importance of water. I think, from a geo-

political global perspective, if we get ourselves into this next big bad war, I'm not convinced that it's over oil. I'm more convinced that it's over water, because it's through water that we will be able to control so much of what we do in other parts of our world, whether it's energy or otherwise.

So I'm just fascinated with some of the discussion here this morning, a very thoughtful contribution from each of you.

Dr. Webber, I really appreciate the way that you have outlined some of the ways that you think, from a Federal perspective, there should be greater engagement. I clearly believe that. I've been focused a lot in this committee on what's going on insofar as energy reliability and the fact that we're seeing this shift from coal to natural gas a lot because of what's going on within the market, but also because of the regulatory perspective.

But then you've got this great unknown out there when it comes to what the impact of a warming climate and what the impact of drought will mean on our water resources that are getting impacted, everything from nuclear to hydro to everything else that we want to do to what we're doing with accessing our natural gas through fracking and the availability of water.

So if we appreciate that 7 percent of our energy production right now comes from hydro, and if you were to suggest that because of droughts we're seeing a reduction in our energy production there, how does this impact the reliability of energy across the country, particularly if you're in an area, let's say, where there is a fair amount of hydro and coal, and we see coal moving offline, and we have a prolonged period of drought impacting our hydro or any other aspect of it, then what? Nuclear?

I just think that this is something we need to better understand, and we really need to be coordinating and collaborating. It's my understanding that we've got a number of agencies that have responsibility for managing specific aspects of the energy-water nexus. But these agencies don't necessarily collaborate strategically or consistently on these linked issues.

How can we do a better job there? How do we do that, given that so much of the energy policy as it relates to water is developed not at the national level, but at the regional level, at the State level, or even at the local level? How do we do a better job of the coordination, then, that goes on at these different levels, recognizing that we've got a lot of different agencies that are theoretically tasked to be managing this? Are we doing what we need to do? If not, what do we need to do better?

I'll throw it out—we can start here with you, Commissioner. Give me your thoughts.

Mr. CONNOR. Thank you, Senator Murkowski. This is a theme that I think in the last hearing you touched upon, the coordination that's necessary to move some of these policies forward. I'd say there are two areas I want to address and give an example—hydropower and with respect to water supply.

I think we're moving in a better direction. I think there's a lot of work left to be done with respect to hydropower. The example I'll give is that we entered into an MOU in 2010—Department of Interior, Corps of Engineers, Department of Energy—and we are

very cognizant of MOUs being a feel-good type of document. What we've really tried to do is put it in practice.

So we've aligned our R&D investments jointly with DOE—Reclamation has—to facilitate some pilot projects on new technologies in the area of hydropower. I think we've got about 16 projects that are in various phases of implementation. The bottom line is we have less water and we need to have more efficient turbines, and that's what that's focused on.

We've also entered into an optimization program that we're doing with the Corps and the Department of Energy that we're now starting to implement this fiscal year on Reclamation projects—2 percent to 3 percent gains in efficiency from this optimization program. I think it's something that we can use not just at Reclamation facilities, but at Corps of Engineer facilities. They are the largest hydropower producer in the country.

Then we're also looking at basin-wide solutions, where we can shore up the reliability of hydropower on some facilities and maybe look at resolving some of the environmental issues in other facilities in a way that you can actually increase the generating capacity from a particular facility. So in the hydropower area, I think working at that level across those agencies, we can work on the technology side and create opportunities that we can then work with the private sector on.

On the water supply side, you hit it exactly. It's not a resource that is federally controlled. We are trying to work through our basin studies program of engaging all the key players in the water arena, from states to local entities——

Senator MURKOWSKI. Who should be in charge of that?

Mr. CONNOR. I don't know that any one entity can be in charge of that in the area of water resources, quite frankly. It crosses State lines. Most of these basins are in multiple states, so you're not going to have any one State that can control the process. Certainly, there are Federal interests, but there are not Federal water rights that make up the majority of water resources in these basins.

So we've got to work through on a collaborative basis, but we've got to be very results oriented. I think, quite frankly, given these extended droughts and the projections under a changing climate, we've got people's attention so that they're cutting through the infighting that can naturally occur.

Particularly, the Colorado River basin—it's remarkable the amount of progress that we've made among the 7 basin States, the key municipal entities, the Federal Government, and now even with Mexico.

Senator MURKOWSKI. Let's keep going down the line, if we can, to get some more ideas on how we can coordinate what is already happening within the agencies. So how do we really collaborate to a better degree?

Mr. PULWARTY. From that standpoint, I think it's an extremely rich question. Thanks for the question, Senator. The issues surrounding the enabling infrastructure that we have for monitoring and understanding of ground water measurements and understanding of the relationship between ground water and surface water—in the case of New Mexico last year at the Rio Grande,

went almost virtually entirely in summer to ground water, because surface water was basically nonexistent.

When we ask where should coordination take place, given the different forms of accountability that the agencies and their partners have to take shape, we then ask the question: What are the areas of collaboration in monitoring and forecasting, in impacts assessment, and in the use and communication of information?

One of the big successes of the National Integrated Drought Information System is that it is nominally led by NOAA, but it is inherently interagency, developing the efforts in which the agencies who take part in collaborative mechanisms also see the benefits to themselves become critical. From the standpoint of working on the Colorado, on the Apalachicola, Chattahoochee, Flint, we ensure that the benefits of the information we're providing is linked to the lead agencies who are operating in that area, the Corps in the case of ACF, certainly Reclamation in the case of the Colorado basin.

Given that issue, I really think that one of the major points that was made by Pat Mulroy—which is an opportunity to stand back and say, "How well are we reconciling different views of what is happening in different watersheds?"—is critical. Instead of the rush to apply information, a good approach is to say let the agencies stand back and say, "How best should we collaborate on this issue?"

In the case of the Colorado, we have a leeway until around 2024 in order to do this. From the standpoint of collaboration, the key aspects have to be strengthening our monitoring systems, because we're basically losing stream gages and so on; strengthening our ground water recharge estimate; but really working with the agencies on the mandates that they have in designing an effective information system to support adaptation being undertaken by the State and local levels.

What I mean by that—and we have many examples and one led by Reclamation, the Climate Working Group on Water, WestFAST, and others—is to work with the states, the feds, the tribes on developing appropriate information systems for planning. Where that comes to bear is by saying which agencies are working together on monitoring and forecasting, which agencies are working together on risk assessment, and which agencies are working together on communicating and preparing information, such as USDA, and then coordinating that into an effective information system. One example is NIDIS.

Senator MURKOWSKI. Dr. Pulwarty, before we go down the line here, it was my understanding that under the Energy Policy Act back in 2005, it required DOE to implement this program of research, demonstration, development, and the commercial action, to look just at what you have talked about in terms of the existing Federal programs. To my understanding, DOE is not doing that. Is NOAA doing that, then, through——

Mr. PULWARTY. Certainly in the case of drought, and as it links to floods, I wanted to add, simply because we look at floods as things that help, and droughts, and so it plays a role. When we put out a forecast, we're saying, well, what is likely to end these conditions—well, is it likely to flood?

NOAA is coordinating from the standpoint of research and information. But the key aspect there is that it is problem oriented. It defines drought as the problem and says, "Work with your partners as effectively as possible." As has been widely said, there's no one agency that can do all of this. That's fairly clear. But the end result is that we do have go back up the chain to respond to our mandate and our measures of accountability.

Where it becomes really critical is in working with our partners, such as the water utilities and others, and ensuring that we're coordinating effectively to provide information and planning to support their activities. In the case of the National Integrated Drought Information System under Public Law 109–430, that has been the approach we have taken.

Senator MURKOWSKI. Ms. Mulroy.

Ms. MULROY. Yes. I'd like to echo what he just said, and I can give you a concrete example of it. The single most important thing Congress can do is force interagency cooperation. To talk about having one agency in charge, in all honesty, it'll take so much politics; it'll be so difficult to do; and, quite honestly, we don't have the time for it. I mean, the changes are occurring.

But you can, through the way you budget and the way you set things up, force interagency cooperation. That really showed itself—and I've got to give huge credit to Mike for herding all the cattle through the Mexico 319 discussions. You had the ultimate collision of the treaty clause of the Constitution and the compact clause of the Constitution.

The U.S. Government had primacy in all international affairs, but had no water with which to sit at the table. They had to bring the states to the table in an international discussion. It was an interesting exercise, watching us get to that point, and I'm giving Mike a lot of credit for this. He, personally, really helped make a lot of this happen. But it proved just how valuable it was.

When the states and the Mexicans finally were able to sit in one room and really understand each other's issues and really began to work together, and the two parts of the Federal Government really started cooperating and working in tandem, we moved mountains in a very short period of time. That's what's critical, that level of interagency collaboration, programmatically aimed at a single outcome.

Senator MURKOWSKI. Great.

Dr. Webber.

Mr. WEBBER. It is a great question. So I'm going to give you a little bit of good news, which is, organically, people within the different agencies are already starting to find each other and work together. So people at the Department of Energy, U.S. Geological Survey, EPA, National Science Foundation, and the Department of Homeland Security all have a different interest in this issue, and they're finding each other in a very unofficial way through different conferences.

However, it could be accelerated, expedited, and improved. I think there are 3 things you can do. I think you can give this whole issue a legislative mandate and give it the authority that it's important and that you want to see something done. I think you could

give it a budget. Right now, there's not really a budget for this issue.

So people are finding each other and convening among themselves, but aren't really efficiently tasked for it necessarily or don't have the budget for it, and you could help clarify the roles. The Department of Homeland Security cares about the energy-water issues from a national security or a reliability perspective. The Department of Energy cares about it from a potential constraint on energy.

The EPA cares about what Energy does to improve water quality through treatment or what it does to put water at risk from spills. The National Science Foundation has a research mission. The U.S. Geological Survey has a water quantity and data mission.

They all have different missions, and I think you can help clarify those roles. Give it a mandate and give it a budget, and then it becomes not an unofficial organic thing where people find each other, but a task of all the agencies.

That might be a way to get going, as opposed to creating a new agency, like Pat Mulroy says. That might be a better way to get going with the existing assets, with people who are already interested and just are trying to clarify roles.

Senator MURKOWSKI. Good point.

Dr. Carter.

Ms. CARTER. To add to the positive word of collaboration, I would add innovation, so essentially to allow and to assist the states in some innovative activities that they are attempting already, and we may see more after the 2012 drought. You have innovations at the State levels recently on how they're managing ground water. An example is Kansas.

You have innovations which were tested and are being reformulated some in Georgia related to the management of the surface-ground water relationship in the Flint River. So I'd say in addition to just collaboration among the Federal agencies, it's having that collaboration allow for that State and local level innovation as well.

I think an example of that—maybe a little bit large—was the Western Governors Association did become interested in grid reliability issues, in particular, related to the hydropower question that you asked of what would be the impact. They had DOE do—DOE labs, Sandia and Argonne, do a West-wide assessment, and they did identify ERCOT in Texas and the Pacific Northwest as being of the grid. Those two were the most vulnerable.

We don't have a similar assessment for the East, so we don't know, for example, if there are other North Carolinas out there, like the example that Roger Pulwarty gave. So I think one of the things we've seen is that the states and Governors are attempting to understand these issues and to grapple with them, and seeing how to bring Federal resources to support and allow those is one way that we've seen successful or interesting developments.

Senator MURKOWSKI. Great. I appreciate the responses that you've each given.

Mr. Chairman, thank you for the latitude to just engage in a little bit of dialog here on a very important issue.

The CHAIRMAN. I think your questions were very helpful, so you have latitude on my watch all the time.

Let me ask about a couple of other areas. I think you all have picked up that this committee, and Senator Murkowski and I care tremendously about hydropower. We have called it one of the forgotten renewables. That was the message when I went up to meet with Senator Murkowski's constituents.

We have these astounding votes in the House of Representatives recently for hydropower expansion. It's almost like you hear about 422 to nothing, and people say that Congress is on an alternative galaxy when you're talking about hydropower. These are exceptional kinds of votes.

Senator Murkowski and I keep on packing the statistics: 60 percent of the clean power in the country; opportunity for 60,000 megawatts of growth. This is a very, very exceptional success story. I want to ask you about the potential for disruption to hydropower from climate change. Let me kind of just walk you through it and see what you think of this whole area and get your take on it.

In the Northwest, the snow in the mountains serves as an additional reservoir that slowly releases the water over the spring and the summer. If the snow melts earlier in the year because the temperatures are warming, the question becomes: What is that going to do to the availability of water for hydropower and other uses in the summer?

So, Dr. Pulwarty, why don't you tell me what you think of how I've kind of unpacked the issue here and also tell me your assessment in terms of how this could affect the availability for what Senator Murkowski and I want to do, which is to build on this in the future. I mean, it's our goal to tap that potential for 60,000 additional megawatts of clean power.

What's so exciting about the hydropower story is—and certainly back when I started looking at this issue when I had a full head of hair and rugged good looks and all that—there was a lot of arguing back and forth between the developers and the environmental folks. As Senator Murkowski and I have noted, those folks have been working together now, and so we're seeing a lot of common ground, and that's one of the reasons why you see this incredible set of votes in the House for hydropower.

So tell me what you think about the potential ramifications for hydropower and the success story stemming from this issue of climate change, particularly as we would see it from the Pacific Northwest with that snow in the mountains and the additional reservoir and how that releases over the spring and summer and what happens if the snow melts earlier.

Mr. PULWARTY. Thank you very much for the question. From the standpoint of changing runoff over time, especially for the Pacific Northwest and Alaska, as we look at the changes in earlier runoff, the question becomes: What is the appropriate time for storage that also balances the so-called parity between hydropower, salmon, and other resources that are needed?

I think from one of the major lessons that you're seeing and was just described, the Northwest Planning Power Act of 1980 certainly led to new collaborations among the states and the Federal agencies. In other parts of the country where losses due to higher temperatures from evapotranspiration becomes critical, then the hydro-

power head is reduced simply because we're losing water to the atmosphere in drier conditions.

In the case of the Pacific Northwest, where there's not yet full agreement on the total amount of precipitation, but there is agreement on the timing of the flows in a changing climate, I think the critical aspect is balancing the tradeoff between when storage occurs in the earlier system, when flood control then happens—as you know better than most, the reliability of flood control becomes critical when flood control is emptying and storage occurs very early in the spring season, and then other melt water comes down. We have that tradeoff occurring on the Columbia River basin as we speak between Canada and the United States.

Hydropower on smaller tributaries is, of course, being recommended across the West, especially for the Pacific Northwest. Selecting higher level, higher elevation hydropower facilities is now coming in as a question, simply because we're seeing the runoff earlier at higher elevations.

The major issue relative to the Pacific Northwest is the spread and scale of those reservoir storage, whereas in the case of the Southwest, we know the broader the reservoir, the more you lose to evaporation. In the Northwest, the limits on evaporation seem to be a lot less. So what ends up happening is that the viability of increasing hydropower in places, especially major tributaries, becomes more viable.

The CHAIRMAN. From a historical standpoint, how do these droughts stack up, in your view, Dr. Pulwarty? I mean, everybody knows—you know, is this the worst, is this the most consequential? How do they stack up compared to the other droughts on record?

Mr. PULWARTY. It's an excellent question, because when we work with water providers, when we work with farmers, the first question we get is not what will happen, but is this something we've seen before. So this becomes a very fundamental question.

In the testimony, I mentioned that the spread, the aerial extent of the drought last year, 2012, which is still continuing in the West, was only exceeded by 1934, which had more months, with over 60 percent of the country in record. What helps us out in this context was that 2011 was wet. The 1950s were, in fact, even more severe in terms of Oklahoma, West Texas, and New Mexico.

There are droughts in the past, however, that have lasted 10 to 20 years that exist in the tree ring record. What was mentioned by pretty much all of the witnesses today was that the viability of our systems during multi-year droughts is what calls this into question.

We've done a fantastic job. I mean, when John Wesley Powell said in the late 1800s we can't develop the Colorado River, we developed it, and we're still there. So a lot of things were put into place that were actually very viable for managing risk. What comes to bear is the comparison between this present drought, 2011, 2012, 2013, and the potential for increased severity of drought conditions from temperature.

When you add a temperature increase on drought conditions, we're not sure what we get. It could actually be more surprising than we think, as occurred during 2002. In the case of many of the vegetation in the Southwest, they've lasted through previous droughts, the 1930s, the 1950s, but a lot of them are not lasting

through this one because of the combination of temperature and dryness. The magnitude of the drought is immense. The temporal, the number of years, we've seen other droughts like this.

The CHAIRMAN. Dr. Webber, one question for you at this point. What are the opportunities for using markets and marketplace forces to improve the situation? I mean, you all are studying at the—I guess it's technically called the Clean Energy Incubator at the University of Texas. I want to go back to school and study in that program. That sounds like good stuff.

But how might markets be used to integrate renewable energy to increase water supplies?

Mr. WEBBER. I think there's an opportunity with policy and technologies. But one thing we have with water is highly dysfunctional markets today. Water is not priced at its real value. It's highly regulated. It's about as far from the market as you can imagine. If we had more of a market system where water was valued, then people would automatically wish to conserve, because we tend to conserve the things that are valuable.

Also, if you had a price for water that matched its actual contribution to society, you might get to see interesting transactions emerge. So one thing I see is that in Texas, we have agricultural users, who are the largest users of water, as with the rest of the Nation. They tend to get the water very cheap or very free. They cannot afford the equipment for irrigation efficiency. It's cheaper to waste the water than to pay for the efficiency.

Next door is the energy sector looking for water for oil and gas production in shale. The energy sector has a lot of money and wants water. The agricultural sector has a lot of water and wants money. Normally, you would just do a transaction and trade money for water. But we're not really set up that way for water markets in Texas or the rest of the United States.

If you did it the right way, the energy sector would give its money to the agricultural sector and get the water. The agricultural sector would have the money it needs to invest in efficiency and would, therefore, still be able to grow its crops, but with less water, making water available for the oil and gas guys and have water available for the streams. So this idea is that markets can make this all more efficient with how it's allocated.

Then there's also the opportunity, once you have a price on water, to pay for integration of renewal energy onsite. You can use wind or solar, which is often located near brackish water, and use wind treated water to make fresh water.

Or you could use onsite—oil and gas facilities that are producing a lot of dirty water from the shale gas production could do onsite treatment with flared gases to make it cleaner. Once you have a price on water, a lot of these things would happen pretty quickly.

The CHAIRMAN. We're juggling Internet taxes, which is extraordinarily important to a State that is being forced against its will under this legislation to go out and collect these online taxes for everybody else in America. So I've got to go to the floor. What I'd like to do is have Senator Murkowski ask any additional questions and make any closing remarks. It's always fitting, really, that she has the last word.

Senator Murkowski, if that's all right with you, why don't you just ask any additional questions—I don't think any other colleagues are going to come—and make any closing remarks that you wish and wrap us up?

Senator MURKOWSKI [presiding]. Mr. Chairman, thank you for the opportunity for just one final comment, and go fight the good fight, because Alaska also doesn't have that sales tax. So I'm with you on that one.

I just wanted to ask one final question, and this is precipitated by your response, Dr. Webber. We're clearly in a situation where at times of low water availability, water shortages, extended periods of drought, and just great uncertainty, we don't know what next year is going to yield. We can look at our farmer's almanac and hope that we are right. But it's tough to predict with real accuracy.

So you're going to have tensions between your user groups. As you point out, the agriculture sector uses far more water. The energy sector likes to believe that they've got more money to play with. So I appreciate your discussion here about the pricing of water.

But are we seeing pushback on specific types of energy development because that energy production might be more water intensive? So you have pushback from the ag sector. You have pushback just from the cities because they recognize that these are issues that are hot. You don't want to raise the cost to the consumer.

But you've got remarkable energy potential sitting just right there, but the process that you would use is more water intensive than others. Are we seeing that type of standoff between user groups right now?

Ms. MULROY. We're not necessarily seeing a standoff, but what we are seeing is a very clear recognition that in areas that are especially water lean, like Nevada, that the type of energy facility that is built makes all the difference in the world.

In 2002, then Governor Kenny Guinn, during the big energy problem in the western United States—and Nevada had the Kern Valley pipeline coming right through southern Nevada—he said, clearly, to all the merchant plant developers, "You will build air-cooled gas plants. You will not build water-cooled gas plants," because the relative difference is 3,000 acre feet for a water-cooled facility versus 300 acre feet for a dry-cooled facility.

All solar is not alike. In Nevada, we want photovoltaic solar rather than thermal solar. Any kind of energy use that is very water intensive is something that isn't appropriate for that particular location. Now, that doesn't mean there aren't other areas where it can be.

What you're seeing more and more is the water sector is becoming extremely energy efficient, because it's its biggest cost factor. States as a whole and whole regions are looking at, given their particular set of circumstances, what are the appropriate kinds of energy to have in that venue.

Senator MURKOWSKI. Does anybody else care to comment on that?

Dr. Webber.

Mr. WEBBER. Yes. I think you've identified properly that there is resistance or stakeholder conflict that can emerge, and it's peacefully done in many cases. What we see is in Texas, which is a pro-oil and pro-gas State, some local areas are looking to prohibit the use of water for oil and gas production. So even a state that sees oil and gas production very favorably sees water as a more important resource and will put in prohibitions or some sort of constraints on that production.

Even though the shale oil and shale gas production might be small water use compared to everything else around, it's the marginal user. They're the new user. So there's already 100 gallons allocated. The next guy wants another gallon. People say forget it.

So we definitely see some pushback, and we see it with power plants as well. People wonder now about whether new power plants should be allowed to have the cooling systems the way they want, looking to Nevada as a model, actually—"Well, Nevada can do dry cooling. Why can't we do dry cooling in our region"—that kind of thing.

So we're definitely seeing it show up in the permitting process, where people are engaging about power plants to talk about the cooling systems. We see it with new water users for oil and gas production. In an ideal world, we could allocate it the right way and get the right efficiencies and systems in place so there's enough water for everybody and enough water left over for nature as well.

Senator MURKOWSKI. It almost makes you wonder as we see more and more in terms of areas that are water lean, as you describe it, Ms. Mulroy, where there will be that push to move out that technology that was viewed as absolutely acceptable—you know, solar thermal—absolutely acceptable, but because of the water intensity, a push to move to other technologies that would provide for the same level of production but using water in a more conservative manner.

I really appreciate the information that you have all put out there. I think that this has been very helpful to the discussion. It is a reminder to us that when we talk about energy and energy production, we can't discuss it in isolation. It has to be in conjunction with the water, the water access and the availability and the certainty of it.

As we see greater uncertainty that is brought about by a changing climate, how we deal with this, how we adapt to it, I think, is going to be a real challenge for us, particularly as we note, and as you have all noted, that this is a very regional situation, but the impacts can go far beyond the region when we look to our Nation's energy consumption.

So thank you for your very thoughtful presentations and the discussion this morning. With that, we stand adjourned.

[Whereupon, at 11:40 a.m., the hearing was adjourned.]

APPENDIXES

APPENDIX I

Responses to Additional Questions

RESPONSES OF NICOLE T. CARTER TO QUESTIONS FROM SENATOR WYDEN

FEDERAL ROLE IN DROUGHT

Question 1. Do you believe we need to be doing more at the federal level to address these impacts? If so, what can we do?

Answer. In 1998, Congress passed the National Drought Policy Act (P.L. 105-199), which created the National Drought Policy Commission. In 2000, the commission submitted to Congress a report with a number of policy recommendations. The report recommended integrating drought information, creating a National Drought Council, and developing a national drought policy with preparedness at its core. To date, Congress has acted on the first of those recommendations with the creation and funding of the National Integrated Drought Information System (NIDIS), which is currently up for reauthorization (S. 376).

Recent drought experiences provide additional information for decision-makers considering the federal role in drought. The USDA-led effort to respond to the 2012 drought under the National Disaster Recovery Framework represented an evolution in federal drought response. It provided a new process for coordinating and leveraging federal resources and actions. Recent droughts also have shown the increasing prominence and use of the Drought Monitor and related tools for communicating conditions and forecasts. NIDIS coordinated a December 2012 National Drought Forum that identified priority actions. In addition to recommending reauthorization of existing drought programs for the U.S. Department of Agriculture, the Bureau of Reclamation, and NIDIS, the forum's priority actions included:

- Prepare or revise drought preparedness plans by federal agencies, states, tribes, communities, utilities, and others;
- Accelerate efforts to build a nationwide integrated drought information system.
- Improve the observations, monitoring, and forecasts related to drought, including the socioeconomic and environmental impacts.
- Pursue a multi-stakeholder intergovernmental process to develop recommendations for a coordinated national drought policy framework.

Over the last 15 years, legislative drought discussions have included the question of whether there is a need for a national drought policy. Similar to discussions of broader federal natural disaster policies and programs, an element of the congressional drought policy debate has been how to structure drought assistance and what and whom to target with assistance. Broadly, assistance can be used to reduce the impacts during the drought, or to promote drought preparedness and drought resiliency so that the economic and social impacts are less when a drought occurs. To date, most federal government assistance primarily aims to ease economic impacts during the drought, with less emphasis on—and fewer results in—promoting long-term resilience and adjustment.

States continue to be the leaders for most drought planning and preparedness activities, in large part because Congress has generally deferred to the state's primacy in intrastate water allocation which largely determines how waters are distributed among competing uses, including during dry conditions. The sophistication, resources, and approaches of these state planning activities vary widely. Drought preparedness and planning efforts ideally are helpful in replacing the need for and expense of unanticipated emergency actions with actions that improve drought resilience and that also may provide benefits in good water years.

ENERGY-WATER NEXUS

Question 2. Given the amount of water needed to produce energy, what is the appropriate federal role in responding to energy's intensive water demands?

Answer. Nationally, the energy sector's water consumption exceeds municipal and industrial use; it is second to agriculture, which represents roughly 70% of consumption.

The energy sector's demand for water varies regionally; the impact of that demand on local competition for water also widely varies depending on available resources and state water rights and access regimes. Decisions about whether to prioritize or restrict water withdrawals or consumption are generally left to the states as part of their water allocation responsibilities. Water quality impacts, rather than water quantity impacts, have received the majority of federal attention.

While the energy sector's access to water supplies is often controlled by the states through water rights or withdrawal permits, the federal government can influence the demand for water by the energy sector. For example, federal policies (and market conditions) that promote greater domestic energy production generally result in more domestic water being used by the energy sector. The federal government also can reduce or dampen the energy sector's demand for water through a variety of mechanisms. Options include tools to:

- promote water-efficient energy sources,
- promote water conservation and efficiency in the energy sector,
- promote energy conservation and efficiency to reduce demand for energy and the embedded water, and
- support research and development of technologies to reduce energy sector water use.

Data collection and assessments also can inform energy and water decision-makers in the public and private sectors. Whether these tools are most appropriately employed by the federal, state, or local governments is part of the ongoing debate about how to respond to energy sector water demands.

Question 3. Several of you raised the need for better data and information in improving energy-water strategies. What steps can we do to make this happen?

Answer. In a series of reports, GAO has documented some of the challenges and gaps in energy-water data. In a 2012 report, GAO stated: "making effective policy choices will continue to be challenging without more comprehensive data and research."[1] Congress has asked for recommendations from the Department of Energy on developing an energy-water research program, but has not received those recommendations to date.[2]

While high-quality data and information are important to informed decision-making, there are expenses associated with data collection, quality control, and analysis; there also are challenges to maintaining current and consistent data sources over extended time frames. This is particularly true for a rapidly changing and mobile energy industry. Discussion of questions like the following may help focus limited federal resources:

- Which decisions—federal, state, local, or private—are being targeted for improved data inputs?
- What are the data gaps associated with the most significant decisions?
- Which decisions could most benefit from improved information?
- Are there existing data efforts on which to build?
- Who owns or has access to the data and under what conditions will this data be provided or shared?

Much of the U.S. energy sector—and thus a significant portion of energy-related research—is private. When devising an approach, policy-makers must weigh what data is important, what proprietary data may be collected, whether to protect such data, and if so, how. While the private nature of some data complicates collection and management, it is not uncommon for the government to face this issue when compiling industry-related information. Early and regular energy industry input into the development of efforts to increase energy-water data collection may facilitate acceptance and implementation and avoid costs and conflicts.

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[1] U.S. Government Accountability Office, Energy-Water Nexus: Coordinated Federal Approach Needed to better Manage Energy and Water Tradeoffs, GAO-12-880, September 2012, http://www.gao.gov/assets/650/648306.pdf.

[2] Congress in §979 of the Energy Policy Act of 2005 (P.L. 109-58, 42 U.S.C. 1639) requested that the Secretary of Energy submit to Congress recommendations for future actions for a research program related to energy sector water use and water sector energy use; the recommendations have not been delivered to Congress.

A challenge of relying on existing sources of data is achieving consistency when compiling information collected from multiple state, local, and private sources. Many of the energy industry's water-related actions are determined by state or local laws and regulations, and most water-related compliance information, if collected, is submitted to local or state agencies. Compiling data into a single national database, therefore, is complicated by the degree to which the private energy sector is required to or chooses to release information, the amount and types of information that the states or local entities choose to collect and share with the federal government, and the consistency and comparability of data from different states.

Access to energy-water research is changing. Efforts are underway at the Department of Energy to organize energy-water related studies on a publicly-available online platform.[3] Additionally, in February 2013 the White House Office of Science Technology and Policy released a memorandum that directs U.S. funding agencies with over $100 million in annual research expenditures to develop a plan to support public access to the results of federally funded research.[4] Agency implementation of the directives in the memo may influence the availability of some research results relevant to energy-water issues and their management.

WATER MANAGEMENT

Question 4. What role can and should new water storage projects play in meeting our country's water needs during times of drought?

Answer. GAO is in the process of updating its survey of states' views on water supply issues. In 2003, GAO published the results of its original survey of states' views. At the time, GAO found that "state water managers reported their highest priority was more federal financial assistance to plan and construct their state's freshwater storage and distribution systems and also favored having more input in federal facilities operations."[5]

How to adapt to drought risk and whether to construct additional storage or pursue other water supply techniques (e.g., aquifer recharge, desalination of brackish waters, reuse of wastewaters, reallocation of existing storage, water conservation, water efficiency, water transfers) are decisions generally left to the state, local, quasi-public, nonprofit, and private entities responsible for supplying water. Their decisions are likely to be shaped by the cost of the alternatives, their reliability during droughts, and other factors (e.g., opportunities and tradeoffs for hydropower, recreation, protected species, etc.).

Question 5. A few of you mentioned water infrastructure in your testimony, and I would ask that the panel expand on the connection between aging water infrastructure and drought and what needs to be done to better manage our infrastructure?

Answer. Water resources infrastructure and urban water treatment and distribution infrastructure is aging. Drought highlights the consequences of aging and older infrastructure, such as reduced reservoir capacity due to sedimentation, reduced reservoir capacity due to pool restrictions for dam safety reasons, water leaks in urban distribution systems, and inefficiencies from unlined and uncovered irrigation canals. Decisions about whether to invest in upgrades to infrastructure are shaped by the financing available for the upgrades and their cost-effectiveness and reliability compared to other water supply augmentation alternatives.

For reservoirs, sediment accumulation reduces storage capacity. In the United States, sedimentation restrictions on capacity are increasing as reservoirs age, particularly for the smaller rural water supply reservoirs that were built with anticipated useful lives of 50 to 100 years. For example, a number of reservoirs in the Central Plains have lost from 20% to 50% of their original useable storage volume.[6] While many of these reservoirs were initially constructed with U.S. Department of Agriculture assistance, they are locally owned and maintained, thus raising the question of the federal role in these facilities and in supporting rural water supplies. While structural modifications can help pass additional sediment downstream, oper-

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[3] The site links to over 150 articles and reports related to the energy-water nexus: http://en.openei.org/wiki/Water_and_energy_studies.

[4] John P. Holdren, Increasing Access to the Results of Federally Funded Scientific Research, Executive Office of the President, Office of Science and Technology Policy, Memorandum for the Heads of Executive Departments and Agencies, Washington, DC, February 22, 2013, http://en.openei.org/wiki/Water_and_energy_studies.

[5] U.S. General Accounting Office, Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages, GAO-03-514, July 2003, http://www.gao.gov/assets/160/157452.pdf.

[6] "From Dust Bowl to Mud Bowl: Sedimentation, Conservation Measures, and the Future of Reservoirs," Journal of Soil and water Conservation, vol. 65 (January/February 2010). Hereafter referred to as "From Dust Bowl to Mud Bowl" 2010.

ational changes and soil conservation management are part of the portfolio of response options.

For federal reservoir facilities, the following is known.

- Of more than 600 reservoirs operated by the U.S. Army Corps of Engineers, less than 10% were reported as having water supply operations restricted by sedimentation. The majority of the impacted reservoirs were located in the Tulsa District, which covers most of Oklahoma and southern Kansas.[7]
- About 35% of Bureau of Reclamation reservoirs have been surveyed, and according to survey results, about 5.4 million acre-feet of storage capacity has been lost to sedimentation.

In order to protect public safety below dams with safety deficiencies, a common interim measure for higher-risk dams is to put into place reservoir pool restrictions. For federal facilities, the following is known.

- A number of Army Corps of Engineers facilities have restrictions involving lowered pools or restrictions on flood control pools. Some of these are in areas impacted by drought, such as Isabella Dam in California, which has its capacity reduced to 63% of normal; Wolf Creek Dam in Kentucky (with repair work to be completed in late 2013); and Martis Creek Dam in California (at the confluence of Martis Creek at Truckee River near the Nevada border). Other Corps projects with dam safety concerns that may produce pool restrictions are spread across the country; for example, Moose Creek, Alaska; Success, California; Herbert Hoover, Florida; Clearwater, Missouri; Canton, Oklahoma; East Branch, Pennsylvania; and Center Hill, Tennessee.
- For the Bureau of Reclamation, two dams were experiencing pool restrictions for safety concerns in the winter of 2012-2013: Guernsey Dam in Wyoming, with a restriction reducing storage of a 73,810-acre-foot-capacity reservoir by 4,656 acre feet (6%); and Red Willow Dam in Nebraska, which is a 86,630-acre-foot reservoir undergoing repairs, has its storage reduced by 79,885 acre feet (92%).[8]

These restrictions may be removed if actions are taken that relieve the safety concern.

How to manage the aging federal water resource infrastructure, prioritize reinvestment, make new investments (e.g., levees and coastal storm protection measures), and share responsibilities between the federal government and nonfederal beneficiaries remains a topic of discussion. For example, federal investments in Corps dam safety assessments and rehabilitation projects are playing an increasing role in the agency's portfolio and asset management strategies are increasingly being investigated and studied.[9] Efforts to significantly increase actions to address these issues through federal fiscal resources are challenged by the current federal fiscal climate.

Question 6. Much of the attention during the 2012 drought was focused on the lack of precipitation, soil moisture, and surface waters, but I am curious to know, what role does groundwater management play in drought resiliency? How are states and others managing this resource?

Answer. Not only do aquifers provide underground storage, but also they often underlay areas without convenient access to surface waters. The convenience of groundwater is one of its major attractions as a water supply; this convenience can result in aquifers being used not only during dry years but also during good water years (which may reduce groundwater availability during dry years). About 40% of the nation's public water supply and much of the water used for irrigation is provided by groundwater.[10]

How groundwater was used during the 2012 drought remains largely unknown at this time, but information and analyses are likely to be forthcoming as agricultural surveys and state and local monitoring data become available.[11] Long-term trends provide some of the most useful insights into the use, reliability, and management of groundwater resources. A 2013 U.S. Geological Survey (USGS) report of ground-

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[7] M. Jonas, F. Pinkard, and J. Remus, "USACE Reservoir Sedimentation: Data, Assessment, and Guidance," 2nd Joint Federal Interagency Conference, Las Vegas, Nevada, June 27July 1, 2010.

[8] "From Dust Bowl to Mud Bowl" 2010.

[9] National Research Council, National Water Resources Challenges Facing the U.S. Army Corps of Engineers, Washington, DC, 2011, http://www.nap.edu/catalog.php?record_id=13136.

[10] National Research Council, Investigating Groundwater Systems on Regional and National Scales, Washington, DC, 2000, http://www.nap.edu/catalog.php?record_id=9961#toc.

[11] The U.S. Geological Survey (USGS) provides online access to "Groundwater Watch," a national database of groundwater wells that includes current or recent conditions. The monitored wells in the database, however, are not evenly distributed nationally or regionally.

water depletion from 1900 to 2008 found that "the rate of groundwater depletion has increased markedly since about1950, with maximum rates occurring during the most recent period (2000-2008)."[12]

Like surface waters allocations, management of aquifers is largely a state responsibility; some states choose to create special groundwater management or conservation districts. The management approaches for aquifers vary widely; the approaches taken can be influenced by physical factors such as how quickly an aquifer is recharged and its connectivity to surface waters, as well as by social preferences to maximize groundwater availability during dry years or for regular use as a water supply. Groundwater depletion (and the consequent land subsidence) is well known in many parts of the United States, and in some regions aquifer management is less about trying to reverse depletion and more about managing the decline to prolong benefits, including water supplies during dry years.

Kansas in 2012 took steps to allow water permit holders greater flexibility in when they withdraw water. Most state water right holders may apply for a multi-year flex account; the account provides for a five-year permit that temporarily replaces an existing annual water right. The permit allows the holder to exceed the annual quantity but restricts total pumping over the five-year period. How this regime performs as a business risk management tool for irrigated agriculture, and its impact on aquifers during the five-year period that started with the 2012 drought, are likely to be closely tracked. Kansas is one of the western U.S. states, like Washington and Idaho, which use the same water allocation system for both surface and groundwater. This conjunctive approach is particularly relevant in regions where groundwater significantly contributes to the baseflow in streams.

Groundwater depletion or contamination raises concerns about drought and low water resiliency. This is because aquifers often function as multi-year storage reservoirs that are drawn upon most heavily in dry times. Also for water users that are distant from surface supplies, groundwater can be difficult and costly to replace if aquifers are overdrawn or contaminated.

Responses of Nicole T. Carter to Questions From Senator Murkowski

Question 1. Please further describe how water resource opportunities and challenges in meeting energy demand vary regionally within the United States.

Answer. Most energy sector water-related opportunities and challenges fall under one of the following three energy topics:

- energy resource extraction and processing,
- electric generation, and
- electric grid reliability.

The response below is organized around these topics and how they manifest themselves regionally.

For most energy resource extraction, processing, and use, water is either an essential input or one that is difficult or costly to substitute for, and degraded water is often a waste byproduct. Regional water resource opportunities and challenges related to energy will vary based on:

- which energy resources are being developed in the region,
- the local and regional significance of the energy sector's water use, and
- the regional conditions for management of energy sector wastewaters.

Each energy resource, technology, and practice uses water differently and has different impacts on water resources. For example, water is essential to the coal production. It manages dust in mining activities and is the basis of coal slurry for transport. Dewatering of some surface and underground mine sites produces wastewaters requiring management. Surface mining sites can alter runoff and infiltration patterns and may degrade water quality. Surface mine remediation often requires water for revegetation. Inadequate mine tailings and wastewater management techniques may pose risks to water supplies and ecosystems. Regions with coal mines therefore will have these water issues to manage. Whether the water that is used in the coal process for activities like managing dust, slurry transport, and mine remediation is significant will depend on the local availability of water and the other demands for that water locally and regionally.

As of early 2013, no authoritative data on the freshwater consumed in energy resource extraction and processing across the range of conventional and unconven-

[12] L. F. Konikow, Groundwater Depletion in the United States (1900-2008), U.S. Geological Survey, Scientific Investigations Report 2013-5079, Reston, VA, 2013, http://pubs.usgs.gov/sir/2013/5079/SIR2013-5079.pdf.

tional fossil fuels and processes existed. Existing data sources were either incomplete or relied on sources that did not reflect current practices. This has thwarted efforts to accurately compare freshwater inputs across fossil fuel and renewable energy alternatives. From the available data, a few relative relationships do appear to hold. The spectrum of water intensity of fuels starts with conventional gas at the lowest end, coal and unconventional gas next, followed by oil, and irrigated biofuels is at the upper end.[13] For oil, the relative water intensity of conventional and unconventional oil remains unclear. Similarly, few data sources are available for comparing the range of produced water quantities and qualities derived from both conventional and unconventional fuel extraction and processing activities.

In addition to the energy sector being a rapidly growing consumer of water, the fossil fuel-water relationship represents a vulnerability for the development and use of these energy resources. The most salient vulnerability is disruption of fossil fuel extraction, processing, and use due to water quality or quantity constraints. Fossil fuel transport also may be disrupted by water conditions, such as flood-induced pipeline breaks resulting from riverbed scouring, flood-or storm-related refinery or distribution system disruptions, and drought-or flood-impaired fuel transport.

The energy-water resource relationship is not only about how a region's fossil fuels extraction and processing impacts local and regional water resources, but also about how the power sector uses water resources and is vulnerable to local and regional water conditions. Water availability problems, such as regional drought, low flow, or intense competition for water, can pose a risk to electric power production, particularly hydroelectric and thermoelectric generation. During low-flow or drought conditions (or high-heat events), which often occur during the hot summer season, water intakes and high water temperatures may harm or limit thermoelectric power plant cooling, potentially forcing facilities to scale back generation during high demand. While alternatives are available to reduce the water needs of power plants, many of the available alternatives come at higher cost and may reduce operational efficiency and electric output.

The two common cooling methods are once-through cooling and evaporative cooling. Once-through cooling pulls large quantities of water off a water body, discharges the power plant's waste heat into the water (which may raise the temperature of the withdrawn water by 10° to 20°F), then returns the majority of the withdrawn water. Once-through cooling, while largely a non-consumptive water use, requires that water be continuously available for power plant operations. This reduces the ability for this water to be put toward other water uses and can make cooling operations vulnerable to low streamflows. Most once-through cooling facilities are in the eastern United States and are associated with older facilities. Many coastal facilities also use saline water for once-through cooling. Evaporative cooling withdraws much smaller volumes of water for use in a cooling tower or reservoir, where waste heat is dissipated by evaporating the cooling water. Evaporative cooling consumes water. Many power plants operating in water-abundant regions use once-through cooling, while newer facilities and facilities in more arid regions often use evaporative cooling and are increasingly considering dry or hybrid cooling.

Once-through cooling using both fresh and saline waters has raised concerns about impacts on ecology (e.g., impingement and entrainment of aquatic species) and quality of the receiving water body (e.g., elevated temperature and chemicals of the discharged cooling water). Consequently, the regulatory context of a power plant often will significantly shape the choice of cooling technologies. While the siting of power plants may be shaped by access to water for cooling, often siting is driven more by access to transmission, fuel supplies, and demand centers.

While the water intensity of natural gas as a fuel depends on how it is extracted, natural gas-fueled generation is generally less water-intense and less water-dependent than coal-powered electricity. This is because many gas-fueled electric facilities use engine-based technology that requires no or considerably less water for cooling. Therefore, displacement of coal generation by natural gas generation may reduce the future water footprint of power generation.

An assessment of the drought vulnerability of electricity in the western United States found the majority of basins showing limited risk under most scenarios and found that the risk that did exist was amenable to mitigation by known strategies,

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[13] International Energy Agency, World Energy Outlook 2012, Paris, 2012; E. Mielke, et al., Water Consumption of Energy Resource Extraction, Processing, and Conversion, Cambridge, Massachusetts: Harvard Kennedy School, 2010; World Energy Council, Water for Energy, London: World Energy Council, 2010.

maintaining excess generation and transmission capacity.[14] That is, while examples exist of low water conditions curtailing generation from particular thermoelectric facilities in the western United States, generation shortfalls can be made up by increasing generation at other facilities or purchasing power from other sources or grids. While these actions maintain the level of service provided, they typically increase the cost of service for utilities and their customers. While identifying broad resiliency, the western U.S. assessment revealed two regions whose electric generation was at greater risk—the Pacific Northwest and Texas. The Pacific Northwest was shown to be vulnerable because of its heavy reliance on hydroelectric generation. The Texas grid was vulnerable because of heavy dependence on thermoelectric generation that relied on surface water for cooling and because of the region's high drought climate hazard.

In 2012 drought covered nearly 80% of the contiguous United States, and many locations experienced record heat. Generation was curtailed at a number of thermoelectric facilities, and low river conditions raised concerns about the transport of fossil fuels. However, no significant grid reliability problems developed. Instead, it appears that the 2012 drought had a greater impact on ethanol production than it did on electric generation. This contrasts to the Texas electric grid during the summer of 2011, when the state was experiencing intense drought and heat.

In the summer of 2011, high heat in Texas resulted in increased demand for electricity, and power plants were operated for extended periods at maximum capacity. The operator of the grid that covers 75% of the state and 23 million people put into effect its emergency action alert system, which at first recommended conservation by customers but eventually deemed customer conservation critical to avoid rotating outages. In the end, only one plant on the Texas grid had generation curtailed due to lack of water in the summer of 2011; others were nearing curtailment when the weather conditions improved. During and after the summer of 2011, power plant operators reduced their low water vulnerability by building pipelines to alternative and impaired water sources, acquiring additional water rights, lowering water intake structures, and installing additional groundwater pumping capacity.[15]

The Texas grid is particularly drought-vulnerable due to its limited connections to the other U.S. grids, which reduce the ability to purchase power to offset generation curtailment. During a few days of summer 2011, the peak demand purchases in the real-time wholesale electricity market for the Texas grid traded at or near the market cap (i.e., $3,000 per megawatt-hour). After the 2011 drought experience, the Texas grid operator instituted changes to reduce its water vulnerability. All new generation facilities as of 2013 must provide proof of water rights before they can be included in the grid planning that largely determines grid access. To date, little data is available on the extent to which low-water renewable technologies may be used to mitigate the Texas grid's drought risks.

As of early 2013, no similar assessment of drought vulnerability for electricity in the eastern United States had been performed. There are facilities in the eastern United States that have had to curtail operations in the past due to low flow conditions; the lost generation is made up elsewhere in the grid. Curtailments of thermoelectric power facilities in the eastern United States are most likely due to concerns that discharges from once-through cooling systems will increase the temperature of the receiving body to an environmentally unacceptable level that harms aquatic fish and plants.

Question 2. Please describe which federal agency should be responsible for leading initiatives regarding our nation's energy system and the availability of water to support it.

Answer. While some countries and U.S. states have water departments or agencies, the federal government in the United States does not have a single entity managing water-related programs and activities. Instead the federal water-related work is distributed across a wide array of agencies.[16] It is in the federal agencies that manage or are responsible for various sectors of the economy, society, and the environment that rely on and use water that Congress and the executive branch generally have placed water initiatives. For example, water initiatives and programs that primarily address water quality and relate to drinking water and wastewater treatment are housed at the U.S. Environmental Protection Agency. The Department of State and the U.S. Agency for International Development oversee U.S. ef-

[14] C.B. Harto, et al., Analysis of Drought Impacts on Electricity Production in the Western and Texas Interconnections of the United States, Oak Ridge, Tennessee: U.S. Department of Energy, 2011.

[15] Ibid.

[16] For more information, see CRS Report R42653, Selected Federal Water Activities: Agencies, Authorities, and Congressional Committees, by Betsy A. Cody et al.

forts related to water as it affects international development and international relations. The U.S. Geologic Survey typically has focused on water science and data as part of natural cycles and the human environment.

Question 3. Within your work at the CRS, you have posed several interesting questions as it relates to the energy-water nexus. In one instance you ask, "Are states being unfairly burdened with the responsibility of increased water use and competition resulting from federal energy policies, or is this part of the responsibility that comes with state primacy in water allocation?" Do you have any additional insight to this question now?

Answer. The CRS question referenced was posed in CRS Report R41507, Energy's Water Demand: Trends, Vulnerabilities, and Management, by Nicole T. Carter; the context of the question included data indicating that the energy sector's water demands are growing in the United States, and as part of a broader discussion of perspectives on how to respond to the energy sector's growing water demand and water vulnerability, and who bears the cost. GAO in a 2012 report stated that "it is important for Congress and federal agencies to consider the effects that national energy production and water use policies can have at the local level."[17]

Nationally, the energy sector's water consumption exceeds municipal and industrial use; it is second only to agriculture, which represents roughly 70% of consumption. Projections attribute to the energy sector 85% of the growth in domestic water consumption between 2005 and 2030. The energy sector is the fastest-growing water consumer in the United States. This projected growth derives from anticipated demand for more energy, increased development of domestic energy sources, and greater use of water-intense energy alternatives. From 2005 to 2010, much of the growth in the energy sector's water consumption was attributed to the expansion of corn-based ethanol as part of the transportation fuel mix, in response in part to production incentives and consumption mandates.

Much of the energy sector's growth in water demand is concentrated in water-constrained or drought-susceptible regions. The High Plains—consisting of portions of Texas, New Mexico, Colorado, Kansas, Nebraska, Wyoming, and South Dakota—is one example of a low-rainfall area. Much of the High Plains has faced water supply issues for decades, such as the declining level of portions of the Ogallala aquifer since the mid-1960s.[18] Expansion of biofuels in this area is an additional demand exacerbating already competing water uses.

Federal actions that promote energy conservation and efficiency likely reduce not only energy consumption but also the water embedded in the avoided consumption of energy. The water savings benefits of recent federal promotion of and investments in energy efficiency and conservation have not been reported. Similarly, the water savings benefits of federal support for less water-intense energy, such as wind and photovoltaic electric generation, also have not been reported.

Response of Nicole to Carter to Question From Senator Flake

Question 1. Last year, the Director of National Intelligence issued an assessment on Global Water Security, finding that poor water quality and shortages will lead to global instability. What lessons and expertise can water managers in the United States share with water managers in other countries to assuage water conflicts and add to global stability with regard to water issues?

Answer. As Senator Flake notes, a February 2012 Intelligence Community Assessment of Global Water Security[19] illustrates the strengthening view of water as critical not only to public or environmental health but also to political stability, food and energy supplies, and climate change mitigation and adaptation. Specifically, the report warns that water is anticipated to increasingly contribute to instability in nations important to U.S. national security interests. At the same time that water can have international security implications, governments often closely guard their authority and ability to manage and use their domestic water resources. Some activities that may improve water management include development of water-related expertise (e.g., training of water ministry staff, facility operators, climate and agricultural scientists, and civil engineers); exchange of experiences (e.g., drought and flood

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[17] U.S. Government Accountability Office, Energy-Water Nexus: Coordinated Federal Approach Needed to better Manage Energy-Water Nexus: Coordinated Federal Approach Needed to better Manage Energy and Water Tradeoffs, GAO-12-880, September 2012, http://www.gao.gov/assets/650/648306.pdf.

[18] For more on and a map of the aquifer, see V. L. McGuire, Changes in Water Levels and Storage in the High Plains Aquifer, Predevelopment to 2005, USGS, USGS Face Sheet 2007-3029, 2007, http://pubs.usgs.gov/fs/2007/3029/.

[19] Intelligence Community, Global Water Security, Office of the Director of National Intelligence, February 2012, http://www.dni.gov/nic/ICA__Global%20Water%20Security.pdf.

monitoring and forecasting), best practices, and lessons learned; and sharing appropriate environmentally sound technologies and know-how.

While the Intelligence Community Assessment of Global Water Security does not include recommendations, the following findings are of note and may be helpful in identifying actions consistent with the ICA findings.

Resource Management

- "Between now and 2040, fresh water availability will not keep up with demand absent more effective management of water resources."
- ". . . from now through 2040, improved water management (e.g., pricing, allocations and 'virtual water' trade) and investments in water-related sectors (e.g., agriculture, power, and water treatment) will afford the best solutions for water problems."

Agricultural Efficiency

- "Without mitigation actions (e.g., drip irrigation, reduction of distortive electricity-for-water pump subsidies, improved use of agricultural technology, and better food distribution networks), the exhaustion of groundwater sources will cause food production to decline and food demand will have to be satisfied through increasingly stressed global markets."
- "Because agriculture uses approximately 70 percent of global fresh water supply, the greatest potential relief from water scarcity will be through technology that reduces the amount of water needed for agriculture."

Technologies and Knowledge

- "The United States will be expected to develop and disseminate satellite and other remote sensing data and hydrological modeling tools that allow users to better understand and manage their resources."
- ". . . the absence of good hydrological modeling and water flow/level measurements (from the ground or via remote sensors) creates distrust among nations sharing a common basin."
- "Although the United States is recognized as a leader in water technology, other countries have identified research in water technology and will challenge US leadership over time."

Cooperative Forums

- "New or updated international agreements would lessen the risk of regional tensions over water."

On March 22, 2012, the U.S. Department of State released the Intelligence Community Assessment on Global Water Security and launched the U.S. Water Partnership (USWP), which is focused on technology and expertise transfer from the United States to international clients. The USWP was presented as a means to address the increasing demand for U.S. assistance and expertise identified by the Intelligence Community. USWP is a U.S.-based public-private partnership established to unite American water expertise, knowledge, and resources, and mobilize those assets to address water challenges internationally. USWP members include the Department of State, a number of federal agencies (e.g., U.S. Army Corps of Engineers), a variety of private companies, academic and professional groups (e.g., Environmental Law Institute, University of North Carolina Water Institute), and nonprofit entities (e.g., World Resources Institute). The intent is to facilitate international organizations and government identification of and access to the "best of U.S." water expertise and technologies. In the long run, the goal is to turn global water issues into an opportunity to apply and expand current U.S. water leadership. This is to be achieved by improving access to U.S. water knowledge, building capacity internationally through U.S. knowledge, and facilitating U.S. private and public water partnerships and expert teams addressing international water challenges.

One of the more visible water outcomes from the United Nations Conference on Sustainable Development (UNCSD or "Rio+20") on June 20-22, 2012, in Rio de Janeiro, Brazil, was the commitment by 45 chief executive officers representing a range of global companies to advance corporate water management practices (e.g., develop policies and incentives to improve water productivity and efficiency), as part of the U.N. Global Compact, and their call on governments to make global water security a top priority.[20] This type of corporate commitment and call for action by

[20] United Nations, "Rio+20: Business Leaders Commit to Water Sustainability at Rio+20; In Special Communiqué, CEOs Urge Complementary Action From Governments," press release, June 18, 2012, http://www.unglobalcompact.org/news/240-06-18-2012.

governments is representative of two trends. The corporate commitment illustrates how many actors are looking for solutions among their peers and through collaborations with others, rather than as a direct outcome of U.N. forums and activities. The call for government action represents that water is seen as one area that requires government action because it creates a collective risk to business and society, through flooding, scarcity, and pollution, and that addressing the complexity of water problems often exceeds the influence and resources of individual companies or citizens.

RESPONSES OF ROGER S. PULWARTY TO QUESTIONS FROM SENATOR WYDEN

FEDERAL ROLE IN DROUGHT

Question 1. Do you believe we need to be doing more at the federal level to address these impacts? If so, what can we do?

Answer. Past planning and responses to anticipate, manage, and reduce the impacts of drought have been successful for smaller droughts. However, the major events of 2012 illustrated that more could be done at the federal level to address drought impacts.

Additionally, the National Integrated Drought Information System (NIDIS), with its many partners, has made great strides in addressing drought early warning and drought impacts across the United States (U.S.). In December 2012, NIDIS convened high-level drought experts and stakeholders from all levels of government and the private sector in a National Drought Forum, and the resultant report[1] highlighted the need to increase public awareness, communication of drought-related information, and drought monitoring programs, and recommends actions such as the reauthorization of NIDIS and the expansion of Memorandums of Understanding among federal agencies to increase interagency collaboration. Also, in 2012, the Administration implemented the National Disaster Recovery Framework (NDRF) to respond to the drought impacts affecting the country. This foundational work is contributing to additional collaboration and information-sharing regarding drought across the federal agencies. As part of the President's Climate Action Plan, the Administration is leveraging the work of NIDIS, the recommended actions from the National Drought Forum, and the NDRF and launching a cross-agency National Drought Resilience Partnership. The National Drought Resilience Partnership will be a "front door" for communities seeking help to prepare for future droughts and reduce drought impacts. By linking information (monitoring, forecasts, outlooks, and early warnings) with drought preparedness and longer-term resilience strategies in critical sectors, this effort will help communities manage drought-related risks.

ENERGY-WATER NEXUS

Question 2. Given the amount of water needed to produce energy, what is the appropriate federal role in responding to energy's intensive water demands?

Answer. While NIDIS has no direct role in establishing energy policy and regulations, it could play an important role in conducting applied research and developing services that meet societal challenges by ensuring the best available monitoring and research informs management and practice and by disseminating this information. Agencies like DOE and others could have important contributions to this discussion and could play a role in encouraging efficiency in water used for energy development and production and/or encouraging new technology development.

One of the primary objectives of the original NIDIS Act of 2006 addresses the provision of a comprehensive drought early warning information system that:

> collects and integrates information on the key indicators of drought in order to make usable, reliable, and timely drought forecasts and assessments of drought, including assessments of the severity of drought conditions and impacts. . . and communicates this information to policy and decision makers at the federal, regional, state, tribal, and local levels of government; the private sector; and the public.

Water supplies and availability are under stress in multiple areas across the U.S. Some of these areas have longstanding issues related to water stress such as the Colorado River and the Rio Grande River Basins, and these challenges are likely to increase with development and climate change. Furthermore, water stress from multiple competing demands has developed even in areas that receive relatively

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[1] http://www.drought.gov/drought/content/national-drought-forum-summary-report-and-priority-actions

good annual rainfall (e.g. 40-50 inches) such as the Apalachicola-Chattahoochee-Flint (ACF) River Basin, parts of North Carolina, and the Tennessee River Valley. One of the roles NIDIS and its partners play is in leveraging existing federal, tribal, state, and local data and information, improving where necessary, and ensuring information about vulnerability and risk is being communicated to specific sectors, such as the energy-water sectors, to reduce impacts and costs associated with drought. NIDIS has undertaken such actions in several of its systems, such as the ACF Early Warning System, by serving as a coordinating mechanism or platform for identifying data gaps; integrating sources of information from federal, state, tribal, and local entities; and communicating this information through the U.S. Drought Portal,[2] drought outlook forums, and directly to decision makers through our network of partners. Improving links between drought and water resources plans remains critical.

NIDIS has been able to play an authoritative role in coordinating and disseminating information. As areas coping with water stress continue to develop and evolve, it will be critical for NIDIS to continue its work.

Question 3. Several of you raised the need for better data and information in improving energy-water strategies. What steps can we do to make this happen?

Answer. Several agencies, including DOE, EPA, USGS, and others have important contributions to make in this discussion. From NIDIS' perspective, steps that we can take to make this happen are:

(1) Improve the process for water consumption and withdrawal data submissions from the energy sector to the U.S. Energy Information Administration (EIA) database.—In response to a 2009 GAO report,[3] and in conjunction with the U.S. Geologic Survey, EIA has been implementing improvements to its collection of water data; however, a recent study funded in part by NOAA[4] may suggest additional avenues for improving EIA's data collection. The study results have been provided to EIA for review.

(2) Continued monitoring of weather and climate conditions.—National monitoring systems are critical for understanding current and anticipated drought conditions. For instance, USGS stream gauges, SNOTEL measurements, satellite measurements, and daily surface and upper-air weather and radar observations, including derived rainfall products, are important components of our monitoring systems.

Soil moisture, which is the water stored in the upper soil layer, is a crucial variable in a number of issues: drought and flood forecasting, predicting agricultural drought impacts, managing water resources, and mitigating wildfire risk. Soil moisture measurements are used to estimate rainfall runoff, which is important for forecasting droughts or floods, and are an important variable for driving streamflow and weather forecast models.

Evapotranspiration and evaporation measurements are also important for drought monitoring and forecasting. Both evapotranspiration and evaporation represent an important part of the water cycle—when water is returned to the atmosphere from the Earth's surface. Evapotranspiration rates impact how much water is available to recharge aquifers or for streamflow. As noted in the December 2012 USDA-DOC MOU, an improved soil moisture monitoring network would provide a more comprehensive view of drought conditions in the U.S. Data from the coordinated network will improve the Nation's ability to assess current conditions as well as contribute to predicting the likelihood of future drought.

(3) Power companies effectively use drought indices and indicators as management triggers, thereby reducing potential risks ahead of time.—In addition to enhancing current monitoring, understanding how to use the information we already have is also important. Power companies may use streamflow, groundwater, reservoir levels, rainfall, the U.S. Drought Monitor, or any number of other indices to make management decisions regarding water supply management at all stages of drought. However, determining how to use these indicators and indices without acting too soon, which could result in unnecessary restrictions, or waiting too long to take action, which could result in a water shortage, must be carefully calculated and assessed. NIDIS engages the NOAA Regional

[2] www.drought.gov

[3] Energy-water nexus: Improvements to Federal Water Use Data Would Increase Understanding of Trends in Power Plant Water Use, U.S. Government Accountability Office, GAO-10-23, Oct 16, 2009: http://www.gao.gov/products/GAO-10-23

[4] Averyt, K., J. Macknick, J. Rogers, N. Madden, J. Fisher, J. Meldrum, and R. Newmark (2012) Water use for electricity in the United States: an analysis of reported and calculated water use information for 2008. Environ. Res. Lett. 8 015001 doi: 10.1088/1748-9326/8/1/015001

Integrated Science and Sectoral Applications Programs to produce impacts assessment and decision support tools which could assist power companies in this planning.

(4) Continue groundwater monitoring and research, particularly those that focus on interactions between groundwater and surface water. According to a 2011 report by the Subcommittee on Ground Water of the Advisory Committee on Water Information:[5]

> "Ground water is the source of drinking water for nearly 130 million Americans each day. . ..Although overall water use in the United States has been relatively steady for more than 20 years, ground-water use has continued to increase, primarily as a percentage of public supply and irrigation."
>
> ". . . The Nation's ground-water resources are under stress, and increased interstate and national attention is needed to assure sustainable use of the resource."
>
> ". . . Impacts include declining water levels and contamination of ground water from chemical use and waste disposal. Increased ground-water demand is expected in all sectors of the economy, including the heavy-use sectors of agriculture, drinking water, and energy production."

Farming communities have survived through the Great Plains' droughts by pumping groundwater from the region's aquifers. The levels of those aquifers have been dropping at an accelerating pace. A number of states and the USGS have issued reports in recent weeks highlighting sharp drops in regional water levels due to increased groundwater pumping. From 2001 to 2008 groundwater withdrawals have accounted for 32 percent of the cumulative depletion over the course of the entire 20th century. In some locations, water table levels have fallen 160 feet since the mid-20th century. Recharge is a slow process even in wet conditions and virtually non-existent during drier periods. Farmers have to lean more heavily on groundwater in the absence of precipitation as happened on the Rio Grande and Pecos rivers last year, and continue to do so this year so far. Among the High Plains states, only Kansas mandates that its farmers meter their water use, a good example to follow. In other areas, water managers have to assemble a massive amount of indirect data—from the power usage of water pumps to test wells to meteorological data—to try to estimate how much water is being used in a given year. Enhanced groundwater monitoring and research will help power companies to assess their water supply vulnerabilities during drought.

(5) Explore providing drought outlooks tailored to the energy sector on short (seasons to years) and longer-term (years to decades) time scales.—These outlooks would be produced at the seasonal to decadal scale to inform real-time decisions of water managers and power companies, as well as their long-term plans. NOAA, through its mission "[t]o understand and predict changes in climate, weather, oceans, and coasts, and to share that knowledge and information with others," is a major provider of climate data and information services for the nation. NOAA's role in leading NIDIS uniquely positions the agency to partner with other agencies and the public and private sectors to ensure the nation has the information it needs to support energy security. The largest growth in freshwater consumption by the energy sector is expected in the Southwest, the Northwest, and the High Plains. These regions are already experiencing intense competition over water and disputes over river and aquifer management, and some are projected to experience increased water shortages in the future, due to climate change and other factors. Through NIDIS and its regional partners, NOAA has shown its ability to work effectively with other agencies including USACE, DOI, USDA, and with state and tribal governments on drought and water resources. NOAA will extend these successful partnerships to include the Department of Energy (DOE) and state energy departments in these regions by investing in and providing data and research that informs decision-making and expands technology choices. The Secure Water Act (42 U.S.C 10361-10370) directs federal water and science agencies to work together with states and local water managers to plan for climate change and other threats to water supplies and to take action to secure water resources for communities, economies, and ecosystems. NOAA is identified in the Secure Water Act as a source for the

[5] National Ground-water Monitoring Network - Results of Pilot Studies, The Subcommittee on Ground Water of the Advisory Committee on Water Information, 2011. May be accessed at: http://acwi.gov/sogw/index.html

credible science required by other agencies, state, tribal, and local decisions makers, and the private sector.

WATER MANAGEMENT

Question 4. What role can, and should, new water storage projects play in meeting our country's water needs during times of drought?

Answer. New water storage projects to meet the nation's water needs during drought could play a role to reduce vulnerabilities to drought and mitigate both near term and long term impacts, however this must be balanced with competing needs for increasingly scarce water resources, including environmental needs. The development of new water storage projects will need to be better integrated into state, tribal, and local drought plans, not only in terms of which new projects to pursue, but also how the management of new projects will be sustained and how they will advance objectives to increase resilience. Decisions on whether to pursue new water projects, and then their siting and design if approved, should be informed both by in-depth understanding of current and evolving regional climate conditions and by reliable projections of regional future climate variability and change (temperature, precipitation, evaporation, runoff timing and yield, long-term reliability of storage for particularly drought-sensitive regions). Providing a comprehensive understanding of climate and weather extremes will help ensure new water projects are able to meet the full spectrum of authorized purposes such as flood control, water supply, irrigation, hydropower, navigation, recreation, and fish and wildlife habitat. Decisions on how to retrofit existing infrastructure, to restore or enhance storage capacity with dredging, or to increase overall project storage capacity should likewise be informed by a clear understanding of future climate conditions and potential risks.

One example of retrofitting existing infrastructure is Aquifer Storage and Recovery (ASR), which is undertaken with the purpose of both augmenting groundwater resources and recovering the water in the future for various uses. Aquifer Recharge (AR) and ASR wells are found in areas of the U.S. that have high population density and proximity to intensive agriculture, dependence and increasing demand on groundwater for drinking water and agriculture, and/or limited ground or surface water availability. AR wells, for example, have been utilized to deter salt water intrusion into freshwater aquifers and to control land subsidence. ASR wells have been used in Arizona, New Mexico, and Nevada to store and recover water for drinking water supplies, irrigation, and more recently, ecosystem restoration projects such as the Comprehensive Everglades Restoration Project.

Question 5. A few of you mentioned water infrastructure in your testimony and I would ask that the panel expand on the connection between aging water infrastructure and drought and what needs to be done to better manage our infrastructure?

Answer. Drought and associated high temperatures and extremely low precipitation can dry soils so deeply that the soil contracts and shrinks away from buried water pipes. Increased water usage, especially during drought periods, raises pressure inside the water lines. Both factors add strain to pipeline walls, making older pipes more susceptible to leaking and bursting. Much of the nation's underground water lines are 80 to 100 years old and approaching the end of their lifespan. According to the U.S. Environmental Protection Agency, U.S. water utilities lose an average of about 10% of their water through leaks and other causes,[6] adding further stress during drought. That number is pushed higher in the event of large-scale system failures.

During a drought, one of the least costly and most effective strategies for a municipal water system to employ is maximizing conservation practices and increasing more efficient use of existing water supplies. Preserving existing supplies when there is a shortage due to hydrologic conditions can extend a limited supply and delay the need for more draconian curtailment measures. Evaluating and maintaining water infrastructure integrity is a vital conservation best practice.

While NIDIS does not manage water infrastructure, one of its key purposes is to provide accurate and timely information on drought conditions and associated risks, such as the risks to water infrastructure systems, to facilitate proactive mitigation and management decisions. Providing information for increasing public awareness and educating those affected by drought, including municipal water systems, on the

[6] U.S. Environmental Protection Agency. Drinking Water Infrastructure Needs Survey and Assessment. Fourth Report to Congress. 2007. EPA 816-R-09-001; American Society of Civil Engineers. 2013 Report Card for America's Infrastructure. May be accessed at: http://www.infrastructurereportcard.org/.

impacts of droughts to their operations and ability to supply water, is an important value that NIDIS brings to communities. NIDIS provides information and data to help outline and inform actions required to reduce the loss and damage expected from drought events. It also works with both urban and rural communities to understand impending drought events, identify potential risks (such as those associated with compromised water infrastructure systems) and preparedness strategies to proactively plan for potential failures. NIDIS also works closely with the municipal water supply community to educate and inform stakeholders on best practices to maximize the benefits of conservation and water efficient practices, which include the reduction of water line losses due to leakage.

RESPONSES OF ROGER S. PULWARTY TO QUESTIONS FROM SENATOR MURKOWSKI

Question 6. The Energy Policy Act of 2005 required the DOE to implement a program of research, development, demonstration, and commercial action to address energy and water issues and assess existing federal programs, but it is our understanding that the DOE has not yet implemented this program. What is NOAA doing at this time to address this issue?

Answer. The nation's energy-related water consumption is projected to increase by 50% by 2030. In addition, projections attribute 85% of the growth in domestic water consumption by 2030 to the energy sector alone.[7] Much of the anticipated growth in energy's water demand is in water-constrained areas, potentially exacerbating low availability during summer and droughts, and increasing competition with existing uses. More than 80% of U.S. electricity is generated at thermoelectric facilities that depend on access to cooling water, with approximately 24 of the nation's 104 nuclear reactors situated in drought-prone regions. As noted in a Washington Post article in September 2009:[8]

> "Drought and rising temperatures are forcing water managers across the country to scramble for ways to produce the same amount of power from the hydroelectric grid with less water,. . . . . .as low water levels affect coal-fired and nuclear power plants' operations and impede the passage of coal barges along the Mississippi River. "

Energy resource and technology paths chosen and capital investments made in the near-term are likely to establish long-term trajectories for the energy sector's water use. Given present trends in energy and water demand[9] alone, impacts are projected to increase for future droughts. Recent droughts, such as 2007-2009 in the Southeast, 2012 across the U.S. (projected to continue into 2013) vividly illustrate these concerns.

The capacity to deliver assessment and early warning information integrating the observations, monitoring, process understanding, and modeling of water resources to support energy production and management across climate timescales (e.g. from months to years to decades in advance) is a critical enabling capability. Critical to managing water resources to support energy production is an understanding of climate variability and change, extremes, and trends to improve forecasts of water supply, especially in characteristics of concern for effective early warning such as drought onset, magnitude, duration and recurrence. NOAA develops and improves drought and water resource monitoring, understanding of drought impacts, and forecasting capabilities to provide the information that impacts energy security. These include improved research, technology, and coordination to:

- improve predictability for drought and flood onset, duration, severity, and recurrence, for use in energy infrastructure siting and production given decadal-scale and longer-term forcing;
- understand the role of heavy precipitation events and land surface conditions in amplifying or reducing the severity of drought and flood impacts on the energy sector;
- develop timely, accessible communication tools (e.g. regional and sub-regional outlooks and assessments) to inform preparedness and adaptation to promote energy security; and

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[7] U.S. Congressional Research Service. Energy's Water Demand: Trends, Vulnerabilities, and Management (R41507, Nov. 24, 2010), by Nicole T. Carter. Accessed: 18 June 2013.

[8] Eilperin, Juliet. "Climate change challenges power plant operations." Washington Post, 09 September 2009.

[9] "U.S. Energy Sector: Vulnerabilities to Climate Change and Extreme Weather," July 2013, Department of Energy. May be accessed at: http://energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf

- partner with private and public sector energy producers and power administrators to improve information coordination for prioritizing investments and to inform climate-sensitive energy risk management from watersheds to coasts.

Question 7. Uncertainties—including the future makeup of the nation's energy portfolio and the potential impacts of climate variability—must be considered when developing and implementing national energy and water policies. Please describe what you believe will be the future makeup of our nation's energy portfolio, as you make decisions on how to address these issues.

Answer. Several agencies, including DOE, EPA, NOAA and others, have important contributions to make in this discussion. NIDIS plays a central role in addressing improvements in data quality through improved integration of data and information across climate timescales, such as intraseasonal (month to month) to interannual, or trends at the decadal or centennial scales. Better information on water-energy linkages will be key to managing the tension between water supply and power production. Decision makers in the public and private sectors need the most accurate and timely information possible on water supply and demand. Improvements in data quality will allow for more accurate assessment of water stress that can allow governing bodies to plan for sustainable water demand.

One example of this work is the NIDIS effort to provide seasonal climate and drought outlook information at both a national and regional scale. The outlook concept is part of the larger NIDIS effort to establish a comprehensive set of Regional Drought Early Warning Information Systems across the U.S. The outlook information and process has been successful at anticipating the development of drought impact to sectors like energy and agriculture. For example, in late 2010, NIDIS held an outlook forum in Albany, Georgia, for the ACF River Basin. The conclusion from the forum was that drought would develop in the region over the winter and there was a strong likelihood this would lead to a multi-year drought. In 2011, drought did develop in the region and did not end until early 2013. Throughout the drought event NIDIS continued to update the seasonal outlook information through webinars (co-produced with USACE, USGS, state agencies, and universities), outlook statements, and additional outlook forums. Based on survey information following the event, the information provided had a significant impact on awareness and understanding of the drought and effective coordination of responses.

Uncertainties also exist in our understanding of present climate variability and how this might change in the future, given climate change and other factors. Useful interannual (year to year) predictability of drought events for specific locations in the U.S. continues to hinge critically on the predictability of natural variations in the oceans, which are now themselves showing significant warming.[10] One particularly important aspect of long-term change are changes in soil moisture due to increased warming. Understanding regional differences is key. For example in the Southwest U.S., greater temperature increase together with greater reduction in precipitation, are likely going to make droughts more severe and sustained compared to events elsewhere in the U.S.

Question 8. Please describe how regulations and energy policies may impact water and its availability.

Answer. While NIDIS has no direct role in establishing energy policy and regulations, its core value in these efforts is to provide authoritative, credible and accessible science, data, and information necessary to inform these discussions and policy outcomes. The first step in making informed decisions about power and water is to ensure that decision makers in the public and private sectors have accurate, timely, and readily available information on water supply and demand. NIDIS can and does provide that information and does so through a variety of products and communication pathways (although please see NOAA's response to Chairman Wyden's question #3 above for more information on how we can improve data information even more). One recent example of NIDIS' involvement in energy-water issues is close collaboration with the Western Governors' Association to assist them in developing strategies, policies, and initiatives aimed at exploring the water-energy nexus.

Response of Roger S. Pulwarty to Question From Senator Flake

Last year, the Director of National Intelligence issued an assessment on Global Water Security, finding that poor water quality and shortages will lead to global instability.

[10] Seager, R. and M. Hoerling (2013) Atmosphere and Ocean Origins of North American Droughts. Journal of Climate (submitted)

Question 9. What lessons and expertise can water managers in the United States share with water managers in other countries to assuage water conflict and add to global stability with regard to water issues?

Answer. Climate extremes, variability, and change, together with increasing development pressures, exacerbate conflicts among water-sensitive communities and have impacts on economies and environmental systems. Climate models project increased aridity into the twenty-first century over large parts of Africa, southern Europe, the Middle East, the Southwest U.S., the Caribbean, Western Australia, and South East Asia.[11] [12]

U.S. expertise on water resource assessment and management in both the public and private sectors is highly regarded and will be sought after worldwide. Improved water management and improvement of institutional capacities to treat water and encourage efficient water use will likely be the most effective approaches to mitigate water-related social tensions.

Other countries will likely look to the U.S. for support to develop legal and institutional arrangements that resolve water disputes or advance cooperative management of shared waters based on the lessons learned in the U.S. River basin management, including treaties and river basin organizations, can provide stability, increase cooperation, and mitigate political grievances over water. Currently, water basin agreements often do not exist or are inadequate for many nations sharing watersheds. New or updated international agreements would lessen the risk of regional tensions over water. Even well-prepared river basins are likely to be challenged by increased water demand as well as impacts from climate change, such as increased variability in extreme events. The need for implementation of sound policies for managing water resources at the local, national, and regional levels will likely be heightened by the need to support major development projects.

Additionally, because of existing expertise and resources, the U.S. may disseminate remote sensing data and hydrological modeling tools that allow users to better understand and manage their resources. Key in this setting is the proposed Global Drought Monitoring System being coordinated among agencies and international partners under the Group on Earth Observations (GEO) to which the U.S. is a signatory. The goals of the Information System are to:[13]

- strengthen the scientific and observational foundations to support early warning for drought onset, severity, persistence and frequency;
- improve linkages between climate and streamflow modeling during drought;
- conduct spatial analysis of water demand during drought;
- develop risk and vulnerability profiles of drought-prone regions and locales, including impact of climate change adaptation interventions on food and water availability, access and use; and,
- place multiple indicators within a statistically consistent triggering framework-cross-correlation among units before a critical threshold.

The U.S. is a leader in the GEO process and is actively promoting coordination across surface-based and space-based observing systems and sustained operations with its international partners in the GEO process. As highlighted in the GEO 2012-2015 Workplan, key to this effort is the maintenance of intergovernmental mechanisms and support from partner countries for developing and coordinating terrestrial, ocean, and climate observations needed for climate studies and forecasting through complete and stable global observing systems (Global Climate, Terrestrial, and Ocean Observing Systems).

The GEO Global Agricultural Monitoring initiative (GEO-GLAM) will bring together existing national and regional monitoring systems to establish a "system of systems" for monitoring global agricultural production and food security. This will require making these systems more compatible and interoperable, promoting common data standards, and strengthening transparency and data sharing. GEO-GLAM will focus initially on four key crops—corn, rice, soybeans, and wheat—that are widely traded and whose production is dominated by the world's main agricultural producers. Since agriculture uses 70% of the global freshwater supply, this sector

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[11] Dai, A. (2011) Drought under global warming: a review. WIREs Clim Change 2: 45-65. doi: 10.1002/wcc.81.

[12] World Climate Research Programme (2011) Climate Observation and Regional Modeling in Support of Climate Risk Management and Sustainable Development, Consolidated Country Reports.

[13] Pozzi, W. et al. (2013) Towards Global Drought Early Warning Capability: Expanding international cooperation for the development of a framework for global drought monitoring and forecasting. Bulletin of the American Meteorological Society, doi: 10.1175/BAMS-D-11-00176.

has the most potential for efficiencies and savings while maintaining existing food security and market needs.

Lastly, NIDIS works with the Famine Early Warning System Network (FEWSNet) to: (a) inform the development of strategic responses to anticipate crises and crisis evolution; (b) provide capabilities for generating problem-specific risk assessments and scenarios; (c) effectively communicate options to critical actors for the purposes of decision-making, preparedness and mitigation; (d) understand social vulnerability in order to identify entry points for actions to manage present conditions and to mitigate future risk; and (e) identify the institutional processes that support closer inter-institutional collaboration among research and agencies that direct information interventions and responses, such as extension services, development projects and non-governmental organizations. NOAA research and operations are providing critical information in support of the implementation of FEWS NET.

RESPONSES OF MICHAEL E. WEBBER TO QUESTIONS FROM SENATOR WYDEN

FEDERAL ROLE IN DROUGHT

Question 1. Do you believe we need to be doing more at the Federal level to address these impacts? If so, what can we do?

Answer. I believe that more can be done at the Federal level to address the impacts of drought. In particular, the Federal government can play a role in collecting data on water resources (streamflows, aquifer levels, etc.) to aid planners, can fund R&D for novel solutions, and can help establish guidelines to reduce the requirements for water-intensive industries. Because many water systems (rivers, lakes, aquifers) span across multiple states, it is difficult to delegate the data collection and planning entirely to state governments. Furthermore, the federal government is more effective and experienced at supporting the R&D systems nationwide than the states are. Lastly, it is common for the Federal government to set performance-based standards for energy efficiency, emissions, and so forth. Doing something similar for water is reasonable.

ENERGY-WATER NEXUS

Question 2. Given the amount of water needed to produce energy, what is the appropriate Federal role in responding to energy's intensive water demands?

Answer. I think that the EIA, which collects statistical information on energy, could also collect data on the energy industry's water needs. That data collection should be standardized and clarified so that consistent units and reporting conventions are used. It would also be useful to conduct analysis to determine the ways by which water scarcity triggers vulnerabilities in the energy sector.

Question 3. Several of you raised the need for better data and information in improving energy-water strategies. What steps can we do to make this happen?

Answer. It would be helpful to expand and clarify the mandate for the USGS and EIA (and other relevant agencies such as the EPA) to collect data, and then to fund the data collection efforts. In recent history, the funding has been cut and/or the mandate to collect data has been unclear.

WATER MANAGEMENT

Question 4. What role can and should new water storage projects play in meeting our countries water needs during times of drought?

Answer. New water storage projects are an important option to consider. However, their suitability as a solution will depend on site-specific conditions. Underground storage, known as Aquifer Storage and Recovery (ASR), is also an option worthy of exploration. While storage is important, it should not be pursued at the exclusion of other promising approaches, such as conservation, efficiency, advanced technologies, and so forth.

Question 5. A few of you mentioned water infrastructure in your testimony and I would ask that the panel expand on the connection between aging water infrastructure and drought and what needs to be done to better manage our infrastructure?

Answer. Our aging water infrastructure is worthy of discussion for two reasons: 1) it is leaky and inefficient, which means it loses a lot of water and the water it doesn't lose is not used efficiently, which exacerbates the effects of drought, and 2) it does not include the latest technology upgrades (such as advanced metering and communications), which makes it less resilient when drought occurs. Fostering the innovation of advanced sensing technologies would help. These might include minia-

ture flow meters that can help maintain an inventory of flows to pinpoint leaks, and remote leak detectors.

RESPONSES OF MICHAEL E. WEBBER TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. Please describe your perspective on what options the Federal Government has to collect, maintain and make available accurate, updated and comprehensive water data. Which Federal agency should be the lead on this initiative?

Answer. The Federal Government can give a clear mandate to relevant agencies to collect the data and can then provide the funds to do so. For water quantity assessments related to water resources (groundwater and surface water), the USGS (U.S. Geological Survey) is the best candidate to be the lead agency. For water uses by the energy sector, the EIA (Energy Information Administration) is the best candidate to be the lead agency. For water quality assessments, the EPA (Environmental Protection Agency) is the best candidate to be the lead agency.

Question 2. What is your view on the need for better assessment and study of water-energy nexus themes as they relate to potential stresses on current and future water supplies?

Answer. Areas for additional assessment and study include: 1) the interdependencies of different infrastructures, and how those interdependencies can cause cascading failures (that is, a water constraint can cause the electrical system to go down, which can cause the pipeline system to go down, so a water failure becomes an electricity failure which becomes a natural gas failure; or vice versa, a power outage becomes a constraint on the water system), and 2) the development of decision support tools. Local, state and federal planners lack the support tools they need to make decisions about different scenarios. Developing those tools would be valuable for predicting, avoiding and managing the potential stresses on supplies.

Question 3. Please describe how the United States can satisfy all the expected water needs of existing and newly proposed power plants, including concentrated solar, in arid and semi-arid regions.

Answer. There are several options, including switching to 1) power plants that do not require cooling (such as solar photovoltaic panels or wind), 2) more efficient power plants whose cooling needs are lower (such as natural gas combined cycle), or 3) cooling technologies that do not require water (such as dry cooling, which can be used with natural gas, coal, biomass, or concentrated solar). In addition, energy conservation reduces overall demand for power, which can mitigate strain on water supplies for power plant cooling.

Question 4. Please describe the regions in the country that may not expect a significant water challenge within the next decade.

Answer. For the most part, every region of the country faces some level of risk for a water challenge (including droughts or floods). Therefore, every region has a stake in effective planning.

Question 5. What do you see as role of the Department of the Interior in working with local and state entities to plan and manage for water supply and wastewater disposal, treatment, or reuse related to energy development on federal lands?

Answer. The DoI has a role in collecting data, conducting field studies, and studying the relevant science. The DoI also has a role to protect water quality and to ensure that energy decisions on Federal lands does not compromise water supplies for those lands or for neighboring lands.

Question 6. How do costs of electricity and water affect policy and technology choices in this area?

Answer. The costs of electricity and water are very important drivers of the different policy and technology choices. In particular, because water is so inexpensive, water-intensive options for power plant cooling and energy production are selected. If water were more expensive, then water lean approaches would be adopted more often.

RESPONSES OF MICHAEL E. WEBBER TO QUESTIONS FROM SENATOR FLAKE

During the hearing, it was suggested that water markets could be used to properly price water and encourage market forces to efficiently allocate limited water resources. Water, however, is unlike other commodities; it plays a critical role in essential human functions, while also serving as an important component for agricultural and industrial uses. As such, it seems that any sort of water marketing scheme would require minimum procedural safeguards.

Question 1. What procedural safeguards should be considered when creating a water market?

Answer. Water markets could be used to efficiently allocate resources, but they introduce the risk to human rights that people living in poverty will be priced out

of the market, compromising their health and livelihood. Thus, water markets needs to balance the need to ensure a minimum level of access to clean water while also allocating resources efficiently. If everyone is granted access to unlimited volumes of really clean, cheap water, then much of that water will be wasted. That scenario is a close approximation to today's situation. If water prices were higher, then the largest users (agriculture, industry, energy, municipalities, etc.) would reduce water waste and be more efficient with their use. These priorities can be balanced with an inverted block pricing scheme, where the first few gallons per person per day of clean, treated water are free or very cheap (to make sure water is available to people for drinking, cooking and cleaning, which meets our human rights objectives), above which the prices increase for larger users. Those higher prices will spawn conservation, but because the first few gallons are available at a reasonable price, no human rights to water are violated.

Question 2. Should the marketing of water rights be limited to use within the watershed or basin of origin?

Answer. An expert on water rights would be better for this question. In my opinion, generally restricting the bulk of water use to its watershed or basin or origin sounds managing transfers is reasonable, though inter-basin transfer for a portion of the water has been conducted for millennia with success in various parts of the world. Those decisions would have to be balanced against the various public good and ecosystem priorities of the source and destination of the water.

Question 3. Should marketing of water rights only be permitted to the extent that such rights have previously been beneficially used by the water right holder and actual water use is verifiably reduced by the water right holder (e.g., requiring fallowing or non-development agreements)?

Answer. An expert on water rights would be better for this question.

Question 4. Should a water marketing scheme differ depending on the type or nature of the water right being marketed (e.g., surface water, reserved rights, decreed rights, riparian water rights states, prior appropriation rights, interstate transfers, etc.)?

Answer. Yes. Quality of water (fresh, brackish, sea, effluent, etc.) should also be considered.

Question 5. If the marketed water right has a federal component (e.g., Indian water rights) what role should the Secretary of the Interior play in approving a water rights lease?

Answer. An expert on water rights would be better for this question.

Question 6. Last year, the Director of National Intelligence issued an assessment on Global Water Security, finding that poor water quality and shortages will lead to global instability. What lessons and expertise can water managers in the United States share with water managers in other countries to assuage water conflict and add to global stability with regard to water issues?

Answer. Generally speaking, water strains can be a trigger for conflict and hostilities, both internally and between countries, and water abundance can be a source of peace. For example, some have cited drought as one of the triggers for the Syrian conflict (as drought pushed farmers into the cities looking for jobs, leading to high unemployment and civil unrest). Working together to find water solutions can be a path towards peace and cooperation.

RESPONSES OF MICHAEL L. CONNOR TO QUESTIONS FROM SENATOR WYDEN

Question 1. Much of the attention during the 2012 drought was focused on the lack of precipitation, soil moisture, and surface waters but I am curious to know what role does groundwater management play in drought resiliency? How are states and others managing this resource?

Answer. Groundwater is a key component to drought resiliency. When surface water supplies are stressed, many water users turn to groundwater to replace the deficit. Groundwater is, therefore, an extremely valuable source of supply in much of the arid West, both in areas served by Reclamation, as well as those parts of the country without Reclamation facilities. Reclamation has some project-specific authorizations dealing with groundwater and some projects under study which entail the use of water banks or subsurface storage. However, in general, Reclamation projects make only limited, incidental use of groundwater. In some cases, groundwater pumping can impact surface water supplies for proximal uses. According to the Congressional Research Service, a full understanding of the impacts of drought are "confounded" by the varying levels of reliance among states and local communities on groundwater, and the uneven distribution of the resource. The U.S. Geological Survey has prepared several reports studying the role of groundwater in do-

mestic water supplies, as well as the effect of groundwater withdrawals on streamflow. [1] [2] The degree to which groundwater and aquifers are managed by state and local agencies differs widely depending on the location.

Question 2. I recently introduced legislation to reauthorize the Drought Relief Act which expired last year. The legislation raises the authorization level to $110 million. How would this increase help the Bureau of Reclamation in mitigating drought impacts?

Answer. The Drought Relief Act provides Reclamation with one of many tools to address drought, and we support the extension of this authority to fiscal 2018, as is contemplated in S. 659. With respect to the authorization level of $110 million, as stated in Reclamation's April16, 2013, testimony, given that there remains a capacity for over $15 million in authorized appropriations for this program under the existing authorization ceiling, the Department does not believe an increase in the authorization of appropriations is necessary at this time. If the authorized appropriations ceiling should become a more urgent constraint, we will evaluate the need for an increase to the appropriations ceiling at that time.

Question 3. What assistance has Reclamation provided under the Drought Act authority to Oregon in the last 10 years?

Answer. Using supplemental appropriations provided in fiscal 2010, Reclamation provided $10,536,585 to Oregon organizations for the following drought-related activities:

- Horsefly Irrigation District-temporary pumping station to lower pump intake $138,986
- Klamath Irrigation District—variable frequency drives and efficient well pumps/motors $246,050
- Enterprise Irrigation District-well development $550,000
- Klamath Water and Power Authority—Water Bank $8,037,687
- Klamath Tribes—Drought and Endangered Species Management $1,563,862

TOTAL: $10,536,585

Question 4. What actions are Reclamation's offices and facilities taking in response to drought conditions this year in western and central portions of Oregon?

Answer. Western and Central Oregon projects are not experiencing drought conditions this year and are expected to have adequate water supplies in 2013. For Eastern Oregon projects, operational strategies for drought conditions are determined by the managing districts. Owyhee Irrigation District has announced it will curtail allotments due to low water conditions. Vale Oregon Irrigation District has not made any announcements as to its intended management actions yet, but continues to watch the water supply outlook.

FEDERAL ROLE IN DROUGHT

Question 5. Do you believe we need to be doing more at the Federal level to address these impacts? If so, what can we do?

Answer. Reclamation is committed to continuing the Department's WaterSMART Program, which has proven highly effective at securing and stretching communities' water supplies both before and during periods of drought. It is anticipated that the program will exhaust its authorized appropriations for the WaterSMART water and energy efficiency grants in the next year. Therefore, in order to continue use of this highly valuable program which is significantly contributing to drought resiliency in the West, an increase in the authorization ceiling will be needed. A requested amendment to Section 9504(e) of the Secure Water Act of 2009 (42 USC 10364(e)), raising the ceiling from $200 million to $250 million, is part of the Appropriations language section of Reclamation's FY 2014 budget request, and will require action by the Congress.

ENERGY-WATER NEXUS

Question 6. Given the amount of water needed to produce energy, what is the appropriate Federal role in responding to energy's intensive water demands?

Answer. Federal agencies have an interest in promoting the conservation of water and energy, but also have a responsibility to evaluate the impacts of energy develop-

[1] Barlow, P.M., and Leake, S.A., 2012, Streamflow depletion by wells-Understanding and managing the effects of groundwater pumping on streamflow: U.S. Geological Survey Circular 1375, 84 p.

[2] Maupin, M.A., and Arnold, T.L., 2010, Estimates for self-supplied domestic withdrawals and population served for selected principal aquifers, calendar year 2005: U.S. Geological Survey Open-File Report 2010-1223, 10 p.

ment on federal lands and natural/cultural resources managed by federal agencies. These efforts can help insulate communities from the effect of shortfalls in the supply of energy and water, save money, and make available supplies for additional uses, while protecting water for environmental purposes.

Question 7. Several of you raised the need for better data and information in improving energy-water strategies. What steps can we do to make this happen?

Answer. The Department, through its WaterSMART Program, emphasizes the nexus between energy and water use, and includes scoring criteria for grant projects that conserve both. The Secretarial Order creating WaterSMART recognized the water demands of energy development. As a result, in addition to saving hundreds of thousands of acre-feet of water, WaterSMART projects across the West are expected to save over 40 million kilowatt-hours of electricity annually-enough power for 3,400 households and additional savings are targeted for the future. Additional milestones are described in the program's three-year progress report, online at http://www.usbr.gov/WaterSMART.

WATER MANAGEMENT

Question 8. What role can and should new water storage projects play in meeting our countries water needs during times of drought?

Answer. Within the last few years, Reclamation has completed or helped facilitate several new storage projects that added water supplies in critical basins. These recent projects include (1) the completion of Ridges Basin Dam as part of the Animas-La Plata project and Colorado Ute Tribes Settlement; (2) Brock Reservoir on the Lower Colorado River, which helps regulate flows and conserve storage in Lake Mead; and (3) Los Vaqueros Reservoir expansion in California's Bay-Delta Region, a perennially water short area. Reclamation will continue to look at storage opportunities, both surface and subsurface, which make technical and financial sense and can help improve overall water management.

Question 9. A few of you mentioned water infrastructure in your testimony and I would ask that the panel expand on the connection between aging water infrastructure and drought and what needs to be done to better manage our infrastructure?

Answer. The water infrastructure constructed by Reclamation and our partners in the West was built to mitigate for the reality of drought. We believe that the problem of drought is best addressed proactively through collaborative planning, targeted investments and an emphasis on water conservation, all of which we are focusing on through WaterSMART and other initiatives. As the region continues to grow and experience changes in climate and the economy, we will continue to evaluate and plan for the impacts of drought. This year, we will continue to seek efficiencies in our infrastructure, continue to operate to that reality, and through programs like WaterSMART, continue to fund proposals by our customers to accomplish water-saving efficiencies of their own. In the longer term, the Department is working every day to equip our agencies, partners and other resource managers with the data they need to answer the questions they face about water supply and use and to continue delivering water and power in the face of drought and our changing global climate.

COLORADO RIVER BASIN

Question 10. How will has the recent Supply/Demand study affected talks among the Colorado River Compact parties? Have the Upper Basin States and/or Lower Basin States met to address the conclusions of the report?

Answer. Reclamation continues to collaborate with the Colorado River Compact parties on a daily basis. Since the Study's completion in December 2012, Reclamation has been actively engaged in discussions with the seven Colorado River Basin States to design a process to pursue next steps. Building on the collaborative approach demonstrated in the Study, a multi-stakeholder process has been designed that will include the formation of three working groups to pursue activities related to urban conservation, agricultural conservation, and healthy river flows for ecological and recreational resources.

Question 11. What is the status of the shortage criteria? Are there plans for revisions or an update?

Answer. Reclamation has been operating Lake Powell and Lake Mead in accordance with the "Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead" since 2008. The Guidelines, signed December 2007, will remain in effect for determinations to be made through December 31, 2025. Determination regarding water supply and reservoir operation decisions will remain in effect through 2026. The Secretary will, no later

than December 31, 2020, initiate a formal review to evaluate the effectiveness of the Guidelines. The Secretary will consult with the Basin States in initiating that review.

RESPONSES OF MICHAEL L. CONNOR TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. What is the appropriate federal role in responding to energy's water demand?

Answer. As stated above in our answer to questions six and seven, Federal agencies have an interest in promoting the conservation of water and energy. These efforts can help insulate communities from the effect of shortfalls in the supply of energy and water, save money, and free up supplies for additional uses. The Department, through its WaterSMART Program, emphasizes the nexus between energy and water use, and includes scoring criteria for grant projects that conserve both. In addition to saving hundreds of thousands of acre-feet of water, WaterSMART projects across the West are expected by their sponsors to save over 40 million kilowatt-hours of electricity annually-enough power for 3,400 households-and additional savings are targeted for the future. Additional milestones are described in the program's three-year progress report, online at http://www.usbr.gov/WaterSMART.

Question 2. The GAO has determined that a number of agencies have responsibility for managing specific aspects of the energy-water nexus, but these agencies do not consistently or strategically collaborate on these linked issues to ensure a harmonized approach to energy and water resource planning. How do you intend to harmonize a federal approach to this issue?

Answer. Different agencies have individual missions, and bring their own capabilities to the task of water and energy management. Depending on what aspect of the energy water "nexus" is under consideration, not all Federal activities can or shou ld be "harmonized," but outright conflicts can and should obviously be avoided. The Department uses its participation in interagency task forces and Memoranda of Agreement/Understanding with other agencies to assure that its priorities in the area of water and energy conservation are consistent with activities underway at other agencies. For example, in March 2010, the Departments of the Interior, Energy, and Army entered into a Memorandum of Understanding to help meet the Nation's hydropower needs and to align ongoing and future renewable energy efforts.

Question 3. One of the challenges to coordinated energy and water policy is that energy policy is developed at a national level and water policies generally are developed at a regional, state, and local level. How can improve the collaboration and coordination of your efforts on a more local level?

Answer. Reclamation maintains a robust dialogue with its stakeholder community, which fosters collaboration and coordination at the regional, state and local level. Through participation in technical workshops, industry standard-setting acti vities, policy conferences and other venues, Reclamation strives to maintain awareness and coordination with energy and water policy choices being pursued by its partners.

In December 2012, the Department of the Interior joined the National Integrated Drought Information System Office (NIDIS), the Western Governors Association and several other groups and agencies in hosting the National Drought Forum (NDF). The NDF included a series of plenary and breakout sessions to discuss the extent of the 2012 drought and outline actions that could help with drought response going forward. A draft NDF Report was released in February and highlights have been provided to local entities to provide strong examples of steps that can be taken to prepare for ongoing drought conditions.

The President triggered development of another initiative through his directive to "help the Midwest and states, like Colorado, move faster on projects that help farmers deal with worsening drought." Building on regional meetings held in the summer and fall of 2012 to hear concerns from affected communities, a Central U.S. Drought Mitigation Regional Team (DMRT) was formed in February to facilitate collaboration among Federal agencies (and their respective stakeholders) with ongoing and/or planned programs or projects. This effort will focus on the States of Colorado, Iowa, Kansas, and Nebraska. Reclamation is among the cooperating agencies in this effort, which is being led by the U.S. Department of Agriculture (USDA), with participation from the Army Corps of Engineers and the National Oceanic and Atmospheric Administration.

Question 4. Drought also can influence a variety of other natural hazards and processes, such as wildfire, rapid erosion, and invasive species. What is the Department doing to understand and reduce the full spectrum of drought-related risks on federal lands and adjacent properties?

Answer. The Department is taking action to better understand the risks posed by drought, including impacts on federal lands and adjacent properties. The Department continues to focus on farmers, ranchers, small businesses, and communities that are being affected, while recognizing that drought conditions have profound impacts on federal lands that support wildlife, fisheries, and plant communities. The Department continues to utilize all available tools when addressing drought. It is an issue that requires adaptive land management and thoughtful science-based approaches.

The Department's Climate Change Policy (523 DM 1) aims to effectively and efficiently adapt to the challenges posed by climate change to its mission, programs, operations, and personnel. The Department will use the best available science to increase the understanding of climate change impacts, inform decision-making, and coordinate an appropriate response to impacts on land, water, wildlife, cultural and tribal resources, and other assets.

The Bureau of Land Management (BLM) is implementing this policy through Rapid Ecoregional Assessments (REAs), which synthesize existing information covering nearly 800 million acres of the Western U.S. to better understand resource conditions and trends and identify opportunities for resource conservation, restoration and development. In addition, the BLM is implementing a national strategy to monitor the status and trends of BLM managed resources and lands on a landscape scale and is using the data to support adaptive management for drought conditions. The BLM is also developing guidance for proactive plans to address potential drought-stressed areas and plan for supplementing water sources. The BLM and U.S. Geological Survey (USGS) are collaborating on the Human Dimensions of Climate Change to offer information, guidance and applied research to inform management decisions. Furthermore, the USGS puts out regular drought monitoring products to support the Department's policy. VegDRI, in regular production since 2009, combines a variety of data to distribute weekly maps of vegetation conditions. WaterWatch indicates drought conditions through real-time streamflow information published on a web portal (waterwatch.usgs.gov). Both are used by State and nongovernmental partners. The National Park Service utilizes climate change based scenario planning for park management that, where relevant, includes the effects of drought.

Under the direction of the FLAME Act, the Department's wildland fire management program has been participating in the development and implementation of an intergovernmental, collaborative National Cohesive Wildfire Management Strategy, which seeks to unify wildland fire management policy and strategies in order to address risk factors, including the effects of drought. The wildland fire management program uses planning and operational decision support tools and methodologies that help manage drought-related risks.

Question 5. Drought is resulting in interest in identifying flexibility in the operations of federal reservoirs and in federal programs. How do you see the Department of Interior using its existing authorities to better prepare for and manage drought?

Answer. Reclamation operates its reservoirs pursuant to annual operation plans with continuing attention to mitigating the impacts of drought. As referenced in our testimony, we employ a number of tools, which include:

- using excess capacity of project facilities for storage and conveyance of project and non-project water for use both within and outside of project boundaries (consistent with applicable authorities);
- purchase of water (from willing sellers) for ESA purposes and to mitigate losses and damages to communities from drought;
- regulating the quantity and timing of reservoir releases (consistent with agreements);
- educating producers confronted with reduced water supplies on research-based irrigation scheduling and management strategies; and
- WaterSMART grants, Title XVI water recycling project funding, system optimization reviews.

Given the ongoing drought in Califo ia, we are currently taking actions on the Central Valley Project (CVP) to provide additional supplies to supplement low contractual allocations. These actions include rescheduling available storage, ; acquiring supplies from willing sellers; diversifying supplies to wildlife refuges that are served by project water; and constructing a new intertie between the CVP with the State Water Project that has provided more flexibility to pump water when it's available, adding tens of thousands of acre-feet of additional water supply to the project on an annual basis.

In the Colorado River basin, which has suffered through drought conditions for more than a decade, reservoir levels have dropped significantly and there were strong concerns during the early part of 2011 that the lower Colorado River basin could be in a shortage condition for the first time ever. A number of operational agreements have been executed over the last 10-15 years to promote conservation and increase the amount of water stored in Lake Mead-all with the idea of mitigating the impacts of long-term drought. The most recent agreement is Minute 319 to the 1944 Water Treaty with Mexico, a historic arrangement between the United States and Mexico that was signed last November, providing a range of binational benefits including (1) establishing a program whereby Mexico can temporarily reduce its annual water order, allowing that water to be delivered in future years; and (2) providing for additional water supplies to U.S. entities through conservation and efficiency improvements in Mexico.

RESPONSES OF MICHAEL L. CONNOR TO QUESTIONS FROM SENATOR FLAKE

The energy-water nexus involves a wide variety of considerations from the impact of drought on energy production to the energy needs for water delivery. In Arizona for example, the Navajo Generating Station provides power to pump approximately 1.5 million acre feet through the Central Arizona Project. Likewise, water augmentation proposals, such as desalination, would require significant energy resources.

Question 1. Can you elaborate on the role of energy reliability and affordability in future water security of the Colorado River system?

Answer. Reliable energy supplies have been and will continue to be essential to future water security on the Colorado and all river systems. The Department is pursuing an 'all-of-the-above' energy strategy aimed at promoting reliable and sustainable practices that maximize supplies of domestic energy. Hydropower produced by the Colorado River Storage Project, for example, has resulted in favorable rates for electricity provided by electrical cooperatives in the southwestern U.S.

During the hearing, it was suggested that water markets could be used to properly price water and encourage market forces to efficiently allocate limited water resources. Water, however, is unlike other commodities; it plays a critical role in essential human functions, while also serving as an important component for agricultural and industrial uses. As such, it seems that any sort of water marketing scheme would require minimum procedural safeguards.

Question 2. What procedural safeguards should be considered when creating a water market?

Answer. At the policy level, OMB Circular A-25 establishes Federal policy regarding fees assessed for Government services and for sale or use of Government goods or resources. Among the procedural safeguards identified in the circular are considerations that market prices create neither shortage nor surplus of the good, resource or service. Reclamation's procedures for facilitating the transfer of water among willing sellers and buyers is consistent with A-25, and anticipates additional safeguards achieved through compliance with the National Environmental Policy Act and other statutes.

Question 3. Should the marketing of water rights be limited to use within the watershed or basin of origin?

Answer. Water rights are administered by the states and water right holders. This is a question best decided at that level.

Question 4. Should marketing of water rights only be permitted to the extent that such rights have previously been beneficially used by the water right holder and actual water use is verifiably reduced by the water right holder (e.g., requiring fallowing or non-development agreements)?

Answer. See the response above.

Question 5. Should a water marketing scheme differ depending on the type or nature of the water right being marketed (e.g., surface water, reserved rights, decreed rights, riparian water rights states, prior appropriation rights, interstate transfers, etc.)?

Answer. See the response to question 3.

Question 6. If the marketed water right has a federal component (e.g., Indian water rights) what role should the Secretary of the Interior play in approving a water rights lease?

Answer. Indian water rights marketing is a complicated topic. The majority of the congressionally approved Indian water rights settlements contain leasing provisions, which often define the role of the Secretary of the Interior. However, each marketing provision is unique, tailored to the agreements negotiated among the parties on a case-by-case basis.

Question 7. What lessons and expertise can water managers in the United States share with water managers in other countries to assuage water conflict and add to global stability with regard to water issues?

Answer. Reclamation operates on river systems that cross many states and two international borders. A central lesson for avoiding conflict and promoting stability in water issues is to promote open communication and transparency among all parties and to encourage problem solving through cooperation and creative thinking, rather than litigation. Because of the robust communication between Reclamation, the seven basin states and Mexico, a number of multi-party agreements have been executed on the Colorado River to reduce potential shortages, the most recent agreement is Minute 319 to the 1944 Water Treaty with Mexico. Minute 319 is a historic arrangement between the United States and Mexico that was signed last November, providing a range of binational benefits including (1) establishing a program whereby Mexico can temporarily reduce its annual water order, allowing that water to be delivered in future years; and (2) providing for additional water supplies to U.S. entities through conservation and efficiency improvements in Mexico.

RESPONSES OF PATRICIA MULROY TO QUESTIONS FROM SENATOR WYDEN

FEDERAL ROLE IN DROUGHT

Question 1. Do you believe we need to be doing more at the Federal level to address these impacts? If so, what can we do?

Answer. The key to weathering drought is resource flexibility, which requires that municipal, agricultural and industrial entities have the ability to respond quickly to changing conditions. While the integrity of the National Environmental Policy Act should remain sacrosanct, an expedited track for water-resource projects that are necessitated by prolonged, debilitating droughts could substantially reduce the timeline associated with acquiring federal rights of way, a process that can sometimes span a full decade and preclude rapid response to drought conditions. Resource diversification also requires significant infrastructure in most cases, and the costs associated with that infrastructure can be debilitating for both water providers and ratepayers. Legislation such as S.601, which contains a provision supporting access to low-interest bonds for water infrastructure, would significantly enhance water providers' ability to quickly build necessary treatment and conveyance facilities to diversify their water supplies, with the added benefit of generating largely private-sector construction jobs. In areas such as the Southwest where the Department of Interior governs water resources, it is also essential that the agency maintain the authority to foster and authorize agreements and projects that optimize both the use of water resources and the health of the system as a whole. The Bureau of Reclamation's efforts in this area have been invaluable to the entire Colorado River Basin community.

ENERGY-WATER NEXUS

Question 2. Given the amount of water needed to produce energy, what is the appropriate Federal role in responding to energy's intensive water demands?

Answer. Just as there is no silver-bullet solution to water resource challenges, there is no single federal policy that can neatly address the water needs of our nation's diverse energy sources. For instance, it is well understood that hydraulic fracturing consumes significant quantities of water. While that might not be an appropriate use of resources in water-scarce areas such as the Southwest, it may be a reasonable beneficial use of water in water-rich regions of the country. Similarly, "wet-cooled" versus "dry-cooled" generation facilities involve a tradeoff between water consumption and energy output. In areas such as the Midwest where availability of water resources may not be a concern, it seems reasonable to accept the higher water consumption in exchange for greater energy output, while the same would not be true in Nevada. In the broadest terms, the optimal Federal role would be encouraging regionally appropriate energy generation technologies that reflect an awareness of each region's water resource conditions. Looking at this problem from the other side of the equation, however, it is clear that there is a productive Federal role in reducing the consumption of energy among all sectors. Such reductions would result in a reduced need for electrical generation and, in turn, for water resources to support that generation. Related to this, Federal incentives to energy producers for improvements in the water efficiency of these facilities would also incentivize technological advancements in this area. With fully half of the nation's water withdrawals being used to support energy generation, there is no question that this is the single greatest opportunity for water savings.

Question 3. Several of you raised the need for better data and information in improving energy-water strategies. What steps can we do to make this happen?

Answer. There is a substantial body of work in existence related to the nexus between energy production and water consumption, and vice versa. What has historically been lacking is a coordinated, comprehensive effort to compile the myriad datasets and analyze them for the purposes of producing in effect a "best practices" guidance document. This in turn would provide a useful tool for policy-making and potential incentive programs. For instance, an inventory of electrical generation facilities by location and type, along with their consumptive water uses and output, would be informative for Federal regulators seeking to encourage alignment between generation technologies and local water resource conditions. An example of this would be an initiative being undertaken by the Sandia National Laboratories, which is attempting to systematically encapsulate this complex and interdependent relationship and translate it into actionable recommendations. Any efforts by the Federal government to further this initiative would benefit both the water and energy sectors.

WATER MANAGEMENT

Question 4. What role can and should new water storage projects play in meeting our countries water needs during times of drought?

Answer. Water storage projects already play a critical role in insulating water users from drought by buffering the effects of reduced precipitation and encouraging conservation among users. As an example, the ability to "bank" water in Lake Mead has made a significant positive impact on its elevation because it eliminates the disincentive that previously existed wherein one state's unused allocation automatically transferred to downstream users. In the narrowest view, local water storage projects will reduce the impacts associated with short-term variability in climatic conditions. In the broader sense, however, regional water storage and conveyance facilities have the potential to entirely reshape how the United States manages water. While the notion of large-scale water projects has been the subject of some skepticism and even derision, the reality of the future will not be reflected in a single pipeline that stretches from the Midwest to the desert Southwest, but rather a series of interrelated projects that protects flood-prone regions, recharges groundwater aquifers, supports Great Plains agriculture and reduces withdrawals from Western sources such as the Colorado River. Just as our nation developed national networks to move electricity, oil, natural gas, coal and timber, so too can it create an infrastructure network to convey water for the benefit of all concerned. If indeed scientists' predictions prove accurate and some regions become inundated while others grow more parched, it would seem more than reasonable to consider options that solve both problems.

Question 5. A few of you mentioned water infrastructure in your testimony and I would ask that the panel expand on the connection between aging water infrastructure and drought and what needs to be done to better manage our infrastructure?

Answer. Water infrastructure is often given short shrift because it is for the most part invisible. Crumbling roads and unsound bridges are easy to identify; with water infrastructure, failure only becomes apparent when large-scale breaks occur. However, the implications of aging infrastructure on water resources are enormous. Approximately 14 gallons out of every 100 delivered by public water agencies never reaches a home or business, but is instead lost to leaks. Based upon historic deliveries by municipal water agencies, this system loss equates to more than 2.5 trillion gallons of water a year—a quantity sufficient to fill approximately 4,000,000 Olympic-size swimming pools. In the context of water conservation initiatives, a 14 percent reduction in system-wide demand is phenomenal. Beyond the resource implications, the energy-intensive nature of water treatment and delivery means that water systems are expending significant amounts of energy to treat and move water that will never reach its destination. This, of course, exacerbates the strain on water resources for the production of electricity. The key impediment to water agencies' efforts to reduce these system losses is financial cost. Rehabilitating aging systems can cost tens if not hundreds of millions of dollars. There is unquestionably a role for the Federal government in addressing this issue, not in the form of grants or subsidies but rather in providing access to low-cost Treasury bonds. Both the Association of Metropolitan Water Agencies and the American Water Works Association strongly believe that water agencies should be financially self-sufficient. The ability to draw upon this low-cost source of funding—as reflected in S.601—would significantly reduce the impact of infrastructure reinvestment on ratepayers and thereby

accelerate the rate of replacement and, accordingly, the reduction in system water losses.

Question 6. What are the short and long term planning decisions you have made as a water manager to meet the growing challenge of supplying drinking water to southern Nevada during this period of prolonged drought? What are the costs of these decisions and how are you paying for them?

Answer. For many years, the Southern Nevada Water Authority was focused on building water infrastructure quickly enough to keep pace with the fastest-growing region of the United States so that lack of water availability did not impede the community's economic prosperity. During the past two decades, our agency invested more than $2.5 billion in the community's water system, including construction of a new water treatment facility, expansion of the existing facility, and construction of miles of lateral water lines, pumping stations and related facilities. Drawing upon recommendations of a community-wide citizens committee, we structured a financial model that placed the majority of the financial responsibility upon the developers, who then imbedded those costs into housing prices. Beginning a little more than a decade ago, the issue of providing water to an increasing population was compounded by a drought of historic severity that struck the Colorado River, which represents 90 percent of the community's water supply. Our agency responded decisively by enacting new restrictions and development codes across all jurisdictions that significantly reduced the footprint of new residents and businesses while reducing the water use of existing customers. At the same time, it has invested approximately $180 million in incentivizing the replacement of 150 million square feet of grass with water-saving desert-appropriate landscapes. However, we recognized that Nevada's use of Colorado River water is insignificant in context to the system as a whole and would do nothing to slow the decline of the region's lifeline. Therefore, we initiated permitting that would reduce our community's dependence upon the drought-plagued river by drawing upon renewable, unused groundwater resources in the east-central portion of the state. Having invested tens of millions of dollars and a decade of work in this process, we earlier this year received rights of way from the Bureau of Land Management to construct conveyance facilities for our permitted water rights; the construction timeline is contingent upon Colorado River conditions, but the construction cost is estimated at more than $3 billion. Simultaneously, worsening conditions in Lake Mead compelled us to initiate construction of a new drinking water intake that would provide the community access to a high-quality—albeit potentially reduced—water supply from the Colorado River even during severe shortages. A newly formed citizens committee is evaluating a range of options to equitably share the financial burden associated with this infrastructure, which is far more difficult to bear due to the near-cessation of development in Southern Nevada. This is another instance under which a Water Infrastructure Financing and Innovation Authority (WIFIA) funding source would be exceptionally valuable. All funding for the projects we have already constructed, are being constructed or anticipated to be constructed in the future are paid for locally. There is not a dime of Federal money involved in any of them.

Question 7. What lessons learned can you share with the Committee for the benefit of other water managers?

Answer. There are far too many to recount, but from the perspective of a municipal water agency, two lessons stand at the forefront. First, the importance of water resource diversification cannot be overstated. In 2000, the Southern Nevada Water Authority signed a pact that gave it effectively unlimited direct use of the Colorado River for more than 15 years; within two years, the drought had virtually eliminated that supply. It is not necessary to actually physically construct alternative supplies in advance of their necessity, but given the realities of permitting and litigation, it is essential to take measures that will allow those supplies to be brought to bear quickly if needed. In the Southwest, rapidly deteriorating conditions do not provide the luxury of leisurely implementation horizons. The second is to develop and utilize a funding structure that fully and equitably reflects the value of water. It is no secret that many water rate systems fail to fully recover the costs associated with treating and delivering water. This is particularly true among low-use residential customers and among businesses protected by fire lines, who receive the benefit of asset protection often without paying for the system capacity necessary to support it. Our experience has been that while customers in all sectors are relatively receptive to periodic incremental increases in the cost of water, they are particularly resistant to the imposition of new charges. Therefore, it is in the best interest of municipal water managers to assess fees on all services that warrant it from the outset, even if those fees are nominal.

Question 8. Much of the attention during the 2012 drought was focused on the lack of precipitation, soil moisture, and surface waters but I am curious to know

what role does groundwater management play in drought resiliency? How are states and others managing this resource?

Answer. Because they react much more slowly to variations in climatic conditions, groundwater aquifers represent a tremendous resource in managing water supplies. Additionally, as entities like the Central Arizona Project, the Southern Nevada Water Authority, Orange County, Calif., and others have demonstrated, aquifers can be used as subterranean reservoirs for conserved or surplus water. During the past few decades, the science behind groundwater hydrology has advanced significantly, giving water managers valuable new tools to manage this vital resource sustainably. In terms of how groundwater is managed now, approaches and regulations vary wildly from state to state. For instance, in places like California, there are few codified rules governing its use, despite significant drawdown issues in some part of the state. At the opposite end of the spectrum, Nevada has arguably the nation's most restrictive groundwater law, which decouples water rights from land ownership and quantifies the "perennial yield" of each basin in order to protect the resource and the surrounding environment. Eastern states have an entirely different set of rules, wherein riparian rights are often assigned with property ownership. While developing a one-size-fits-all water policies for these markedly distinct regions would not be productive, a reconnaissance-level assessment of these various approaches and resulting conditions within their sphere of influence would likely yield insights about the benefits and limitations of each management strategy.

COLORADO RIVER BASIN

Question 9. How has the recent Supply/Demand study affected talks among the Colorado River Compact parties? Have the Upper Basin States and/or Lower Basin States met to address the conclusions of the report?

Answer. The release of the Colorado River Basin Supply and Demand Study has been beneficial to the seven states that share the river's flows in that it has quantified both the nature and scope of the challenges ahead. Moreover, the inclusive, collaborative manner in which the study was developed strengthened already productive relationships among the states' representatives, many of whom participated on a technical level. The end product was one that was universally accepted by the states, forestalling unproductive discussions about the nature of the problem and the gamut of solutions available. With the parameters established, the states have begun to discuss the feasibility of various potential actions and prioritize them for more refined analysis. Principal representatives from all of the Colorado River Basin states have met since the finalization of the study, and are now working together to chart a path that will systematically explore both the options already articulated and those that may emerge. What is certain is that no single solution will address the Colorado River's long-term challenges; rather, the solution will take the form of a mosaic, assembled and managed in concert by the various stakeholders.

Question 10. What is the status of the shortage criteria? Are there plans for revisions or an update?

Answer. The first-, second- and third-tier shortage trigger levels and associated responses remain unchanged from the original shortage guidelines adopted in 2007. While there are no plans to amend those criteria, the quantification of shortages below elevation 1,025 and the assignment of said shortages among the Colorado River Basin states and Mexico has yet to be addressed. At this point, the Colorado River community is making a concerted effort to identify strategies that maintain healthy elevations in Lake Mead. If and when conditions deteriorate to a point that first and second stage shortages take effect, discussions will undoubtedly be initiated by the states related to sub-1,025 elevation shortage criteria.

RESPONSES OF PATRICIA MULROY TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. As a water manager, please describe how water resource constraints within your service area have, or could, become energy constraints.

Answer. Despite being situated within the Southern Nevada Water Authority's service area, Hoover Dam—which currently generates an average of approximately 4 billion kilowatt-hours of hydroelectric power annually—is not a major source of electrical energy for Southern Nevada. The community receives less than 25 percent of Hoover Dam's output, with the majority conveyed through regional transmission lines to California and a lesser amount to Arizona. Much of Southern Nevada's energy is derived from generation facilities within Nevada's borders but outside the Las Vegas Valley Hydrographic Basin. Therefore, the relationship between water and power is contingent upon the continued availability of NV Energy's permitted groundwater supplies, which are managed by the Office of the Nevada State Engineer.

Question 2. How can the federal government work with the other interested parties in both the public and private sectors to improve overall efficiency and cost savings of water for energy and energy for water type operations?

Answer. There are two key considerations that warrant exploration and potential Federal intervention. The first is spurring innovation on both sides of the equation, which the Federal government can foster through a variety of economic tools. For instance, there are new water treatment processes available that are considerably less energy-intensive than many currently adopted systems. Similarly, capitalizing on the movement of treated water through the use of hydroturbines or similar technologies has demonstrated noteworthy results. However, incorporating these new technologies into a water utility's operations is often expensive, with a long rate of cost recovery. There are also energy production innovations on the horizon that could dramatically reduce the water consumption associated with power generation; again, these improvements come at a cost. To the extent that the Federal government elects to take a proactive role in fostering such innovations, there is a significant long-term yield to be derived. The second consideration is evaluating the type of energy production technology being applied and its appropriateness given the availability of water resources in that particular area. While again this falls into the broader discussion of the Federal government's appropriate role because of potential regulatory outcomes associated with this analysis, the relationship between choices of energy production and local hydrologic conditions is not one that has been explored in any significant depth.

Question 3. What is your view on legislation to promote better practices for water-energy nexus related operations?

Answer. Given the aforementioned site-specific nature of these relationships, the critical word is "promote" rather than "regulate." Too often, people associate Federal intervention with restrictions rather than incentives. As it pertains to fostering technological innovations and promoting best practices, there is little question that Federal guidance and support provided through the legislative process could help change the way this nation thinks about the water/energy marriage. Ultimately, there is no single approach that will be successful in every locale because conditions vary so dramatically in different parts of the country. However, guidance that presented a suite of geographically specific options and recommendations, coupled with incentives to encourage investments in innovation and the adoption of best practices, could yield a positive outcome.

Responses of Patricia Mulroy to Questions From Senator Flake

The energy-water nexus involves a wide variety of considerations from the impact of drought on energy production to the energy needs for water delivery. In Arizona for example, the Navajo Generating Station provides power to pump approximately 1.5 million acre feet through the Central Arizona Project. Likewise, water augmentation proposals, such as desalination, would require significant energy resources.

Question 1. Can you elaborate on the role of energy reliability and affordability in future water security of the Colorado River system?

Answer. Water is of limited value without the means to deliver it. The resource itself is virtually free; it is the treatment and conveyance of water where the vast majority of expenses are incurred. Of the many cities that rely upon Colorado River to serve their citizens, Las Vegas is one of the few actually located within the Colorado River Basin and it is the only one in close proximity to the river itself, and is also unique in recycling virtually 100 percent of its indoor water. As you astutely observed, vast quantities of water are pumped to Arizona's desert cities. Similarly, San Diego, Los Angeles and other coastal California cities import their Colorado River water from great distances, as do Denver, Salt Lake City and Albuquerque. The reality is that, in the modern world, people seldom settle in a particular location because of its proximity to a reliable water supply. Rather, there is an expectation that through the genius of engineering, water will be conveyed to them. However, with the rare exception of a gravity-feed system, water must be pumped to its destination, and doing so requires substantial electrical energy. For example, our agency alone spent almost $45 million last year alone for operational energy costs. Electrical power is already a significant factor in water pricing, and it will only increase as the strain on our energy supply increases. Desalination, which is certainly feasible from a technological perspective and would at least in some small measure alleviate stress on the Colorado River, currently has an exceptionally large energy footprint. Given economic conditions, that certainly will be an inhibiting factor for its broad adoption. Any mitigation strategies, whether they involve bringing new

water into the system or having water users utilize resources from outside the Colorado River Basin, will necessarily entail considerable energy costs.

Question 2. Last year, the Director of National Intelligence issued an assessment on Global Water Security, finding that poor water quality and shortages will lead to global instability.

What lessons and expertise can water managers in the United States share with water managers in other countries to assuage water conflict and add to global stability with regard to water issues?

Answer. There are a multitude of lessons that water managers in the United States can share with their counterparts in other countries, and many that our counterparts can share with us. Unfortunately, however, important practices related to water resource management are difficult to apply in other countries because their political and legal structures are not conducive to implementation. Despite criticisms from abroad and within our own borders, the United States is first and foremost a nation of laws. Those laws provide a structure that—while occasionally rigid—creates certainty and provides opportunities for legal relief. Having closely studied conditions and conflict over water in the Middle East, I have observed that much of the intractability of these problems stems from an inadequate framework for resolving disputes, either between countries or within them. Beyond that, issues over water resources are interwoven with other issues in relations that are often complex and difficult. With that said, water quality issues are absolutely solvable, and it is both tragic and unnecessary that in the 21st century waterborne illness continues to take more lives—estimated at more than 3.4 million a year by the World Health Organization—than any other cause of death. Moreover, the lack of access to a safe, reliable water supply is a root cause of poverty worldwide and is a nearly insurmountable obstacle to development in those portions of the world. Those issues are only compounded when a lack of water seriously impairs the areas' food supply. While water professionals in the United States have considerable expertise they can bring to bear on this situation, the unfortunate truth is that many of the infrastructure issues plaguing parts of the world are rooted in political instability. However, American water professionals are at work in many parts of the world helping communities build sustainable water supplies. Until and unless the underlying sociopolitical problems are addressed, large-scale improvements in clean water and sanitation are likely to be inconsistent and transient.

APPENDIX II

Additional Material Submitted for the Record

STATEMENT OF THE WESTERN GOVERNORS' ASSOCIATION

This testimony is respectfully submitted to the Chairman and members of the Senate Committee on Energy and Natural Resources by James D. Ogsbury, Executive Director of the Western Governors' Association (WGA), on behalf of the organization.

The WGA is an independent, non-partisan organization of Governors from 19 Western states, three US-Flag Pacific Islands. The Western Governors recognize that many vital issues and opportunities—including water management, forest health, energy development, and wildlife conservation—cross state lines and are shared priorities throughout the West. Western Governors work through WGA to address the key policy and governance issues that arise out of the shared western landscape.

Western Governors have a legacy of leadership in drought planning, energy management, and the complex issues associated with water allocation and use in the West. These issues are critically important to the West and the Governors ask the Committee to consider the perspective of western states in its deliberations on related issues.

DROUGHT PREPAREDNESS AND MONITORING

Droughts and extreme weather events cause significant impacts to economies, communities and the natural environment of the western states. The 2011 drought in the Southern Plains and Southwest cost more than $12 billion;[1] the widespread drought of 2012 will almost certainly cost as much if not more, as the most extensive drought the U.S. has experienced since the Dust Bowl era in the 1930s.

The Governors have tasked WGA to support states in monitoring, forecasting, preparing for and responding to extreme weather events. In June 2011, the Governors signed an MOU with the National Oceanic and Atmospheric Administration (NOAA) to improve the development, coordination and dissemination of climate information and early warning systems in order to reduce disaster risk from extreme weather events. WGA and NOAA have co-sponsored regional meetings since that time, in both the Pacific Northwest and the Upper Missouri Basin, to connect NOAA monitoring and forecasting with on-the-ground decision makers.

WGA also joins NOAA once every three months to publish the Quarterly Climate Impacts and Outlook,[2] a document which shows drought maps, projections, and effects across the region.

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM (NIDIS)

In the mid-2000s, then-Governors Johanns (NE), Richardson (NM) and Martz (MT) spearheaded regional support for the creation of the National Integrated Drought Information System (NIDIS). Since its establishment, state agencies and WGA have provided additional suggestions and guidance to ensure that NIDIS delivers relevant and timely information on drought to western states.

The Western Governors have policy in place that specifically supports the continuation of NIDIS:

> "Western Governors believe a comprehensive, integrated response to drought emergencies, including mitigation planning, is critical to the social, environmental and economic well-being of the West. . .Governors rec-

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[1] http://www.ncdc.noaa.gov/billions/events

[2] Read past issues of the Quarterly Climate Impacts and Outlook at www.westgov.org/initiatives/climate.

ommend the continued development of the NIDIS program, particularly with respect to implementation of regional drought early warning systems."

—WGA Policy Resolution 11-7

NIDIS provides a single, authoritative venue for drought information at its website, drought.gov. It coordinates observations and research from various federal, state, and academic experts, and it provides a 'one-stop shop' for state water resource managers, the agricultural community, the private sector, the media, and others who are affected by drought. From the perspective of western states, where water is often already a scarce resource, the information available through the NIDIS website is an immensely useful planning tool.

DROUGHT'S EFFECTS ON ENERGY AND WATER MANAGEMENT

Water is a critical component of energy development in the West. Water for resource extraction or cooling in thermoelectric plants is essential to operations. Studies have shown that proposed traditional and renewable power plants will be a major driver of new water demand over the next decade. A preliminary analysis by WGA and Sandia National Labs predicts that thermoelectric demands will account for 50 million gallons per day of new consumptive demands. That new demand will be particularly high in the water-stressed Southwestern US, causing even more competition for water in a drought-prone region.[3]

For water management, the effects of drought are even more direct. Water storage in reservoirs allowed westerners to weather last year's severe drought, but tapping into reservoirs means less water in reserve for future drought. In Colorado, where reservoir storage is 16 percent below average,[4] cities in the metropolitan Front Range area are already enacting water restrictions for their residents.[5] New Mexico's reservoirs are even lower, at 24 percent below average.[6]

A dependable water supply is extremely important for both energy and water management. When drought makes that water less-than-dependable, the reliable information on weather and climate provided by NOAA and NIDIS allows decision makers to make better informed plans for both energy and water management.

THE IMPORTANCE OF ENHANCED DROUGHT PREPAREDNESS THROUGH REAUTHORIZATION OF NIDIS

Western Governors strongly support the reauthorization of NIDIS and believe the "Drought Information Act of 2013" (S. 376) is a good vehicle to achieve that goal. Without the resources in NIDIS, the entire nation would take a step back in terms of the access to fast, reliable information for a coordinated and timely response to drought.

In addition, the regional drought early warning information systems that proved successful in the Colorado Basin, the Southeast, and California will extend to other regions through NIDIS reauthorization. NOAA intends to accelerate efforts to build a fully nation-wide integrated drought information system by expanding to critical, drought-sensitive areas suchμas the Midwest, the Pacific Northwest, the Missouri Basin, and the Northeast.

In the West, where a lack of precipitation during winter snowpack accumulation can mean reduced water supplies throughout the year, monitoring and preparing for drought is particularly important. The effects of drought echo through the water and energy management systems and into the everyday facets of life, from household chores to the ability of a city to accommodate new citizens and build its economy. With NIDIS, states can plan for drought and mitigate these and other impacts to water and energy management.

CONCLUSION

Thank you to the Committee for this opportunity to provide input. Western Governors and WGA stand ready to work with you. Please consider WGA a resource as you grapple with drought planning and energy management issues.

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[3] Western Electricity Coordinating Council, 10-yr Regional Transmission Plan: Plan Summary, Sept 2011, pp 88- 94. http://www.wecc.biz/library/StudyReport/Documents/Plan_Summary.pdf .

[4] As of April 1, 2013. Information from NRCS at www.wcc.nrcs.usda.gov. Graph titled: "Reservoir Storage as Percent of Capacity for April 1st, Water Year 2013."

[5] Denver Water, the city's water utility, enacted drought water rules as of April 1, 2013. http://www.denverwater.org/Drought/WateringTimes/. Other utilities in the Denver metro area have enacted similar restrictions.

[6] Ibid at 4.

We look forward to working with Congress to advance NIDIS reauthorization through the legislative process.

WESTERN RESOURCE ADVOCATES,
April 24, 2013.

Hon. RON WYDEN,
Chair, Senate Energy and Natural Resources Committee, 304 Dirksen Senate Building, Washington, DC.

Hon. LISA MURKOWSKI,
Ranking Member, Senate Energy and Natural Resources Committee, 304 Dirksen Senate Building, Washington, DC.

DEAR SENATORS WYDEN AND MURKOWSKI:

In the West, energy and water are inextricably linked; drought exacerbates the challenge of meeting the region's water and energy demands. Western Resource Advocates works to promote solutions to western energy and water challenges, while protecting the West's valuable natural resources. Thank you for your leadership in addressing these issues of momentous importance to communities in our region.

Our principal water supply, the Colorado River, provides water to nearly 40 million people, irrigates over 5 million acres of cropland, and supports over 20,000 MW of energy generation, including both hydroelectric dams and thermoelectric power plants. Drought impacts all of these sectors, in addition to the environment and tourism and recreation-based businesses that depend on the river.

In addition to short-term drought, long-term climate change threatens the availability and reliability of water supplies in the Colorado River basin. According to the Bureau of Reclamation's Colorado River Basin Water Supply and Demand Study, climate change is projected to decrease average annual runoff in the basin by 9%, along with

- A projected increase in both drought frequency and duration;
- Continued warming across the Basin;
- A trend towards drying; and
- Increased evapotranspiration and decreased snowpack.[1]

Given this challenge, we encourage the federal government to support state and local agencies, along with energy and water providers, in pursuing win-win solutions, described in greater detail below.

1. Federal agencies should fund and promote water management strategies that help communities adapt to short-term drought and long-term climate change, while reducing greenhouse gas emissions

Water management strategies that mitigate and adapt to climate change and drought include urban water conservation, expanded reliance on recycled water, and flexible leasing agreements between water users. Water use accounts for an estimated 13% of our nation's energy use[2]; in Western states, where water is often pumped over long distances (e.g., the California State Water Project and the Central Arizona Project), that figure is likely to be even higher. Urban water conservation can reduce customers' water use, saving the energy used to pump, treat, and distribute water, and in the household, to heat water. Similarly, treated wastewater or recycled water can reduce the amount of energy used to pump and treat potable water supplies to customers. Flexible leasing arrangements—often between cities and farmers—can protect cities or industrial water users from drought while providing reliable income to farmers leasing water.

Specifically, the federal government can support these strategies by

- Restoring funding to pre-sequestration levels of $24.6 million for the Title XVI Water Reclamation and Reuse Program and $30.75 million for the WaterSMART Grants Program, which provides funding to support water and energy efficiency measures pursued by state and local water providers. The WaterSMART and Title XVI programs have been well received and have gone a long way towards building a more resilient, self-sufficient and drought-tolerant economy in seventeen western states.

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[1] Bureau of Reclamation. December 2012. Colorado River Basin Water Supply and Demand Study: ExecutiveSummary. Available at http://www.usbr.gov/lc/region/programs/crbstudy/finalreport/index.html.

[2] Sanders, K. and M. Webber. 2012. Evaluating the energy consumed for water use in the United States. Environmental Research Letters, Vol. 7.

- Supporting continued improvements in plumbing codes and standards. Several states, including Georgia, Texas, and California, have adopted more efficient plumbing codes. Updating federal plumbing codes so that they are on par with these state plumbing codes could provide even greater water and energy savings.

2. Legislators and federal agencies should adopt energy policies that accelerate our nation's transition to a more water-and carbon-efficient economy

Water is required to mine natural gas, coal, oil shale, and other resources; and for cooling and other processes at thermoelectric power plants. Indeed, thermoelectric power plants accounted for 41% of freshwater withdrawals in the U.S. In the West, most power plants rely on recirculating cooling systems, which withdraw much less water, but consume most or all of the water they withdraw. A typical western coal plant would consume approximately 540 gallons/MWh of electricity produced, while nuclear and combined cycle gas plants would consume 610 gallons/MWh and 180 gallons/MWh, respectively.[3] In contrast, most energy efficiency measures and many renewable sources of energy, such as wind or solar photovoltaic panels, consume no water. Figure 1* illustrates the location, fuel source, and water use of power plants in six Southwestern states.

Accelerating the transition from carbon-and water-intensive energy sources to water-efficient renewables and energy efficiency will reduce pressure on western water resources. In the Interior West, clean energy policies that have promoted energy efficiency, renewable energy, and a transition away from carbon-intensive power plants now save an estimated 6.3 billion gallons per year, or enough to meet the annual needs of approximately 78,000 households.[4] Colorado's bipartisan Clean Air-Clean Jobs Act passed in 2010 will lead to the retirement of 900 MW of coal-fired capacity. The resulting water savings will be substantial—roughly 5,000 acre-feet (or 1.6 billion gallons) annually—enough water to meet the consumptive water needs of 50,000 water customers in the Denver-Metro area. Similar strategies have been proposed by utilities or state legislatures in Arizona and Nevada, and will likely lead to future water savings in those states.

In western states and across the nation, natural gas will likely continue to play an important role in the transition to cleaner sources of energy. It is critical that—as natural gas is developed—local water resources are protected and methane and other greenhouse gas emissions are avoided, minimized and mitigated to the maximum extent possible.

Perhaps most important, however, is a federal policy to limit greenhouse gas emissions—the primary driver of long-term drought and water scarcity in the West.

* * *

Recent late-season snowfall in Colorado has likely alleviated this year's drought conditions, which, just one month ago, appeared dire. Basin-wide, however, the Colorado River's major reservoirs are still just at 50% of capacity[5], and drought and long-term climate change pose ongoing challenges to western water and energy managers. Today's investments in water and energy infrastructure must be resilient to potential water shortages for decades to come. It is critical that federal policies incentivize measures that help us mitigate and adapt to drought and climate change.

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[3] Figures reflect western power plants. Data from U.S. Energy Information Administration. 2002. Form 767, Steam- Electric Plant Operation and Design Report, Cooling System Information.

[*] Figure 1 has been retained in committee files.

[4] Western Resource Advocates: A Powerful Thirst: Managing the Electricity Sector's Water Needs and the Risk ofDrought (2012).

[5] U.S. Bureau of Reclamation. Lower Colorado River operations schedule. Available at http://www.usbr.gov/lc/region/g4000/hourly/rivops.html. Lake Powell is at 47% of capacity; Lake Mead is at 50% of capacity, as of April 24, 2013.

We sincerely appreciate your leadership on these vital issues.

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Senior Energy & Water Policy Analyst,

BART MILLER,
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MATTHEW NIEMERSKI,
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