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PARTICIPANTS:

Welcome:

SHERYL SANDBERG
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Introduction and Overview of Event:

ROBERT E. RUBIN
Co-Chair, Council on Foreign Relations
Former U.S. Treasury Secretary

The Landscape of Water in the West:

JERRY BROWN
Governor
State of California

ROUNDTABLE: SHOPPING FOR WATER: HOW THE MARKET CAN MITIGATE WATER SHORTAGES IN THE AMERICAN WEST:

Author:

ROBERT GLENNON
Regents' Professor, Morris K. Udall Professor of Law & Public Policy
James E. Rogers College of Law
University of Arizona

Moderator:

MELISSA KEARNEY
Director
The Hamilton Project

PARTICIPANTS (CONT'D):

Discussants:

ELLEN HANAK
Senior Fellow
Public Policy Institute of California

THOMAS ISEMAN
Deputy Assistant Secretary, Water and Science
U.S. Department of Interior

JAMES LOCHHEAD
Chief Executive Officer and Manager
Denver Water

WILLIAM PHILLIMORE
Executive Vice President
Paramount Farming Company

ROUNDTABLE: THE PATH TO WATER INNOVATION:

Author:

BARTON "BUZZ" THOMPSON
Robert E. Paradise Professor of Natural
Resources Law
Perry L. McCarty Director
The Stanford Woods Institute for the Environment

Moderator:

ROGER ALTMAN
Founder and Chairman
Evercore

PARTICIPANTS (CONT'D):

Discussants:

TAMIN PECHET
Founder
Banyan Water

MICHAEL MARKUS
General Manager
Orange County Water District

PETER YOLLES
Founder and Chief Policy Officer
Water Smart Software

MODERATED DISCUSSION: THE IMPACT OF CLIMATE CHANGE ON AMERICA'S WATER RESOURCES:

Introduction:

ROBERT E. RUBIN
Co-Chair, Council on Foreign Relations
Former U.S. Treasury Secretary

Facilitator:

THOMAS F. STEYER
Investor
Philanthropist and Advanced Energy Advocate

Panelists:

WADE CROWFOOT
Deputy Cabinet Secretary and Senior Advisor
Office of California Governor Jerry Brown

PARTICIPANTS (CONT'D):

NOAH DIFFENBAUGH
Associate Professor of Environmental Earth System Science
Senior Fellow
The Stanford Woods Institute for the Environment

PETER GLEICK
President and Co-Founder
The Pacific Institute

SOLOMON HSIANG
Assistant Professor of Public Policy
The Goldman School of Public Policy
University of California, Berkeley

Closing Remarks and Adjournment:

STEVE DENNING
Chairman, General Atlantic
Chairman of the Board, Stanford University

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P R O C E E D I N G S

MS. SANDBERG: Good morning, everyone. I'm Sheryl Sandberg. I work at Facebook, and I am also a member of the Advisory Council of the Hamilton Project, and I have two jobs this morning: I get to welcome everyone to the opening of this meeting, and I get to introduce our first speaker, Bob Rubin.

And it's my pleasure to do both. Thank you for including me.

The Hamilton Project was started by Bob Rubin and Roger Altman, who are both here with us this morning, to promote seriousness of purpose around public policy debate to make sure that we're paying attention to the policies that will lead to inclusive and broad-based (inaudible) and do so by addressing the serious issues of the day with the serious debate that these issues need.

This is currently run by Melissa Kearny, and the whole team is here with us today. We're very excited to have you.

And I think we all agree that in the

challenging times we face today -- challenging times globally, challenging times within our country, challenging times within our state -- seriousness of purpose around public policy has never been more important. So, we're really excited to have the Hamilton Project here with us today.

I'm particularly personally pleased to welcome all of you to California and Silicon Valley. This is the second time the Hamilton Project has partnered with Stanford. The first was two years ago in 2012. And it's not where they typically are. In fact, Bob told me when they first thought about California two years ago -- his quote to me on the phone was, "We're not California people." (Laughter) And then they came and it was a very successful partnership with Stanford and it worked pretty well, so this time he didn't say, "We're not California people," but last night he did manage to say, "We do really like it in New York."

But we're excited to have Bob and Roger and all of you here, because we think Silicon Valley is

important to the national debate. We think the innovation, the technology that's happens here -- and happens in New York and other places around the country and the world -- is a big part of the answer.

Silicon Valley, Stanford -- I think for many people we typify the shift from our industrial- and resource-based economy to a knowledge-based economy. And that's a really important shift. When we talk about it here, we talk about how the knowledge-based economy is not a zero-sum economy. Unlike a resource that either I can have or you can have but two people can't have the same one, if I know something it doesn't mean you can't know it and you can't and you can't know, that represents the growth we think the knowledge economy has.

But it's important to recognize that with this comes really destructive change, challenges for jobs, challenges for education, challenges for the distribution of wealth; and these are challenges that (inaudible) Stanford, the Hamilton Project have to take really seriously.

Today's meeting is on water. And why that makes so much sense is because we also recognize that a knowledge economy is based on a research economy. Everything companies like mine does is based on energy and water. So without the efficiencies that we work for at Facebook -- that I know so many people on the Stanford faculty and others work so hard for -- without those efficiencies we can't continue to create the growth that we want to see for our economy.

So, we're really excited that the Hamilton Project is here partnering with Stanford to talk about water, because we understand how important water is to the underpinning of the knowledge economy that we depend upon.

With that, I'll turn to my second half, which is introducing Bob Rubin.

I had a chance to work for Bob when he was Secretary of the Treasury for many years, and the lessons I learned from him are part of my life every day. When I was first at Treasury, I had been there a couple of days. I didn't know anything. I'm not sure

I ever knew anything, but I particularly knew nothing my first week. And I was in a meeting, and it was in his fancy Secretary of the Treasury conference room, and I was sitting in the back of the corner, not sitting at the table, for any of you who have seen some of my thoughts on that topic.

But to be honest, I'm not sure I belonged to the table, and I felt just lucky to be in the room. I couldn't believe I was there. My whole experience at the meeting was, wow, someone let me sit here. And at the end of the meeting, he shocked me by turning in front of everyone and saying, "Sheryl, what do you think?" Jaw on the table, I'm sure I said nothing at all or nothing articulate at all. But I learned something then, which is to ask everyone in the room what they think, something I've tried to do ever since then in my career.

Just a few weeks later, there was a really hard project at Treasury that essentially had no upside and no leader. And Bob left the fancy Secretary of the Treasury suite and walked over to my

tiny little office and he stood in the doorway -- I'll never forget this -- and he said to me, "Could you coordinate this project?" And I looked at him and said "I don't think that's going to go very well." (Laughter) "I'm new, I'm young, no one wants me to coordinate this project." And he did two things. He looked at me and said, "You're right. This is really hard, and you're not that well set up to do it well, and I'm not sure it's going to go well for you or for us. But we don't have anyone else." (Laughter) "And so I would really appreciate it if you do your best."

And I went home that night, head spinning, and said to my roommate, "My God, the Secretary of the Treasury walked down to my little cubby of an office and asked me to do something that I'm not really well equipped to do. And then he was honest with me, and he told me it was going to be hard. He didn't tell me it would be easy." And I learned something from that, too, and I tell people all the time on my team that they (inaudible). Be straight, be honest. If something's too hard for someone but you need them to

do it anyway, just tell it to them straight. Somewhere between giving (inaudible) your people opportunities, giving them the straight story, showing them that you're willing to metaphorically leave your office and come to them and listen for every voice. So, those are a few of the things I learned from Bob that made Bob such an unbelievable Secretary of the Treasury and has enabled him to contribute in so many ways across American business and across American politics.

So, it's absolutely my great privilege and honor to welcome my mentor and my friend, the great Bob Rubin, to the stage.

MR. RUBIN: Thank you, Sheryl. I actually remember that project. And I was stuck a little bit, because who the heck was going to do some crazy thing like this. But the way to do it was to try to persuade you that if you did it, if I were nice to you and everything else, you might survive, and you have. (Laughter) We were also absolutely delighted to have you be part of our Hamilton project.

I first met Sheryl when I was sitting in my office and Larry Summers, Deputy Secretary, came in and said: I have somebody I want to hire as my new Chief of Staff, and she's the brightest person I had in my time at Harvard. And for those who know Larry, it's not something he says too lightly -- calling people bright and things of that sort. (Laughter) So, I said: Okay, let's see what happens. And I think it would be fair to say that Sheryl has done reasonably well ever since then in business and really, more broadly, for our society.

Sheryl, we are absolutely delighted to have you as part of our Hamilton Project.

Larry, Sheryl, and I have remained good friends ever since those days at Treasury.

This is, as Sheryl suggested, a usually consequential time for water policy. One of the panelists said to me just now that it's terrific how the Hamilton Project has brought people together, because ordinarily what you do is you have discussion on water with respect to agriculture or whatever else

it may be, and what we've tried to do here is to bring it all together into one program and one discussion.

I've had a view for a fair bit of time, although I don't really know much about water, that water could very well raise, in the 21st century, many of the same issues that were raised by Energy in the 20th century politically -- economically and politically. Furthermore, the policy challenges raised by water are really just beginning to garner the kind of attention that I at least think they've (inaudible).

The combination of one of the world's truly great universities, Stanford, with its academic and intellectual work on water, and the Hamilton Project, which is a Washington-based organization that has very much a Washington orientation, brings into one discussion a multiplicity of perspectives and experiences, which I think does add a great deal to the ultra-work product. We did a project two years ago with Stanford, as I think Sheryl mentioned, on energy; and I don't think there's any question that

they bring together all the enormous intellectual power at Stanford with our own, I think, very great seriousness of purpose about matters of intellect, academic matters. And our Washington orientation produced a product that neither one of us were likely to have produced alone. And I hope it will become apparent today that the same kind of synergy is felt in today's undertaking.

Let me briefly say a few words about each of the co-sponsors before we go into the roadmap of the firm. I'll start with the Stanford Woods Institute, which is the part of Stanford that is most involved with this project and is, as all you know, nationally renowned as a hub for environmental research and for environmental breakthroughs. And within that context, fresh water has been pretty much a prime focal area for the Woods Institute.

Woods programs like Water in the West are looking at ways to improve water management; to restore waterways that have been degraded over many, many years; and, the final analysis, to work toward

providing adequate fresh water for everyone. And that's true in both the developed nations and in the developing world.

Woods and Water in the West are convening dialogues and discussions very much like the forum today with the (inaudible) to pursuing those objectives and to improving the nation's water policy regime, and we are grateful and proud to be working with Stanford in this particular forum.

The Hamilton Project is probably not as well known to most of you, so let me say a few words about us. But let me start by saying that part of me with Stanford really has been a great experience. It was true in the energy event and true in these discussions of water, and it's something that we look forward to doing in the future on other issues.

The Hamilton Project began about eight years ago. It was an unusual situation. A group of former government officials, academics, policy experts, and business people with a strong interest in policy came together and decided that there was a real need for an

organization that was nonpartisan and whose only objective was to contribute, to use the phrase that Sheryl used, a seriousness of purpose about policy deliberation, policy debate, and, also in that context and in that spirit, to promote policy development and bringing together that widely experienced group of people. And we did it within the context of the Brookings Institution, which you know is a great intellectual think tank and which gave the Hamilton Project a distinctly broad perspective on the issues that they focused on.

The Hamilton Project does not endorse policy proposals but, rather, what we do is construct fora, as we have have here today, to create serious policy discussions about important economic policy issues to bring together academic and policy experts with practitioners from around the country. And then we do extensive outreach to bring the work product to the media and to the Washington world that we are part of.

When there are policy papers involved, as there are here, they are subject to rigorous peer

review just like they would be in any academic institution. As Sheryl said, we believe in subjective economic policy, growth, and broad-based participation in the benefits of growth and economic security. And it is our view that those objectives can be mutually reinforcing. We support market-based economics, but we also believe strongly in the vital role of the government to perform the many functions requisite for economic success that markets by themselves will not perform.

And that takes us to today's program. Before going to the roadmap of that program, and before introducing our distinguished keynote speaker, who is with us -- and we are grateful, Governor Brown, that you joined us -- let me make three substantive comments on the topic of water.

Firstly, as I said a moment ago, water receives very little national policy focus, and the result is woefully inadequate policy in an area that, as Sheryl suggested, has become critical -- increasingly critical -- to our nation's economy.

You have tension now, serious tension, to different geographic areas, states, localities over water; and you have serious tension between different uses of water -- agriculture and technology, for example. Buzz Thompson, who is a professor at Stanford was kind enough to spend about a half hour on the phone with me the other day. The one thing that struck me was just how massively complex these water issues are, especially when you delve with the second-, third-, fourth-order effects on other parts of our economy.

Secondly, the United States does have large supplies of fresh water. By the way, the situation is very similar in China. They have large supplies of fresh water. But the problem, as you well know, is a lot of development is taking place in areas that do not have supplies of fresh water. The question is how does one break that gap?

And thirdly, water pricing is massively inefficient in this country, and that severely distorts the allocation of water supplies, incentives

for technological advancement, water conservation, and dealing with the problem of water waste.

Having said all that, we are deeply, deeply honored to begin our program with a presentation entitled “The Landscape of Water in the West” by our keynote speaker, distinguished governor of the state of California, Jerry Brown.

Throughout today’s discussions, I will continue going through the roadmap, in a few moments, of our program. I will mention the participants, but I won’t go into their resumes. They’re extremely distinguished, and they are in your materials.

Having said that, I do want to make a few personal comments about the governor.

Jerry Brown and I were classmates at Yale Law School quite a long time ago, and we have our reunion coming up, which both of us will be going to. I don’t know about Jerry, but I’ve been visited by development people already to guess how wonderfully I could celebrate that man. Maybe it’s a little less of a problem for Jerry, I don’t know. (Laughter)

And even at that time, that long-ago time, Jerry was a very unusually creative thinker about the social issues that faced our country. Water is obviously an enormously important issue in California, and Jerry has been deeply involved with it and with great effect. As you know, he, for the first time in California's history, has now put in place a regulatory regime for aquifers for ground water, and he has Proposition 1, pending next election, which I rather suspect he will comment on.

I also think that his extraordinarily impressive accomplishments with respect to regulating ground water is a good example or exemplifies his broader success in making this political system work. And I think that's a lesson for the rest of the country at a time when our Congress is dysfunctional and so many governments around the country are dysfunctional and that dysfunctionality is undermining the future of our country. But I think Jerry as a leader really has a great deal to say to the rest of the country.

For all these reasons, we are deeply honored to be joined by the governor and also by his wife, Anne Gust Brown, who was described by the *New York Times* as his top gubernatorial aide.

Now, before we turn to the governor, let me just go through this roadmap of the program. Our first roundtable is entitled "Shopping for Water: How the Market Can Mitigate Water Shortages in the American West." This panel will focus on market mechanisms that can be used to more effectively manage water and to mitigate the water supply challenges that are equally affecting many areas of the western part of our country.

The panel will begin with a paper by Robert Glennon, Professor of Law and Public Policy at the James E. Rogers College of Law at the University of Arizona. He also will then engage in a discussion with four distinguished discussants: Ellen Hanak, Senior Policy Fellow, Public Policy Institute of California; Tom Iseman, Deputy Assistant Secretary, Water and Science, U.S. Department of the Interior;

James Lockhead, Chief Executive Officer and Manager, Denver Water; and Bill Phillimore, Executive Vice President, Paramount Farming Company.

The Moderator will be Melissa Kearney, Professor of Economics, University of Maryland, a participant in the National Bureau of Economic Research, and Director of the Hamilton Project.

The second panel is entitled “The Path to Water Innovation” and will focus on the current lack of innovation, the water sector, the obstacles to developing new technologies, and the obstacles to developing policies that are responsive to challenges that we face.

The panel will begin with a paper presented by Buzz Thompson, Professor of Natural Resources Law, Stanford Law School, and Director of the Stanford Woods Institute for the Environment.

The discussants are: Mike Markus, General Manager of the Orange County Water District; Tamin Pechet, Chairman of Imagine H_2O; and Peter Yolles, Founder and Chief Policy Officer of Water Smart

Software.

The moderator is Roger Altman, Founder and Chairman of the Investment Bank from Evercore, and former Deputy Secretary of the Treasury.

And the final panel, titled “The Impact of Climate Change on America’s Water Resources,” will focus on the implications of climate change, water policy, and the challenges that poses to water management.

Discussants will be Wade Crowfoot, Deputy Cabinet Secretary and Senior Advisor to Governor Brown; Noah Diffenbaugh, Associate Professor of Environmental Earth System Sciences, and Senior Fellow at the Stanford Woods Institute for the Environment; Peter Gleick, President and Co-Founder of the Pacific Institute; and Solomon Hsiang, Assistant Professor of Public Policy at the Goldman School of Public Policy at the University of California.

And the facilitator and moderator is Tom Steyer, Founder and recently retired CEO of Farallon Capital Management. Tom and I used to work together a

long time ago at Goldman Sachs and Farallon Investment Fund located in San Francisco. Tom retired a couple of years ago and is now one of the nation's leaders with respect to climate policy and climate advocacy.

We will then conclude with remarks by Steve Denning, Chairman of General Atlantic Corporation and Chairman of the Board of Trustees for the Stanford University.

And now it is my enormous pleasure and honor to introduce the governor of the state of California, Gerry Brown.

GOVERNOR BROWN: Thank you Bob and reminding everyone about Yale Law School. It's not like it used to be. In fact there's been a lot more laws since we went to law school. I've calculated that. (laughter) There's been over 50,000 new laws in California, which I've probably signed 12,000 myself. (laughter) So don't worry, any of you new lawyers. There's going to be plenty of work to do.

Well, water. Big topic. Hard to talk

about, complicated, covers a wide range of activities and problems and geographic areas. I've been hearing about water a long time, probably 60 or 70 years long. My father was Attorney General and I can remember over the dinner table him talking about the Arizona California Law Suit which he was the chief lawyer for California and that had been going on for decades and it was all about the allocation of Colorado River water, crucial to California, southern California particularly and also Arizona.

So water was always a big story and even today, lots of the challenges that were brought about, talked about, debated 50 years ago are still very alive. I guess it was Earl Warren who started talking about fixing the delta. This is the body of water that captures the Sacramento River water and then moves it along to the aqueduct for distribution to farms at Santa Clara County and to southern California. And the delta is full of lots of issues and problems and people have been trying to fix it for a long time.

In fact, the California water project, which was Proposition One on the 1960 ballot, won by a very tiny margin. That was the year that Kennedy beat Nixon but Nixon beat Kennedy in California, and nevertheless the water, Proposition One passed then and I'm confident that Proposition One will pass again this November. We have a second Proposition One. It's doing a little better than the first Proposition One. It's a 7.5 billion dollar bond that covers a number of topics, but the point I want to make is that water is not only complicated, it's long debated. We're talking decades. And the water project that was finally enacted when my father was governor and built in subsequent years, had some missing ingredients. And one of them is, how do you deal with the delta, which is a body of water protected by earth and levies that are more than 100 years old and vulnerable to earthquake and to extreme weather events or to rising sea level. And that's a real problem because, for example, Santa Clara County gets half its water through the aqueduct coming from the delta, and if

salt water intrudes, that would be a very bad day at the ballot because half your water would disappear. That's not a little trivial event, that, if you want to put it in economic terms, hundreds of billions of dollars, virtually overnight.

So this is serious stuff. And there's by no means a consensus at this point -- lots of fighting over this. Matter of fact, I proposed a solution to the delta in 1978, passed the legislature, Democratic as well as Republican votes, but it was put to a referendum by an odd alliance of some central valley farm interests and environmentalists in the north. They both put their combined reference and they defeated it and because of that defeat, the next three governors avoided water issues like the plague. And then it wasn't until Governor Schwarzenegger began to address the issue and developed a Stewardship Council to deal with the delta problems and also help put a water bond on the ballot -- an 11 billion dollar water bond that promptly was labeled pork filled and was stigmatized on all sides. So not very easy.

Also in 1978, I established a water commission under the former Chief Justice Wright, was the Chief Justice appointed by Ronald Reagan and he convened a bipartisan group of experts and public servants. And they came up with a plan. And one of the key ingredients of that plan was to regulate the ground water. Well I can tell you, it took from then, 1978 to a few months ago, to get a ground water plan, and so this is not something for a flash in the pan. This is not just for a one term governor. This is really the work of a four term governor. (laughter) You need your first couple of terms just to set the table, make the proposals and then you need your last two terms, thirty years later to finally carry the ball across the finish line, which is what we're going to do. I can promise you in the next four years, water is the key issue and we're going to build on the great work of Earl Warren and Pat Brown and Governor Schwarzenegger and I might even say my first couple of terms. (laughter) And it will be controversial. The issues have not been fully resolved but like energy

and climate change, that have been contentious but also led to very productive initiatives, the same will be true of water, and it will be something that I'm going to put front and center.

Since I'm not doing a lot of campaigning, there has been some question in the press -- will there be anything done in the next four years, because we don't know. But we haven't heard. Well, you're hearing today. Water is going to be a major issue that will be addressed in the California legislature and in Congress and throughout communities everywhere because water doesn't get solved in one office or one place. Water issues are handled by a multitude of local agencies. They're handled by state rules and institutions and also by the federal government. So it's a complicated interplay of governmental jurisdictions at every level and of course, it engages partisan and ideological fervor. You have people who are focusing on biological diversity, you have other people who are focusing on production of agriculture, export of crops, you have people focusing on the urban

areas, you have people focusing on drinking water that in some parts of our state, just doesn't exist. People are literally having to use bucket water for their showers and getting sand out of their tap in various parts of the central valley. We're not just talking a handful. We're talking thousands of people that are dependent on water deliveries. So there's a lot to do. We have a lot of ideas. This goes back into our history, post-World War II and it will continue, because we're not going to get it all done overnight. And that is one of the great challenges in Democratic governance, that we have these elections every four or two years. But the problems don't get solved with a glib TV ad or you know, some -- the latest du jour controversies or debates. This is long standing. It takes perseverance and it takes a lot of collaboration across a broad political spectrum.

And water is not one of these things that you can take it or not or it's a political game of some kind. The hydrological cycle is a part of nature. And we have to get aligned with it. We're

not going to align it with us, except with certain limitations. And in that sense, California has manipulated and interfered with and managed the hydrological cycle in ways that probably have no comparison anywhere in the world. California is a highly engineered and managed water state. And if you fly over it, you'll see all the difference causeways and dams and reservoirs and various other transfer facilities, pumping stations. It's quite complex. It's incredible and the answer is not to go back to some presumed utopia before the gold rush, because that's coming back. We got to manage what we have. And a state that for 10,000 years never had more than a few 100,000 people and now has 38 million, and yet the amount of water that falls is no more today, in fact maybe less than it was over the last thousands of years. So we got a management challenge that's going to take money, it's going to take brains; it's going to take innovation. It's going to take all the magic of the marketplace to bring out the best of our creativity.

So looking specifically where we are, we do have ground water management and that was quite heroic to get. And we got it first of all because we've been working on it --somebody, for over 30 years. Secondly the drought has people's attention. And as farmers particularly put their straw into the ground and suck out more and more water, the central valley subsides and people start to get worried -- where will we be in a few years. So based on that, there has been -- well, it is the greatest support -- ground water management's ever joined and that's why I was able to get a bill on my desk and sign it. So that's key, because you can't ask people to store, bank water, and you need to bank water if you're going to transfer water and where all the water pricing is fine, but you have to have the water. And you have to have it available and you have to be able to move it. Well people will be confident that water underground is being stored if there are rules, and the rules are clear and they're fair and they're effective. So that's how important ground water management is.

Then we -- second big thing was the Stewardship Council working on the delta, and that is very controversial, how we're going to fix that, but you can be assured, we're going to be working on it as best we can. Now we have a water action plan in California. We have a number of steps. I want to just go over some of them. The number one priority for the California Water Action Plan is conservation. We're pretty good in energy. California uses half the energy per capita as the rest of the country. But when it comes to water, the reverse is true. We're using more water. So in both urban area and in agriculture, we have to find ways to conserve. We can conserve in both sectors. And that's going to take -- there's different techniques, technologies. We already have a goal of 20 percent reductions in urban water use by 2020. There's a lot of technology being adopted by farms but there's a lot more we can go. There are millions of acre feet to be derived from water conservation as well as water recycling. You can take water and use it again and again and again.

That's called water recycling. And that's also part of the program.

Capturing storm water -- there is over a million acre feet of storm water that just goes out to the ocean. That can be captured too. But that costs money, takes technology and it takes local authorities to take action and we're going to do that. Local water plans -- integrated water plans that the state encourages, monitors, and in part finances -- that's the second part. And I mentioned the third part of the plan is fixing the delta and that requires a more efficient conveyance because we're not getting the full use of the water that comes. Today, we're in a drought. We don't have the water. But there are times of high quantities of rain, with the climate change it's going to come in ever more sudden torrential forms and we have to find a way to capture it. But when you capture it you also have to be able to move it. And currently the delta is not equipped to do that in the most efficient way.

We also have to restore eco-systems.

California's a big part of the fly way for birds that fly from the north down to South America. Eighty percent of the environment, the river, free-flowing rivers of California are gone, but there are ways to restore and we're trying to do that and that's one of the big conflicts between salmon and smelt and other species and water to be used. And those are contentious. The federal government now has authority under the Endangered Species Act and as I look at it, what it was when we proposed a delta solution in 1978 to what it is now -- much more complicated. And we know more. I'd never heard of a smelt in 1978. It probably existed. I know it existed. (laughter) But it didn't exist in my mind. And we didn't have these biological opinions. So Congress will attempt to change those and there will be lots of fighting about it.

But at the end of the day, you need a balanced plan that protects the diversity of species, that restores habitat, because in restoration of habitat, water can be absorbed in the ground, instead

of just running off. And that's another reason why restoring eco-systems actually captures more water and makes it available. We have to prepare for dry periods. We're in a dry period. Now when water comes and people want to plant, grow and use again, but we need a longer term understanding and plan to be able to use water, but at the same time, you save water for the eventuality of drought. And so we live in a world of calculation and science, but nature follows its own trend. And we can understand nature but not completely. One thing we do know, uncertainty and stuff happens, and we have to be prepared for it and it's not so easy to do that. We've increased water transfers. We can do more and you'll hear more today about water pricing and that's important too.

The Water Bond Proposition One has storage of both above ground and underground and now with the water management of underground water, we're going to be able to make much better use of storage. And the more the ground is restored in the habitat, then the more water that will be captured, go into the aquifers

and be available for later use. We also have to have -- make sure we got safe water for these communities that don't have it.

And then the eight part of the ten point water plan is flood control. This is serious. There was a flood in the 1850's that pushed water from north of Yuba City to south of Modesto. Everything was inundated in between including Sacramento. Well there's a lot more infrastructure there today. And there's a lot at risk. We're talking a minimum half of trillion of assets and seven million people are affected. So we got to make sure we're investing in appropriate flood control. Then we have to worry about managing between the federal and the state government. Lots of, and local, lots of different conflicting regulations, conflicting powers and jurisdictions and that has to be worked through.

And finally we need financing -- money. You have to spend money on things. Proposition One -- 7.5 billion that will be spread -- allocated in various ways to all the different programs I have been

mentioning, but that's not the end of it. There's a lot of infrastructure that has to be built and so local water districts have to have the capacity to raise the funds. It's going to take investment. You're not going to have 38 million, much less 50 million people that we'll have over the next 20 years using water unless we build and invest billions, probably tens of billions of dollars certainly, over the next 10 to 20 years.

So it's a big task and it's one that's hard to talk about because it's covering so much. And I really appreciate that so many people are here to sit and listen and think about it. I've been thinking about this a while and I can tell you, the more you look into it, the more there is. But I'm confident that just as California has led the way in renewable energy and initiatives regarding climate change, we can do the same thing with water. We're in the arid west. We're facing more droughts. We're facing more extreme weather events. We're facing sea level rise, but we can respond to it. We can respond but only by

bringing both parties together, regions north and south, different aspects of the state economy, agriculture, environment, urban businesses and users -- all that has to come together. So it's a real challenge that will test our governing system. So far, our governing system is holding, but the next few years, we're going to have to meet even more difficult tests. So with that I'd just say, vote yes on Proposition One. (laughter) Fasten your seat belts. We're going to have a very exciting ride over the next four years. Thank you very much. (applause)

MS. KEARNEY: My name is Melissa Kearney; I'm the Director of the Hamilton Project and I'll be moderating this first discussion. As was emphasized by both Secretary Rubin and Governor Brown, the challenge of water in the West is a long standing challenge and it demands innovative lasting solutions. Instead of potential solutions we'll be talking about in this first discussion focused on using market mechanisms. So in many contexts and with many goods and resources we rely on market forces to allocate

scarce resources to its highest value. And there's the thought that maybe we could do more in the water area to capitalize on these forces.

So the discussion will be based around a set of proposals that are being put forth in a new Hamilton Project-Woods Institute paper written by Robert Glennon of the University of Arizona and his co-authors, Gary Libecap and Peter Culp. And they're going to argue for five specific reforms, okay, that take advantage of the market forces in order to allocate water and address the water crisis. We're joined by an all star cast of experts with a wide variety of perspectives on the issue. Their full bios are in your programs so I won't go through them, but just to remind everyone, we have Tom Iseman from the Department of the Interior, so we'll have the Federal perspective. We have Bill Phillimore from Paramount Farming Company, so we have the farming perspective, we have Jim Lochhead from Denver Water Utility, the largest water utility in the State of Colorado. He was also named Water Leader of the Year in Colorado.

And we have Ellen Hanak who is a recognized expert and scholar on these topics.

So before we launch into the panel discussion I invite Robert to the panel who will give us an overview of the main idea of the proposals.

MR. GLENNON: Good morning, everyone; it's great to be here. And I'd like to thank both the Hamilton Project and Woods Institute for inviting me and Peter and Gary who are in the second row here to prepare this paper. It was great to hear the Governor's comments. There's a lot of exciting things happening in California.

It's a long paper for those of you who have taken a look at it and they have given me five to seven minutes to set it forth. And so I'm going to go across at the tree top level; we'll get down to the weeds a little bit later on. But first I don't think I need to spend a lot of time talking about the crisis. The Governor made it plain. There's a real problem. California is really at the epicenter. But that said there's just a few items that I'd like to

put forward. One is this photograph of Lake Mead and the Colorado River speaks volumes. We're in the middle of a 14 year drought in the Colorado River and we don't know whether that's the 14th year of a 14 year drought or the 14th year of a 50 year drought. And it is a challenging time. There are predictions of shortages for the States of Nevada and Arizona within two years. The City of Las Vegas is spending a billion dollars to build a third intake pipe because the first two are about to be pathetically above the level of the lake, totally denying water supply for two million people. The future of the Colorado River is one where we're going to see increasing economic growth, increasing population growth. It is the classic problem of supply and demand. California, I don't need to spend much time on that, but 500,000 acres of fallowed land in 2014, some of the most valuable, the most productive ag lands on earth. It is a very sad sight to fly in as I did a couple of weeks ago in Fresno and see just the kind of consequences of this drought. Dead and dying trees

and orchards. As the Governor said, thousands of homeowners whose wells have dried up. Texas finally -- their drought began in 2011, they've already suffered more than $25 billion in loss. It's a very, very tough time. A little town in Texas, Plainview, at a meat packing plant operated by Cargill, it closed; 2200 people lost their jobs. The whole population of the town is only 23,000. This town has been ruined.

So we have a crisis and the crisis asks for serious thinking and a fresh response. This is a photograph of the High Sierra. If this photograph were taken a year ago today on October 20th there would not be a problem. But this photograph was taken in February of 2014. You should not see bare ground in the High Sierra in the middle of the winter. Now is this simply a product of the ongoing drought, temporary fluctuations in snow pack and precipitation level? Is it something to do with climate change? Or maybe is it both? It is a scary time.

When we look at our water systems what we

see is a system that was set up on the assumption that the past would be a reliable guide to the future. There's a new normal; that no longer prevails. And yet there's little resiliency in our water systems. Each person or each group hanging onto their little piece of the pie. We need to build resiliency in the system. And the demands for water are of an extraordinarily diverse sort. The knowledge economy as it was put, this is a Google server forum. You don't think I think even in Silicon Valley about the point that we heard form Sheryl about Facebook needing water, that Facebook, Google, Intel, they all need a lot of water to operate. They need energy and it takes a lot of water to produce the energy, and then they need water to cool these amazing plants. People think of the cloud. Well, there's no such thing as the cloud. There are things like this, data centers. (Laughter) There are now tens of thousands of these data centers, some of them generating as much energy as a decent sized city. This is a new demand. And we have an incredible national need to make sure that

companies like Facebook and Intel and Sysco and Google get all the water they want so that their fabrication facilities are located here, so that these great jobs will be available to our fellow citizens. If you think about water you realize that basically every company needs water. Every company needs water. It's not just the food people, not just the ag. The National Hockey League, those teams every year in their stadiums use more than 300 million gallons of water, for a hockey rink. Deliotte did a study of global 500 last year. Of a tremendous response 70 percent of them said that they currently had a supply problem either in their direct operations or in their supply chain. This is about future of the American economy. And we may fret about running out oil, but water lubricates the American economy just as oil does.

So what are we going to do about it? The Governor outlined some options. Business as usual, more dams, more wells, more diversions. I'd like to suggest that's not very practical. And I'll move on.

We can revisit that later if we want. I think of the problem as needing a portfolio or a menu approach. In our paper what we've tried to do is do exactly that, to outline it this way. Conservation is a big deal, reuse is a big deal. Desal will also be part of the menu going forward. But those things either singly or collectively will not get the job done. We need to go further. Now what can we do? Price signals to encourage conservation, absolutely, and you'll hear more about that in the next panel. But we also have to recognize that what we have in terms of water is a giant milkshake glass, and what we see is everyone who is using water has put a straw into the glass. But there are more and more straws going into the glass. It's a classic tragedy of the common problems. We need to break the relentless cycle of overuse. And what Peter and Gary and I set forward in paper is using market forces to encourage the reallocation from lower value to higher value.

So there are five steps that we suggest we should proceed now. First we need to reform water

law. Water law is arcane, complicated, but at bottom it's this, use it or lose it. That's the rule, use it or lose it. And the consequence of that is a very peculiar concept of waste. In western water law to waste water is not to use the water. To conserve water exposes the water rights holder to loss of the water right. There are no incentives to do what we think needs to be done. The 20 percent that the Governor mentioned, there would be farmers who just can't do that because they lose their water rights. So our first point, it's a pretty roll up your sleeves and get into the nuances of water law, is that we need to remove these disincentives, we need to create incentives for people to use less water, not penalizing them if they should use less water. Second thing we need to do is to create market mechanisms that facilitate water creating. We're thinking about water banks, water exchanges. Right now almost all transfers of water, water trades, are one up. They're complicated; they take a long time, their hideously expensive. Economists will talk about transaction

costs, and boy are the transaction costs immense in doing a trade for water. We need to reduce those transaction costs. And so banks and exchanges would do exactly that. Banks and exchanges would possibly serve as brokers, as clearing houses, they'd provide trading platforms, they would facilitate the transfer between willing buyers and willing sellers. Next thing we need to do, number three, is to use risk mitigation strategies to enhance the reliabilities of water. We would like to take a page from the investment banking community, from the hedge fund business, from the commodities markets, from insurance companies, and look at how they hedge risk. We need to build more resiliency into water supply. Ag supplies, municipal supplies, industrial supplies. We need resiliency and risk mitigation strategy, futures contract, dry year options, offer ways to learn from what other parts of the economy have done and build those into the world of water. That's one way to develop increased resilience. Four, protecting ground water. Back to the milkshake glass. Right now as we

sit here despite this very, very important piece of legislation, sustainability, ground water management act a few months ago, the situation remains that anyone who wants in almost any part of the state can drill a new well and start pumping away with impunity. And that's why all of these homes around the state are having their domestic wells go dry. We need to do better. It's a classic tragedy of the commons. And the final suggestion we have is to continue and expand the Federal role, principally the role of Bureau of Reclamation. I'm very pleased to see what Reclamation has been doing over the last couple of decades. When you think about reclamation most of us I think think about Marc Reisner's classic Cadillac Desert and we think about Floyd Dominy. Well, it's not your father's Bureau these days. It's a completely different world of reclamation. And they have shown enormous leadership in facilitating interstate cooperation and in really giving accurate information for all to digest. They have done some marvelous reporting and we need more of that. We need that kind

of leadership. For example, we need the Bureau of Reclamation to insist on water meters on people who get water from their project. Right now in many parts of the state the State of California has no idea how much water people are using. Even ground water, and especially ground water. People just pump and the state doesn't know how much water is involved. Really you can't manage what you don't measure. We need to do better. Pilot project. I'll offer two that the Bureau could push. One, right now we have in Southern California and Southern Arizona farmers growing alfalfa in the middle of the summer when it's 115 degrees out. There are interesting opportunities for suspending irrigation of alfalfa during the summer. And we need to create opportunities for farmers who do that to financially benefit from doing that. You can't just simply say we think it would be a good idea for you not to. It's their water right. We need to encourage them to do that. And the Bureau can play a tremendous role. Same with drip irrigation. There are opportunities to use drip that now are not there.

So that the fifth.

And finally I'd just like to make a comment about what does this do, this marketing do to farmers, to the farm community, and to the food supply? People are fearful and they should be, but this bullet on the last slide suggests why water trading need not harm rural communities. For one thing the M & I sector certainly doesn't -- the municipal and industrial sector certainly doesn't need to double its supply. A modest increase, our point, in irrigation efficiency would solve the problem. Full stop. A modest increase in irrigation efficiency. Currently about 50 percent of lands that are irrigated are irrigated with flood irrigation. It's an incredibly inefficient form of irrigation, but it's very expensive to modernize. Our solution is straightforward. It's a demand offset system. If someone wants to put a new straw into the glass they need to persuade someone else to take her straw out of the glass. It's not no growth, but it's a system that asks growth to pay its own way. And in that way water trading can be a win-win. It provides

farmers with the capital to modernize their infrastructure, it allows farmers to grow the same product with less water, it allows cities and industry to get the water that's conserved, and finally the costs are borne by those who want the farmers to use less. And that's how it should be.

Thanks. (Applause)

MS. KEARNEY: Thank you, Robert. So, I'm going to start this off with a question to Ellen. Ellen has written extensively and studied very thoughtfully the use of markets in California. So from that perspective how do you respond to the proposals put forth in this paper and what can we learn from the California experience with market solutions?

MS. HANAK: Thanks. And thank you to Robert and your co-authors for a really interesting paper. I recommend plowing all the way through the 40 pages because there's a lot of rich stuff there.

I have a short amount of time so I'm going just highlight a few things. One of them is thinking

about California as an example, I think a lot of the recommendations that they've put forth could be very useful applying them here, but also in some ways California is at the forefront of some of the things that the authors point out with respect in particular to laws that enable water marketing to happen. And so we've got actually a pretty -- it's not by any means a perfect market, but we've got a pretty active market in California. It's about 20-some years old. It really got going during a major drought from the late '80s to the early '90s where the State got involved setting up a water bank, the kind of thing that the authors recommend. We had laws in place already that were passed in the early '80s that made it possible to transfer water without it being taken away from you. You could lease your water and it wouldn't be considered that you were no longer using it. Transferring is considered a beneficial use under California law. So over time what we've seen happen is initially it was really a market for short-term temporary transfers, especially for drought relief,

and over time it's become also a market where cities are buying water to support their long-term needs. Even some farmers who are growing tree crops are getting into long-term deals so that they have more reliability with these transactions. Mostly the water is being sold by farmers, sold or leased by farmers either with extra water in storage or that are able to lower of their own production. Now thinking about that, you know, the market now is about maybe five percent of total human water use. So, you know, there's room for it to get bigger and I think a lot of the recommendations that the authors proposed could help with that.

I'd like to highlight two things that it's important to think about. One of them and with respect to reforming laws and thinking about, you know, are there ways of providing incentives for people to save water and sell it or lease it. I think there are but it's important not to oversimplify that. And the Governor said, you know, water is complex. It really is in this case. And there's a tendency to

assume that everything that you save by adopting more efficient irrigation technology is water that you can make available to sell on the market. And it sounds good and it kind of makes sense at a top level thinking about it. In fact that's not true because most of the water that's wasted when you're doing flood irrigation is actually being used by somebody else already. It's going back into the river and being used by a downstream user or, you know, city, farmer, or the environment. Or it's going into the groundwater basin and it's available for reuse later. So one of the legal reforms that they recommend is adopting some transparent rules so that people know how much consumptive use can be transferred. That's the sort of technical term for the amount that you're actually consuming that's not available for others. California technically has that law. We don't always apply it well. I think it is an important law to get out there and to make transparent so people know how much is available with different crops.

The second thing that I'd just highlight

briefly is the idea I like very much of mitigating and thinking about reliability. I think that's recommendation maybe number three. One way to do that is thinking about how the market can help to support the environment. And in California the market actually about a third of the trades in many years has been water for instream flows and for wildlife habitat. This has mostly been short-term transfers with taxpayer dollars, and that money is mostly gone now. There's very little of that money left. So if we're thinking forward to can we use a market to help bring water into the environment, we really have to find new funding sources for that. Australia which is often considered a model for marketing used $3.5 billion to buy back water from farmers in order to have it available for the market and that's working pretty well. People were grumpy about it initially but it's actually working pretty well. I think California and other Western states should really explore that and, you know, my bid if Prop 1 does pass, this new water bond, is to think about using

some of those funds to purchase water rights for the environment.

Thank you.

MS. KEARNEY: Great. Thank you. Okay. So moving from the state to the federal. Tom, so one of the pillars of the authors' proposals is increased or continued and expanded leadership from the Federal Government. So from your perspective at the Department of the Interior how do you view the Federal role in solving or addressing the water challenges?

MR. ISEMAN: Well, I'm coming at this from the perspective of the Bureau of Reclamation. We're known for owning and operating water supply projects across 17 Western states, we provide water to 30 million people and 1 in 5 irrigated farmers, and, you know, I think it's clear that we face some challenges with respect to water supply allocation and markets can play an interesting role in resolving some of these issues. But it is a complex issue for the Bureau of Reclamation and I wanted to talk a little bit about some of the benefits and the drawbacks that

we see and where we think there's an opportunity for more Federal leadership if not a more active role, which I know might make some people concerned. So some of the benefits and the drawbacks, as we said, you know, there are tensions around water supply allocation across the West. One of the things that we like about water markets is that they allow local solutions, they empower water users. You want to see transactions between willing buyers and willing sellers to resolve these questions about water supply allocation rather than decisions from the Federal government. So there are definitely positives about the benefit that we can see from water markets and water transfers. That said we face a clear tension with some of our agricultural water users that are partners in our water supply projects. We hear concerns about what do transfers do to the agricultural community, the local economy, the ability to grow food for our society. And that's definitely very front and center in terms of our work in water supply and how we think about water transfers. And

that's something that we need to navigate as we look at some of the recommendations in the report.

That said though I was really impressed as I prepared for this discussion to see how much we are using water markets across the Western states to address these issues. And we use them in a variety of different ways. One is essentially to stretch water supplies or reallocate water supplies, and particularly in times of drought. And you see that there in the California with the Central Valley project which is a reclamation project. It's also happening in Southern California where you've got transfers from imperial irrigation in the Palo Verde irrigation districts to the cities of Los Angeles and San Diego. And it's happening in other places as well. One of the good examples is the Colorado Big Thompson project in Colorado where we're seeing more water moving between agriculture and cities on a pretty flexible basis. And there are a lot of benefits to that. One of the emerging examples that I think is really important is something called a system

wide conservation agreement on the Colorado River where we're partnering with four cities including Denver Water to look at how you could implement more market driven essentially conservation activities to improve water supply for the Colorado water river system. So there are definitely cases where we're using this to stretch water supplies. One of the other places where reclamation is really active is in terms o fusing markets to provide environmental benefits. And we have obligations throughout the West to sustain and recover endangered species. And in many projects we're actually an active participant in the market to acquire water for environmental benefits or for refuges or other environmental purposes. It's really surprising me. Just to name a few projects, Klamath Project is one. We're doing it actively on the Snake River in Idaho. It's happening in the Middle Rio Grande and Pecos Rivers in New Mexico. So these are places where we're using markets actually ourselves to acquire water for environmental purposes. We use markets for the purposes of Indian water

supplies and looking at tribal water settlements. And we've used markets to acquire water for tribes, to fulfill settlement obligations. And then the settlements often empower the tribes to use their water supplies; they authorize the use of water supplies in markets and many of the tribes are actually taking advantage of that, to move and to benefit from the economic value of the water that they have.

And finally we're doing some things to institutionalize how we use markets. We do have some policies that speak to measurement and pricing of water at our projects. They're modest steps and we implement them as we move forward in some of our agreements with the water users. We also have systematic approaches for example through our water smart grant program where we actually award project applicants for including ideas about water banks or water markets as part of their proposals.

So I think there's clearly a good track record for reclamation in using water markets. And I

wanted to point to a few of the things that we see potentially going forward. One, as Robert mentioned there's a role in leadership and really the way that we look at that is empowering local leadership. And we need to work with the local water users and empower them to make some of these decisions, some of these decentralized decisions for how to take advantage of markets. But that said there are some innovations that we can look at. Some of the things that are happening right now. One of the things that we're doing is looking to streamline the process and we've done that here in California with long-term environmental compliance. Let's see. We're also looking to play a role in regional solutions to water supplies. And so when you look at things that we've done one of the big innovations that we've done is basin studies and bringing water users together across a basin to think about their water supply challenges and some of the solutions that they might be able to take advantage of. One of the best examples is on the Colorado River, and I think it's really stimulated a

conversation about, you know, let's look at the objective data and some of the challenges that we face and think about how we solve these problems. And markets can definitely play a role in that.

So finally I just want to conclude by recognizing there's an important role for markets. We're very interested in this conversation. I think there's a productive role that we can play with our local water use partners and we really appreciate the convening and the people who have come to the table to discuss these issues today.

Thanks.

MS. KEARNEY: Tom, can I just ask you one follow up question? Because it strikes me as I listen to that what you've described is really sort of this innovative market based projects.

MR. ISEMAN: Right.

MS. KEARNEY: And when I think historically about what the Federal government did I think about big infrastructure projects. Do you see the Federal government role changing or did you just emphasize

market because that's what we're talking about or is that actually?

MR. ISEMAN: No, it's definitely changed. (Laughter) You know, there was an era when we built these projects and it was important we have a lot of infrastructure and really that's the reason now why we need to play a role in thinking about some of these solutions. We have this infrastructure. It puts us at the center of a lot of these questions about water supply allocation. I think water markets are one of the tools that we can use to address that going forward because we're not in the same place in terms of our appropriations and ability to build new water supply projects like we did historically.

MS. KEARNEY: Great, thank. And I know we're going to talk more about infrastructure and innovation in the second panel, so we'll come back to that.

Okay. So let's go to the utilities perspective. It's fascinating that there are already partnerships on the ground between the Federal government and Denver Water and other utilities. So

in your view and your experience, do we need to rely on markets to get some more water allocated to urban users?

MR. LOCHHEAD: Well, certainly the remarks of Governor Brown, Robert, the issues that the paper raises point out in the words of Sheryl Sandberg, that we have a really hard project in front of us. Are we up to it or not? I would argue that in this particular instance failure is not an option. Literally the future of the West is at stake in terms of how we manage, use, and develop our water supplies.

My little slice of that pie is making sure that a city of a million and a half people in the fastest growing economy in the intermountain west has a secure water supply for the next 100 years. And that means not only developing water supply, but making sure that it is here in a healthy sustainable environment for that period of time. And so cities face in the face of a changing climate and in the face of tremendous growth challenges a real dilemma. We're the beneficiaries of vast infrastructure, but the

yield of that infrastructure is that risk from climate change and our ability to develop additional infrastructure is certainly questionable if not nonexistent. We can make a lot of gains in efficiency. Denver Water has reduced our water use by 20 percent over the last 10 years. We spent $100 million and saved a cumulative total of over 100 million acre feet, but that's not the answer, that won't do what we need to do. We can develop reuse and desalinization projects, but those are expensive, they're energy consumptive. And in a non coastal city like Denver reuse is difficult from a regulatory standpoint and desalinization is obviously not on the table. So that leaves us with agriculture. And under the current system, I think the paper is pretty good about pointing this out, in Colorado at least our one option is buy and dry. Going to the market and basically doing a transaction which means we take water from agriculture on a permanent basis, cities get the water and the agricultural economy dies. And that's a solution that's not acceptable to anybody.

The paper points out the fact that we need more innovation and more flexibility in the system, but we face numerous institutional, political, and legal barriers in our ability to do that. Our environmental regulatory structure is based totally on the preservation of the status quo. If you look at temperature, aquatic ecosystems, habitat, all the regulatory framework that we need to go through in developing, using, and managing water supply, it's all based on the status quo, a status quo which will not exist in 20 or 30 years with the advent of climate change and as we see ecosystems literally moving north. So the entire ecosystem landscape is moving out from under us and we have a regulatory framework that's just in place. We face operational constraints from the types of water projects the Federal government operates that are fixed. And we have large amounts of water that are locked up in Federal reclamation projects that cannot get out because of Federal law or Federal constraints or the constraints of local irrigation districts. We have a water rights

administration system that again is premised on the status quo. It's based on use. Taking water from the river, using it, and maintaining return flows that literally is measured to the gallon. And every water rights transaction that needs to be undertaken needs to preserve that status quo. And so the risk of putting one's water rights up for grabs in a water change proceeding, the transactional cost associated with a market transaction, the costs associated with that means that we don't have the ability to be flexible in the marketplace.

Finally, I just want to emphasize the fact that cities are not interested in growing at the expense of either agriculture of the environment. A healthy agricultural economy is essential to the healthy economy of cities. In fact most of the agricultural economy in the United States is based in city in terms of food processing. We are not interested in developing water supplies at the expense of the environment. A healthy environment is absolutely essential to our ability to supply clean

sustainable water to our customers in the future. So we need to develop mechanisms to work together. And as the paper points out I think there's plenty of water in the system to be able to do that if we can find those solutions. And a lot of the argument that at least from a municipal perspective that we face is based around grass. And it's based on this moral judgment that blue grass is bad and somehow cities are evil for encouraging their customers or even developing any kind of blue grass, and alfalfa is good. Or alfalfa is bad and higher value crops are good. We need to get away from these moral judgments about water use and develop a framework to more holistically manage grass. Grass is 90 percent of the water use in the Colorado River Basin, whether it's blue grass, alfalfa grass, or pasture grass. We do a good job as municipal entities of doing demand management around bluegrass. And if we develop the flexible mechanisms and the kind of reforms that are proposed in this paper I think we can have a flexible system of managing grass in the system and do it while

maintaining a healthy agriculture economy and providing for the environment and cities.

MS. KEARNEY: Great. Thank you. So, Bill, Jim was very gracious. He doesn't want to fight with the farmers, but I feel like you're a little bit in the hot seat here because we've heard that water law protects the status quo. It seems like the status quo is pretty good for agriculture, not so much for everyone else?

MR. PHILLIMORE: Well, I have to start off with disagreeing with that. (Laughter) No, no, I think that water markets work. And just as a sort of as a mention, so I work for a farming company and we do, we store water on the surface and underground, we buy water, we sell water. So to some extent we're in the trenches on this stuff every day, enough to say that I live in Bakersfield which is a real sign of being in the trenches for those of you who know California. (Laughter)

But I think it's worth given what all the other panelists have said, of thinking a little bit

about how to improve water markets. And again I'm going to be -- like Ellen my experience is in California, it's not in Denver or Arizona, so I have to speak to thank. And for how to improve market trend, one of the difficulties that we have in water markets in California is the uncertainty of water rights. Water keeps getting taken away from us for the environment. Every time there's a new regulation the state board can take water away from us, U.S. Fish and Wildlife can take water away from us, (inaudible) can take water away from us, water disappears with FERC relicensing. And so I think it's very difficult if you look at any traditional market, one of the things that you need for an efficient market is the basic right or the basic ownership of the product. And without that it makes it very difficult, it makes people very uncertain as to what they should do, especially for a long-term deal.

The second thing that we need for water markets is decent rules, and rules that we know how they're going to be applied and we sort of can at

least predict within some level what the answer is going to be. I'm thrilled -- and actually I think it's true that the Bureau of Reclamation has speeded up their processes. I would just say that from my perspective there's still room for further improvement.

MR. ISEMAN: Right. (Laughter)

MS. KEARNEY: Now you're on the hot seat.

MR. ISEMAN: I know. It's (inaudible).

MR. PHILLIMORE: And so I think that -- so that is the sort of very important side of it. And I also think that, you know, back to Ellen's point that she made earlier is that if water is -- I mean the Australian market on the Murray River, and we looked at that some time ago -- seems to work very well but it's also because when the government wanted water for the environment they actually paid for it and they didn't just go and take it. And it all comes back to the uncertainty in markets. If you don't have certainty in markets the markets are not going to develop well.

And so I think that that was sort of the big thing there. But in the developing markets, at least in California, I see no further role for the government. And I have to disagree fairly strongly with that. I think the government needs to get out of the way. And markets, again there are rules, there are commissions, every water deal, every water trade we try and do we run into two or three different government agencies. They take time; there is no incentive for them to make a decision. Don't get me wrong, I'm not advocating an unfettered free market, but this market is so stultified by regulation that it is not working properly. And so I don't think that we need any greater role of the government, I think they need to let the market develop and then react to where it goes wrong rather than the other way around.

MS. KEARNEY: But you also emphasized a need for rules. So presumably we need the government to enforce the rules of the market?

MR. PHILLIMORE: Yes, but to have rules that are set and don't change on a daily basis or a weekly

basis, or don't depend on which branch of what agency you have to go to that day. And I think that's sort of not uncommon.

MS. KEARNEY: Do you want to respond to?

MR. GLENNON: Sure. I'd love to say a couple of things. First, thank you. Peter and Gary and I are very grateful to these four for such amazing thoughtful comments and it's been very helpful. Let me pick up on Bill's last point about no role for government because I think it really flags comments from each of the four about what will marketing do to the farming communities and to the food supply. And in our paper what we think is that there needs to be oversight by the Federal government. Now we believe strongly in markets. Rules matter; you can't have a market without rules. You can't have a market without property right, something to transfer. I sell you my pen and that depends on a rule that says that at law I own the pen and I can transfer the pen. So we need to have a system set up by law that facilitates trade. And that depends on the role of government. Then

beyond that markets can fail. And there are several people who said what about the impacts of trade. And for that reason we think that particularly when it comes to not the farmers so much -- they're going to make out wonderfully. The farmers are going to be the direct beneficiaries of someone writing a check and paying them to modernize their infrastructure or whatever. But what about the farm workers? What about the businesses who are in the farming community, the John Deere dealer, the pesticide, fertilizer suppliers, local business of any stripe? When you have transfers you have impacts from transferring a public resource, which is what water is, a public resource that's subject to some market rules and aspects but it still is public. So I think we need to prevent the buy up and dry up. To ensure the protection long-term we need over say a certain quantity of water a government regulatory process. Now I'm not familiar enough as Bill with what you've got going on in California. It frankly sounds hideous. So, you know, some streamlining of that is

in order.

But it's also to make sure that the transfers don't harm the environment because as Ellen was saying to start a lot of this water is performing ecosystem services in the environment and if you just willy nilly start transferring large pockets of water you need to take into account what is that doing to the downstream environment. So we're very much in favor of rules, but sensible rules to protect the farm community and to protect the environment.

You know it's worth noting in most of the transfers that have been going on, and Ellen's right, most transfers are farmer-to-farmer taking advantage of spot markets, but in some studies that Gary Libecap and I did we found that aggregate farm income over 25 years in 12 Western states with 3200 trades and leases did not go down. Well, how can that be? Well, because farmers are savvy business people. When someone comes in and offers them some money the farmer can say no, I like what I'm doing, I'm going to use it all. I've got good product, I enjoy it. You know,

maybe I just like losing money. The old joke about how to make a small fortune in farming is to start with a large one. (Laughter) So, you know, so maybe that's the answer. Or they say, you know, that land out by the barn it's all clay soil. We can fallow that; it wasn't very productive anyway. Or they do some adjusting of their crops, they change from one crop to another, or they use the city or the environmental group's money. And in the paper we talk about water trusts in Oregon and huge sums of money being put forward by an environmental group to persuade someone to modernize infrastructure and that's what they do. And then you get to grow the same product with less water. That's the critical part. At the end of the day we have to make sure that we aren't harming farming communities. That's -- we are -- I think everyone on this stage absolutely gets that.

Just one final comment, and that is in response to something that both Tom and Bill talked with the Colorado Big Thompson project working. But

in many areas -- and the reason for that is that the water rights are very clear. You know, you get a share of water and you know what it is and so it's like your pen. You know, I'm going to sell you the blue pen. But in many irrigation districts in particular in California and elsewhere the rights are not quantified for the individual farmer. And the individual farmer is given permission to use a certain quantity of water and they pay for that by acre foot, but if instead of using six they use four, well that just means they paid $20 an acre foot less. They don't benefit financially so they may as well pay the modest amount that the district is charging and continue to use it to grow for example alfalfa year round.

So I'm very encouraged by this opening set of remarks. There's nothing I'm particularly troubled by that anyone on the stage said. Instead I think it's -- we got some potential here, we really do.

MS. KEARNEY: So I'm troubled by one thing you said in your presentation which is that this -- I

mean this all presupposes that we can measure water withdrawn and water used and water rights transferred. How far are we from that reality? I mean it sounds like we need years to get all that data before we can ever really talk about having well functioning markets.

MR. GLENNON: It depends --

MR. PHILLIMORE: No, I don't think that's true at all.

MS. KEARNEY: We have the --

MR. PHILLIMORE: I think that at least in California I think we have pretty good measurement systems. One of the criticisms that I have actually with the paper is that, you know, we've kind of got ground water regulation in California, we need it. But, you know, for us to measure water use by wells, by counting the numbers of wells and putting meters on the wells rather than by using satellites to pick up consumptive use seems to me to be sort of 20th century rather than 21st century. And when I'm talking about measuring consumptive use by satellites, the latest

land satellite has a component, it's not perfect yet and they don't fly over often enough, but just think about the cost of regulating wells, putting meters on and reading those meters in contrast to an airplane flying up and down the Central Valley maybe twice a week. I mean we've got to look at some of those things. I think it's all measureable.

MS. KEARNEY: Go ahead.

MS. HANAK: Just to say Idaho is already doing that and Idaho is using satellite imagery to regulate water rights and ground surface water management. So it's early 21st century, it's not far in the future.

MR. PHILLIMORE: Yeah. No, it's right there. It's not that it's right there now but I mean within a year or two.

MR. LOCHHEAD: In Colorado it's so measured that we're slaves to it. We have to actually -- as I mentioned we have to preserve the status quo to the gallon and that means that any market transaction is in this rigid framework and there's no flexibility.

And you have a system where -- and I'm a water lawyer -- where lawyers and engineers are litigating these issues and it's a barrier to any kind of flexibility or innovation.

MS. KEARNEY: So one other -- go ahead, Ellen.

MS. HANAK: Just, you know, in relation to the ground water issue, I do think that a key to successful reform in California is going to be letting farmers be able to trade their groundwater. And so, you know, right now the legislation just sets up a framework for basin management authorities at the local level to decide what their sustainability management is going to be, but it's going to have to be getting to some sort of sustainable yield over time and an important incentive in that process will be allocating in some way the rights to pump and enabling some folks who maybe don't a have the great soils to sell that water to somebody who's the tree crops on great soils or very productive uses.

MR. PHILLIMORE: I would agree with that but

you do have to be careful because of the way that ground water moves or doesn't move, the different qualities of ground water within a certain area. And, you know, there are certain things in water that work on a very local basis, some work a little wider, some wider still, and I think ground water trading you're going to find will be pretty localized depending a little bit how it's connected to surface water. But if it's pure ground water trading it's going to have to be very localized.

MS. KEARNEY: Okay. Interesting. So I have another practical question for how this would work because, Robert, you've referred to selling your blue pen, but it seems to me selling water is not actually that concrete, right. So when we talk about property rights to right, how in practice -- maybe in the State of California or in other places does this work? Is this withdraw, is it consumptive use, is it for a set amount of time? Does it depend on who else is sharing water from that source?

MR. GLENNON: It can be all of the above.

And Jim can speak to this, but for surface water you get a right to take a certain amount out. There's an assumption that some f that returns to the system; that's called return flow. So you may or may not have your right to find by consumptive use. The problem when you go to transfer it isn't that you don't know how much you can take out, it's everyone else in the system gets to object when you go to transfer it under a rule called the no harm to junior appropriators. Everyone is there. And so what we call for in the paper is let's define water rights by the amount consumed. And it can be by land satellite imagery, it could be -- to flesh out Bill's point, what he's saying is it's not the grey stuff and the balance of the earth changing it's that by satellite you can see that's alfalfa or that's some other crop and you know in that area how much that crop takes. So let's define water rights, have the state water department agencies define water rights by that consumptive use. Then we don't have to get every time someone wants to transfer water into a potential fight that pits of

hundreds of other people on the same system, instead it would be a presumption if you're growing alfalfa in this area this is how much water the alfalfa consumes.

MR. LOCHHEAD: But at the same time we're not sophisticated enough to have a system in place whereby we can have flexible mechanisms. So at this point in time it's very difficult if not impossible for a city to go to a farmer and say I will pay you to rotate the following of your fields, you know, as you choose. Just make sure you provide so much water. Or I will pay you not to irrigate in the heat of the summer, or I will pay you to switch from a higher consumptive crop to a lower consumptive crop, or I will pay you to install conservation measures. All of that is basically undoable because of this regime of having to preserve a set return flow pattern back into the river and because of the byzantine nature of the transactional costs associated with making that kind of a deal. And so what the paper highlights is it's impossible right now for us to sit across the table and actually make that kind of a deal. And cities are

willing to pay third-party impact costs. That should be part of the transaction, but we literally can't get to the table to make that kind of a transaction.

MR. PHILLIMORE: We I think can go in California if you're not growing anything on that piece of property. It's much more difficult to make the judgment say that I'm not going to irrigate my alfalfa during the summer. That's difficult. But if you actually follow that plan then you can. You can do that thing. So again a little bit of a difference between the states.

MR. GLENNON: And we need to build in the kind of changes that Jim's talking about, especially on the alfalfa in the summer. Alfalfa grown in parts of California during the summer uses four times as much water as other cuttings during the year and it produces alfalfa with a lower quality, it's poor quality alfalfa, and it's even poor quantity. The yields aren't very good. So if we're going to protect the farming communities, for goodness sake we have to figure out a way to get the very most wasteful uses

out of the system. And that would be growing alfalfa in the middle of the summer. You don't want to fallow the whole field year round. There is some high quality alfalfa being grown and alfalfa sometimes gets a bad rap as being oh, that's just for people who eat beef. Well, alfalfa is also supporting dairy. And I dare say almost everyone in this room eats yogurt and whatever dairy products, so you've got alfalfa coming that way. And it's a direct production. My goodness you feed Bessie some hay in the morning and you milk her in the afternoon, what could be better food production than that in matter of hours. So we need to protect alfalfa growers in those communities, but we need to get them off of growing it under conditions that's extreme, as in the deserts of Arizona and California in the summer.

MS. KEARNEY: Go ahead, Ellen.

MS HANAK: And these are kind of some things that are doable and, you know, it's not technical rocket science, or I don't know, maybe rocket science is easy now. But what you have is, you know, partly

issues of not having clear regulations at the state level or state and Federal working together, but I think also we have this at the local level sometimes. And in California you have some irrigation districts for example that will allow you if you're a farmer to fallow, to lease water to yourself in another irrigation district, but not lease water to somebody else. And, you know, that's something that kind of doesn't make sense because it leads to all kind of crazy land leasing in order to be able to get the water moving around. Those are the kinds of things I think that potentially can be decided at a state level, basically saying, you know, you've got to make that flexibility.

MR. PHILLIMORE: But it is remarkable the way that people have found to get around those things by leasing land to each other. It's probably like the U.S. tax system, you know, there's so many regulations but the people who operate in it find ways to get around the regulation in order to get the economic deal done.

MR. GLENNON: But all of those require high priced lawyers, and that's okay, Jim (laughter), and hydrologists, also okay for those of you who are hydrologists. It's expensive, the transaction process. They're all -- each one is -- John Leshy once famously quipped that irrigation districts are like snowflakes, each one is different. When you're trying to set up some general rules, something that a state can do and you've got all of sui generis irrigation districts it's darn difficult.

MS. KEARNEY: So I want to ask about a different element or characterization of the problem. So what we've talked a lot about is reallocating water away from let's say low value uses to high values uses or from, you know, farmers who find them with excess supply, to urban users who don't have enough. But there's a really interesting figure in the paper that shows supply is generally flat in the Colorado River basis, generally flat, maybe if you squint a slight downward trend. But it's the demand for water that's rising with no sign of stopping. So we talk about a

water scarcity problem, but when I look at that figure I think well it's not that we have less water we just have too many people who want it, right. And so, you know, is this really a water problem or is it why is everybody living and growing their technology businesses in the driest part of the country? And so it either seems like well maybe we have to shift some of that development or people living here or companies working here have to figure out how to do more with less. That's a little bit different spin than the allocation angle.

MR. GLENNON: The elephant in the room is population growth. We nudged over 300 million in the United States about four years ago and Census Bureau predicts that we're going to hit 420 million by 2060, 2060. That's the lifetime of many of you in the room, not some of us. (Laughter)

MS. KEARNEY: Ellen.

MS. HANAK: So demand -- you're an economist, I can speak to you in the language of our tribe.

MS. KEARNEY: We'll include everyone.

(Laughter)

MS. HANAK: Demand we usually think of as economists as what people are willing to pay for. And I think the basin study is great, but that line for demand is not what people are willing to pay for, it's more what people would like to use. And one of my close colleagues, Richard Howitt from UC Davis likes to say, the problem is not that there's not enough water, there's just not enough cheap water. And so this where markets I think come in because you really are talking about water becoming more scarce, essentially more expensive. What are people willing to pay? Urban areas are willing to often pay for recycled water and for other high cost things, but, you know, there's also just a lot of cheap water still in the Colorado River Basin and some of those uses probably are going to go away.

MR. LOCHHEAD: I guess speaking as one of those evil cities, Denver serves about 25 percent of Colorado's population. We use about two percent of

the State's water. Ninety percent of the water in the Colorado River Basin is used for alfalfa or pasture grass. So it's not a matter of growth. And in fact I think what we should be doing is encouraging highly dense, innovative, vibrant cities as centers of culture and commerce and economy and at the same time maybe we can preserve a vibrant agricultural economy and rural lifestyle that's so important in the West. So I think what we need to do is to free up that market to allow for us to live within our means. And that's -- Tom mentioned the Colorado River system conservation of green land and that's kind of an experiment by Denver Metropolitan Water, District of Southern California, Southern Nevada Water Authority, and the Bureau of Reclamation where we're saying we want to fund pilot projects that will demonstrate how conserved water can be managed from agriculture to the benefit of the river system and the reservoirs in the Colorado River which are at dangerously low levels. And it's amazing the reaction that we've gotten. If we get on the ground farmers they're interested as

business people in doing a deal. If you talk to local politicians they will tell you that this is all about these terrible cities that are going to dry up agriculture and all for the benefit of Las Vegas. (Laughter) So we need to just get over those cultural regional differences and actually get down to talking about how we can do this and keep everybody's economic interest whole.

MS. KEARNEY: Okay. So we're going to open it up for audience questions. And we have folks going around with microphones. Go ahead.

SPEAKER: This may be a dumb question but we have massive pipelines in this country that run for hundreds of miles transporting oil, why can't we do it with water?

MR. GLENNON: We could do it with water and there are some people who would like to do it with water and there are those people who fear we will do it with water. There's a great billboard that shows the Great Lakes -- a natural billboard on the side of the road in Michigan, it shows the Great Lakes, then

it shows California with a straw in one of them and then Nevada with another, and Colorado with a third. And whenever I'm back there I say this is a scurrilous attack on us, we don't want all the Great Lakes. We'd be happy with one of the smaller ones. (Laughter) You can do it but the price of water is very low relative to oil and water is heavy. It weighs, you know each -- your analogy in bottle, a quart weighs two pounds so when you start to talk about an acre foot you're talking about 1350 tons of water moving. And it just isn't worth it. To say nothing of -- can you imagine the regulatory nightmare trying to cross seven states and, oh, the Rocky Mountains, did I forget that? So it can be done but to be, you know, not quite so jovial about it I want to make a point about what's been referred to about the demand/supply study that the Bureau of Reclamation did in 2012. They deserve enormous credit on that. What they said is there are ideas all over the place. Towing icebergs from the arctic, different kinds of ways of saving water. We're going to put all of these things

together and we're going to treat equally every one of them. We're not going to have a preferred solution. They examined 140 or 160 solutions, they subjected them to rigorous cost benefit analysis and they just let the chips fall. Well, at the end of the day projects like that didn't make the cut because there were other things that were so much clearly less expensive. And for me it was -- and for Peter -- we did a little writing on this, it was really the Bureau of Reclamation announcing that these large water projects that we built in the past, that was an interesting era and that era is over. It's not going to happen again. You're not going to find large new dams being built and hundreds of miles of canals, you either have the infrastructure in place now or you're not going to be able to do it. You can tweak the ones in place but you're not going to be doing that. And it was Reclamation that gave a very sober message to the seven basis states saying these ideas just don't make economic sense. What does make economic sense? Conservation and reuse. There are a few others, but

basically conservation and reuse will get the urban sector a long way down the road.

MS. KEARNEY: Okay. We have one over here. Okay, great. Can you please announce your name and affiliation before your question?

MR. BECKMAN: Thank you. David Beckman with the Pisces Foundation. I thought it was very interesting that Professor Glennon put up a slide that said that basically nine percent reduction in ag water use would double water for other users and then I heard an immediate disagreement with that. I think this is a critical question that underlies most of the conversation this morning on the panel and I wondered what is the source of that disagreement if there is one? And maybe each of the panelists could indicate how they view that question. Is that water available with ag efficiency for other users or not? It's an important question.

MR. GLENNON: That's great; I'm glad you followed up on that. Ellen and I had initial discussion that and she thought that maybe there

wouldn't be as much available. It depends. In some areas where you have flood irrigation that water is going back to a river system. In other areas there's no river system but there might be something like the Salton Sea. But regardless of what might be downstream there is a certain measure that's just gone to evaporation loss. And when you're growing alfalfa in the desert when it's 115 degrees out and you're flood irrigating those lands you're losing a lot of water to the air. That water's gone. That's not available for reuse. So I'm not trying to suggest that we can simplistically say that everything not consumed by the crop is available for transfer, not at all. A lot of that water is performing as I said environmental services, but there is some water that's just gone. Let's quantify that and focus on that. Plenty of water.

SPEAKER: That's why -- just one small --

MR. PHILLIMORE: I think actually there is a different point here and that is that where water is very expensive, as in the Southern San Joaquin Valley,

there is no flood irrigation, right. I mean the market place is taking care of these issues if it's allowed to function. And the problem where you've got people flood irrigating alfalfa is that -- and I'm sorry that I'm doing a bad job for my dairy friends but I don't really know all the circumstances -- but it's usually because there is water that is very cheap that they cannot move elsewhere. And therefore they're using it inefficiently. The market will take care of the problem.

MS. KEARNEY: Any more questions?

MS. HANAK: May I just?

MS. KEARNEY: Yes, go ahead, Ellen.

MS. HANAK: Yeah. So I think that the answer, David, is it does depend a lot on where you are. I didn't read Robert's nine percent to mean just improving irrigation efficiency, but reducing agricultural water use by nine percent. And sometimes that has to be with reducing crop production. So the suggestion of reducing summertime alfalfa is actually reducing crop production. But alfalfa is one of those

great crops that you can just let sit around for a while and without killing it. So that's a good way of being smartly efficient with irrigation.

MS. KEARNEY: So we're right on time for our short break before we'll move into our second panel. Thank you to the panelists. (Applause)

MR. ALTMAN: This second panel is going to focus on innovation in the water sector or, as some would argue, the lack of it and why. We have an exceptional group of panelists for purposes of discussing this and I just want to introduce them.

To my immediate left, Tamin Pechet, who is the founder of Ambien Water who is the chairman of Imagine H20 and who has a very rich history, as you can see in your material, as an investor. To his left, Michael Markus who is the General Manager of the Orange County Water District and has enormous experience in construction management and water planning and elements of this whole debate from that perspective.

And to his left, Peter Yolles who leads Water Smart's public affairs activities and previously was responsible for protecting water resources (inaudible) 01:07 conservancy. And then Buzz Thompson, I believe, together with Nucia Jamni 01:14 and David Victor wrote a terrific paper for this event. I hope you've all had a chance to look at it.

Buzz is (inaudible) 01:22 but he's a professor at Stanford Law School. He's also Director of the Woods Institute. And we're going to begin with Buzz summarizing his paper and we'll go from there. Thank you, Buzz.

MR. THOMPSON: Okay. Thank you, Roger. As you've just heard, I'm actually a lawyer by background so I'm going to do something which is really unusual for a lawyer to do, which is I'm going to spend the next seven minutes talking entirely about technology.

Thankfully, on this particular paper, I have two co-authors, Nucia Jamni who is sitting in the second row over here and David Victor from the University of California, San Diego who know far more

about the technologies than I do.

As Secretary Rubin started out by mentioning, water is, I think, going to be the critical issue of the 21st Century, certainly the critical resource issue. And one of the most important things we're going to have to learn how to do is to get along with less, because you're going to hear in the next panel there are vast areas of world, including California, which are going to have less water available to them in a period of climate change than they have today. And technology is going to be one of the crucial elements in solving that oncoming increasing water shortage.

One of the things that the last panel talk about in terms of dealing with water shortages is reducing our consumption. And, in fact, there's really only three ways in which we can learn to do with less. One is is that we can lower the population. That was sometimes that Rob Glennon mentioned we really don't talk very much about. The second thing we can do is we can reduce the amount of

water we utilize. We can conserve water. But then the thing third we can do is that we can turn to technology. And technology is going to be critical in solving the water challenges that we have in this particular century.

Water technology is going to be essential for the type of water treating activity that Rob Glennon talked about in his paper, the Western's water district which is in the Central Valley of California (inaudible) 03:34 the technology and electronics trading system in order to make sure that their internal water market works as effectively as possible.

Technology is going to be important in the type of ground water management which is going to be critical under California's new legislation. There are engineers here at Stanford who are working on new technologies that effectively can do CT scans of the earth, and in the process, having much better sense of what that ground water resource is that we need to manage.

As you heard in the last panel, technology is important to measure water. Technology is also critical for conserving water. Governor Brown mentioned that's the number one goal of the state water plan. And without new technologies, we're not going to be able to conserve as much as we could. And let me give you two further examples of how technology is important, both of them in terms of new sources of water, technologies that can both help us reduce our demand for fresh water at the same time that we reduce our demand for energy. One of those technologies is in the area of recycling.

Historically, the way in which we dealt with water was that we imported water of great distances to where we needed it. We utilized that water and then we dumped it back into the environment again, frequently in California in the ocean where it was not usable. And in having to treat and then dispose of that waste water, we used a mixed amount of energy. As a general amount of about 30 to 60 percent of the energy command of most municipalities is for their

waste water treatment systems. About three percent of all the energy used throughout the United States is for the treatment and then disposal of waste water. We need to change that.

Through recycling, we're already beginning to take that waste water and recycle it in order to get the clean water back that we can utilize again. But what we have to be doing is recycling that waste water not simply for the water but also for the energy that is contained in. No matter how much energy we have to use in order to purify waste water, there is four times that amount of energy embedded in the waste water itself. And so at least in theory, we can produce four times the energy that's actually necessary in order to purify that water for reuse.

The screen at the moment shows some technology which has been developed here at Stanford, the can-do technology. The can-do technology will be one of the first technologies that actually will produce more energy than it utilizes so that not only will it purify water and provide us with more water

that we can use rather than fresh water from rivers and streams but also supply us with energy back to the grid.

Another major area in which we can produce more water in the future for our needs is desalination, and you can see in the upper right-hand corner here, the desalination plan that San Diego is building in Carlsbad. Desalination at the moment is not the answer for water shortages in very many regions of California and the world simply because of its cost. Desal (global phonetic) 06:57 cost on average is something in the nature of about $2,000 an acre foot right now where you can frequently got water through other means of about $500 an acre foot.

And desalinated water is very expensive for several reasons. One of the reasons though is that it requires an immense about of energy. Almost half of the operating cost of your typical desalination plant is energy.

In addition to the costs of operating the desal plants, desal plants are huge operations, is --

again, you can see in that upper right-hand corner -- in order to be able to put the amount of water through those desal plants that we need. We then only have to have very sizable plants with huge footprints. And probably the worst possible place to put it (inaudible) 07:46 which is on, for example, the coast of California. And so, not only do you have huge energy costs but you also have huge construction costs. The question is whether or not we can further reduce the cost of desalination, and there are new technologies on the verge of adoption that should permit us to reduce the cost of desal.

The picture on the lower left-hand corners are representation of grafting. Grafting was first developed and produced in about 2003. It is a form of puraclarven 08:18 in a very thin layer. So grafting, in fact, is so thin it’s basically two-dimensional. But even though it’s extremely thin, it’s also extremely strong. And so graphing opens up the opportunity of being able to get a lot more water through the filter system and doing that at high

volumes because, again, it’s very thin so it’s easy to get water through through it but it’s very strong so you can get a lot of water through it.

There was a recent MIT study that suggests that we can probably reduce the total amount of energy that's needed for desal plants by about 15 percent by moving over to graphing. And perhaps, even more importantly we can actually reduce the size of desalination plants by about a half. We would only need about half as many pressure vessels because of how much water we can actually move through the grafting membranes. And that would permit us, again, to significantly reduce the cost of desalination.

The problem, however, is that we are investing an inadequate amount of money right now in these types of water innovations. And as a result of that, we’re getting much less in the way of new innovative water technology than we really need. This is a slide that shows the number of new patents issued in every year from 1999 until 2011. First of all, in the water sector which you see in the bottom green and

second of all in the clean energy sector which you'll see in the upper blue.

Early in 1999 you had about twice as many patents which were issued in the energy sector than in the water sector, but as you can see, that gap has grown dramatically so that earlier in this particular decade there was a second-fold difference. So even today there is a four-fold difference in the amount of new technologies being produced in water versus being produced in energy.

And no matter how you measure innovation in the water field versus innovation in the energy field -- whether you measure it in terms of the output, the number of new patents being issued, or whether you measure in terms of the amount of money that were in investing in the water technology in terms of either the total investment, the number of new deals in the water sector, venture capital investment, corporate investment, public funding -- water technology is getting only a fraction of the money that new energy technology is receiving.

So the question that this particular paper addresses is what could we do about that. And if you read the paper, you'll see that we have an analyses which shows there's a variety of reasons why new technologies in the water field are coming in at a much slower pace than they are in the energy area. But I want to talk about the four major areas that we focus on in the paper. The first one is pricing. Water prices are far lower than they are for virtually any other comparable resource. And as a result, the demand for new water technologies is much less than it actually should be.

This particular slide here shows the effect of energy prices on new patents in the energy field. And what you'll see is that there's a moderate high correlation between how much we are charging for energy and how many new patents are being developed in the energy area. There's also not surprising the two states with the highest energy prices which are Hawaii and California are then two of the leaders in producing new energy (inaudible) 12:10.

But if you look at water, and this particular slide shows the amount of space as a whole, the vertical axis on this particular slide shows the price that we charge for water. The horizontal axis shows the amount of water which we are distributing. The United States is providing water at one of the cheapest rates of any of the major developed countries around the world.

And so, one of our recommendations is that we should actually begin charging for water the true price of water, and if we do that, that will increase the demand for the types of new water technologies that we need. And there's a variety of reasons why right now why water is underpriced. The first thing is that we actually give away water in the United States. We all pay for water but what we actually pay for is the cost of transporting the water to us and then purifying and delivering the water for us.

Neither California nor any of the other states actually charge us for the water itself, despite the fact that there is opportunity cost to the

environment, to esthetics, to recreation of taking that water out of our rivers and streams. So it was a study in Australia two years ago that tried to look at what the value of the water in the river was compared to just supplying the people. And what they found was that the value of keeping the water in streams was about three times the actual price that we were charging for the water.

So the first thing we should actually do is start charging for the water itself. Second of all, some areas of California -- many areas of the United States as a whole is filled on metered water so we're actually not charged by the amount of water that we use in that. Third, there are a lot of utilities in the United States that are not setting aside the money that's necessary for actually reinvesting in the infrastructure that they have and that is deteriorating over time.

Fourth, water prices in much of the United States are subsidized so there are some states, for example, that still subsidize their water prices with

real estate taxes. Fifth, when we are faced with water scarcity we don't adjust the price of our water to reflect that particular scarce.

I don't think there is any other resource that when it becomes scarcer, the price of that resource actually doesn't rise. So there are a variety of ways in which we underprice water. And if we simply priced it at what its true value was, we would take a major step towards actually providing an incentive for the type of new water technologies that I was mentioning earlier.

Another area is financing. In order to move these new technological improvements on, we not only have to price water properly but we also have to, well, finance it. And water is an area which is highly tapal 15:02 intensive. This particular slide shows the actual amount of capital invested in water compared to prices. But we don't have accurate mechanisms at the moment to actually provide for adequate financing for this investment. So another thing that we propose is a public benefit charge that

would be charged on water usage, and that would then go into a fund that could be used for a variety of purposes but including new R&D.

A third area is the area of regulations. Regulations can both serve as a driver of new technology -- so for example, the Clean Water Act actually drove the development of (inaudible) 15:44 water quality technology. The type of renewable portfolio standard that we have in the energy area in California here has driven new energy technology but regulations can also serve as an obstacle to new technology. And one of the things that we have found in our particular study is that regulations in the water field are providing too much obstruction to new technologies and too little incentive for new water technologies.

And then our final recommendation is that a number of states including, we believe, California should consider opening state offices of water resource, innovation and development. These offices that could be based in an existing water agency like

the California Department of Water Resources could have the responsibility for ensuring adequate prices of water, adequate finances, proper regulation. But then, in addition to that, it could also serve as a common test bed for new technologies and it could then take the information about the new technologies and ensure that those actually get out to the water utilities.

So those are just four of our recommendations in this particular area and I look forward to hearing from the panelists as to their ideas for moving new technologies out.

(Applause)

MR. ALTMAN: Thank you, Buzz, that was great. Now Tamin, I'm going to start with you. The core focus of the first panel and the core focus of Buzz's presentation just now was the importance of introducing market-based mechanisms, especially pricing into the water sector. And two of the three recommendations Buzz's paper makes involves raising prices. So I'm going to draw down a little bit on

that in two ways.

One, do we need to raise prices primarily to finance upgrades in our aging water infrastructure or do we need primarily to raise prices to, in effect, offer returns or attractive enough investment returns to induce innovation? Exactly what is the core reason we need to raise prices? And secondly, how hard it is really to do that? You know, when you start off and begin to be introduced to this supple subject without knowing a lot about it, you have this image that the biggest reason you can't raise water prices is because households don't want their monthly water bills to go up, pretty natural too, unlike the difficulty of raising gas taxes at the federal level.

But any one of the vast majority of water is used for agriculture, and I don't know whether that means that that's why it's especially hard to raise prices or whether actually it would be easier to do that or is easier to do that than if households were the primary concern there, so talk about that a bit.

MR. PECHET: Sure, that's simple. So let's

start with where we are with water prices. How many people know what they paid last month for water and sewer? How many people think whatever you pay now is going up? Okay.

Well one of the issues is that there is no average price for water or sewer that is relevant to an innovative company trying to sell to a customer. The only price that matters is what that customer pays because you have to deliver a value proposition against the price of water.

I agree water rates are rising. They're rising faster. Water and sewer rates are rising faster than any other utility expense. But part of the reason why not very many hands went up for the first question is because they're still low as a percentage of the in-household incomes. So there is room to raise rates. Rates are rising but they're still low.

So why do we need to raise them? Well, again, you have to realize that water is a hyperlocal market. And I think that, on average, water and sewer

rates need to increase but actually some places they're quite expensive. And for some customers they're actually quite expensive. And so it's really a data problem, a figuring out if you want more innovation to reach customers, what customers need higher prices in order to adopt innovation. It's not a universal answer. It is true on average though higher prices will lead to a broader adoption of innovation.

And I think that the underlying question is how many of you think that in the current construct with prices the way that they are that innovation in the water sector is a good business opportunity? Raise your hand of you think that that makes sense.

So you're dealing right now with over a $600 billion industry globally for water and sewer products and services receiving about $200 million in innovation investment in the form of venture capital and angel investment. There are a number of reasons for that. Water is certainly one of them.

If we want to promote more investment we will

need to raise prices. But this is a huge market as is right now with lots of opportunity and not a lot of competitive financing and not a lot of competitive entrepreneurial initiatives to bring innovation to the market. So even if in its current construct, this is a really good opportunity which should only improve as those water rates rise. A primary reason to do that is to create better behavior around water management and to promote more innovation so that we have a more sustainable water future.

The difficulty of that -- I thought that Buzz raised a number of issues behind the difficulty of raising water and sewer rates, but I'd just say from my own personal experience, have a chance to meet with quite a few state and local representatives about water and sewer rates. And behind the scenes, they all universally would like to increase those rates or to better structure them to increase the marginal cost of a gallon of water, but just would like someone else to blame. And one real opportunity is giving someone else the blame as a scapegoat so that, at a local

level where prices are really set, politicians have an easier time doing that.

MALE SPEAKER: Maybe you could go back and tell them to blame the Hamilton Project.

MR. MARKUS: Michael. Let me follow-up in aspect of that. Much is made in the materials for today's forum on the under investment in water and the aging of the water infrastructure, the degree to which, from memory, 700 billion gallons a day I think in this country are lost essentially for reasons of leaks. But at the same time, there are some cities in metropolitan areas right now that are engaged in very expensive multiyear water and sewer system upgrades.

So I know Chicago about a year ago passed a -- although it's the city council at the mayor's initiation passed a 28 percent five-year increase in water rates, water and sewer rates and that's giving you 23:17 to finance a $4.5 billion multiyear upgrade. I believe San Francisco is doing something (inaudible) 23:20 and there are other places I have also heard about.

So my question is how much of that is going on around the country the old-fashioned way, in terms of raising prices with the public being very aware of what the purpose is? And are we doing a lot of that actually, despite the impression that, I must say, some of these materials give or aren't we?

MR. THOMPSON: Well I think it's kind of hit and miss, you know. It does depend on the regions. And I also believe one thing that we do as a water community, a very poor job, is educate people to where the water comes from. We turn on the tap and the water always comes out and we just expect it to come out. And I think that the water agencies also, we maybe don't try to make the case (inaudible) 24:12.

I think if we're a little smarter about our approach to things and we could make the case where the investment -- if we could identify what those needs are and then present those for our elected officials, it'll make it easier for them then to make the decision as to whether to raise rates or not.

I think in Orange County there are several

cities in the past five years -- the city council just said no, we're not going to raise the rates, and for no really good reason. And part of that also, I think, from the water agency's perspective, you can make the case -- you should talk and bring it to the people and not be afraid to address your constituents that you serve and have meetings with them and try to explain to them where the water comes from, what the infrastructure is, what it takes to provide that service for them and then build the case. And once you're able to do that, then I think most of the time you'll be able to proceed along with being able to raise the rates that you need to build the project.

I can speak from experience on this. Our agency (inaudible) 25:27 to recycle water plants. And at the time -- and this was in the early 2000s when we were (inaudible) 25:35 the job, the cost of that water was going to be more than the cost of importing water (inaudible) 25:40 waters through Southern California.

We had made the case that we needed that water supply reliability in building that project and

our board went forward with the project. We built it. It's the world's largest (inaudible) 25:54 project (inaudible) 25:56 thousand feet of water per year, and that's a significant chunk of water.

And, in fact, we didn't even have to make the case the last time. The board decided right after we went online in January of 2008 to expand the facility from 70 million gallons to 100 million gallons.

So in February of this year we'll be producing over 100,000 new feet of water. The recycled water then gives us the local water (inaudible) 26:22.

MR. ALTMAN: Well let me just follow that up for one more second. You know, one might say that historically in this country, or at least modern times, the electric utility sector has been generally speaking, albeit sometimes in bits and starts and more solely than they'd like, able to raise rates and/or pass on the costs, as necessary. And for example, 30 years ago in this country or before that when nuclear power was coming on stream and the cost of nuclear

power plants were so huge, as they are, the utilities that were building them were able to pass those costs on in terms of rate increases or rate adjustments. So why is that sector been, in general, able to do that, especially in revolving giant construction projects, and a lot of sectors has had such (inaudible) 27:17 more difficult?

MR. MARKUS: I think probably because most people can't go to that agency, the rate-setting agency, and express their concern. At the local level it’s very easy for someone to go up to the city council and say, hey, we don’t want you to raise our water rate. And that's why, as I said, I think it’s important for those local agencies to be able to have the knowledge to be able to express in total public why it is important, why it is necessary to raise those rates.

MR. ALTMAN: Okay. Peter, you're next. Buzz showed us that slide on patent contrast between clean energy and water. And much of the very good paper he has or he presented talks about the poor information

(inaudible) 28:17 water and to use this clean energy as the alternative.

One of my reactions to that when I read it first was, well sure, because of the ownership structure; meaning that the energy sector is largely, in fact, the most entirely privately-owned utility sector investor-owned highly regulated (inaudible) 28:38 lots of sectors in energy differently regulated and less regulated. And we've all seen in the past few years in the United States an enormous amount of new investment coming in all kinds of energy and the unleashing of tremendous increases in output. It's really an extraordinary story.

So my questions is how much does simply the ownership structure of water, which I believe 80 percent of the water in this country being owned by local authorities, not investors -- how much does that impede innovation all by itself right there? And are there ways to, in some form or other, liberalize the ownership of the water sector -- and anybody else who wants to comment on this will -- in order to make some

progress against that particular obstacle? Because to me it's probably the number one obstacle.

MR. YOLLES: (inaudible) 29:31 also interacting with many municipalities. So Water Smart, we started in 2009 and we actually raised over $6 million in venture capital, willing to bring (inaudible) 29:46 change to consumers and water utilities to better engage their (inaudible) 29:50 and recommend the best ways you're going to save water, energy and money.

So throughout that process, we're able to map ourselves to (inaudible) 30:03 offer service or enter (inaudible) 30:06 and so on. And one of the things we found is that we were actually lucky in terms of timing when we raise that venture funding, and during this (inaudible) 30:15 bomb where there were about 300 (inaudible) 30:17 today. First half of 2014 only eight water (inaudible) 30:21. So there have been a lot of venture money to help us get started than any other company (inaudible) 30:27 out there today.

Now what we do today is we talk with many

(inaudible) 30:31 or water utilities. And what we do see is, as Mike talked about, the challenges in the raising rates. Part of that is that we see that there is almost a $5 trillion backlog in deferred capital cost (inaudible) 30:48 for the next 30 years. So yes, there is a big challenge in raising rates.

One of the things that (inaudible) 30:55 look at though is the marginal cost of that water supply whereas consumers see the average cost of that water. So the incentives at municipality are very different from what consumer looks like at the home.

So now, when we look at what the structures -- you're right -- in the energy industry, the vast majority, 85 percent of electricity is delivered through investor-owned utilities. On the water side it's the (inaudible) 31:20. About 85 percent of the water is delivered through municipally-owned, publicly-owned water utilities. And when you come back to some of the same challenges that Mike talked about which is the decision-makers about rates are publicly (inaudible) 31:32 not beneficial whether it's

the city council members or (inaudible) 31:34 board of directors of water utilities (inaudible) very different (inaudible) 31:41 investor-owned utilities.

Not saying there are a lot of public subsidies that go into water, probably that's because of the public health nature of the service that water utilities provide. They have subsidized energy cost. They have subsidized conveyance cost (inaudible) 31:57 projects that the Federal Government has built for years, those costs did not get past on to retail water utilities or their customers. So (inaudible) 32:07 actually do have cheap water and cheap water supplies. So those are some of the structural challenges that we face.

Whether or not we want to privatize water utilities, I would say probably not. I think the water utility industry has overall done a very good job of delivering a clean reliable supply of water over the years. I'm not sure we want to mess with that, but I think there are a number of recommendations that this paper (inaudible) 32:31 are

applicable and we could try to move water industry management more towards the way that energy is managed and I think that the paper does a fairly good job of identifying where we could do that.

MR. ALTMAN: Buzz, let me ask you a brief and the same question, which is -- but I want you to challenge my premise because I'm sure you'd agree with at least part of it. I thought the comparison between innovation and clean energy, (inaudible) 32:56, and that and water is a bit of a false one because of its ownership difference.

So a lot of investment in clean energy, for example, advance types of solar, is occurring within 50 miles of where we're sitting right here in the technology community and the venture capital -- well that's backed by the venture capital community. And one of the reasons for that is because, if you're an investor, you have a very long runway and you have all the freedoms in the upside as well as obviously the downside associated with private investment but you don't have that, generally speaking, in the water

sector because of its ownership structure.

So I thought that the differences that you put up on the slide between the two were completely natural as a result of the ownership. Now, what's wrong with my thinking on this?

MR. THOMPSON: Yes. Yes. So it’s actually interesting to think about how the public sector on one hand and the private investor-owned companies on the other might differ in the way in which they deal with new investments, how they price water. I actually thought Mike’s point a moment ago was really quite good for a lot of local municipalities. When they want to raise their water rates, they have to respond directly to the vote, whereas if you have an investor-owned utility, it’s responding to a public utility commission. And I actually thinking the public utility commissions have been much more receptive to the idea that we have to invest in new technologies and, therefore, we are going to let you raise your rates in order to do that.

Having said that, I also really have to live

in a real world. And there was a lot of movement towards privatizing water utilities in the late 1990s and it picked up a little bit of steam and then it basically shut down, and I think there are a variety of reasons for that. One of them is is that people care about their water. They care about their water more than they care about any other utility that they're receiving. And they are suspicious of private companies and whether or not private companies are really going to engage in the type of public (inaudible) 35:14 management that they want.

So although I think you could make some good arguments in that direction, I don't think we are going to see movement towards more privately owned water utilities. And so then the question becomes what can we do in order to help move the public entities towards higher prices. And I think there are several lessons there that we know.

Number one is, if you educate the public, if you help the public understand why it is that you need to raise their water rates then they frequently go

along with it. And that's why you actually have certain number of utilities that have successfully raised their water rates in the United States over the past five years.

And then I think the other thing that we have learned is that it is better to be constantly raising your rates a little bit over time and making sure that you have enough money to invest in new innovations and replace existing infrastructure than what, unfortunately, a lot of local cities do, which is that they refuse to raise rates for like 10 or 15 years and then suddenly they have to have a huge increase in their water rate, which of course gets everyone's attention.

MR. ALTMAN: All right. Let me follow that up. And you might comment on this but anyone else, if you'd like to jump in, please do.

So let's assume that -- you referred to the costs and the energy intensity of desalination. But let's assume that there are -- because even I (inaudible) 36:44 technologist, seen evidence of this

(inaudible) 36:57 coming breakthroughs, technologically speaking in desalination, and perhaps also purification, which make it much more competitive, but on the other hand, the capital costs are going to be huge. So how do you see that being financed and how much of that is the, what I might call the corporate community going to do?

You mention the food and beverage sector and other aspects of the corporate community. How much are they investing? (inaudible) 37:19 this hold equation or not. And if we have those types of breakthroughs are they going to be a major source of investment, since we're all talking about innovation related investment here today, or not?

MR. THOMPSON: So I think that's an excellent question. And historically we have financed new infrastructure in the water field through public bonds where you'd issue the bonds and then you've paid back the cost through revenue over time. Those are increasingly limited. A lot of local water companies are finding it more and more difficult to turn to

traditional public bonds.

This is an area where I think the private sector can have a major role, and that's where you actually have private public partnerships or the private companies actually help to construct the new desalination financing. They use some of their financing ability, and frequently they then run that entity for the public water supplier for a period of time.

Now part of the problem there is it’s kind of interesting because when private agency comes in, their cost of financing is a lot more or can be a lot more. They’re looking for a 12/10 percent return on equity for their financing. And in the public sector we actually have -- and in our agency, it’s AAA/AAA but we haven’t done that in the market in the last five or so years.

The state has a very good program. The state (inaudible) 38:53 and it offers very low interest loans for agencies to (inaudible) 39:02. Right now I think there’s $800 million set aside. Some of that's

been subscribed to already but it's one percent over 30 years. So it makes it easier for the public agency to finance the project and to build the project.

But still that cost of financing, we've taken advantage of at our agency in order to keep the cost of our projects down. And I think the one thing the public agency do have to do is they do have to -- if they could have boards or city council to set policies that maintain funds, reserve funds to build aging infrastructure, to replace aging infrastructure (inaudible) 39:45 refurbishment and replacement fund. And we currently have $70 million in that fund but we're using that every year to replace our infrastructure. As a result, we want the (inaudible) 40:02 at some point in time, having to raise a lot of money to rebuild those projects.

So I think if the public agencies can take a little smarter approach as to what they're doing and have, there again, the elected official's support to be able to support those types of programs, that may be one of the asnwers in the future also.

MR. ALTMAN: Let me just ask anyone on the panel who'd like to answer this. Historically, has there been any federal role in regard to these really large projects? I mean I mentioned the nuclear power example a minute ago. Well today there are, I think from memory, eight to 10 new proposed nuclear power plants in various stages of approval. Approvals take many years. And these are the ones that received approval under the Department of Energy, a loan guaranty program, because they cost not far from $20 billion a piece these days. And so the Department of Energy is actually financing a lot of it.

So if we have breakthroughs in desalinization or whatever it is, has there historically been or would there be a federal role? Or otherwise, who's going to pay for these? Are we going to build it?

MALE SPEAKER: I'm going to step in here and just sort of say, well if you just look at where is the capital coming from to do what we need from an innovation perspective in water, you can stage it. You have early stage financing for high-growth

opportunities that are truly innovative. You have later stage financing for companies that are already developed. Then you have project finance for things like you're talking about, which are projects to generate water supply or do something with waste water to reincorporate it into the water system.

For the most part, as you get later in those stages, the financial markets are pretty competitive. If you can show someone on Wall Street an attractive deal with long-term projected cash flows around the water system, there are lots of people who would like to finance that.

So it’s not that we’re there and there’s no problem there. I think that the real problem is in the earlier stages where we have this long history of innovation in water going back to Roman Orthodox and now we’re looking at all these problems becoming increasingly acute. How do you finance anything that doesn’t have very predictable stable cash flows like a project?

And there, I think, going back to your

earlier question of the comparison between energy and water that Buzz drew, I think it actually is a fair thing to talk about because a lot of the money that would finance early stage water innovation was coming from holders of money who were financing energy deals. And when some of those went south they pulled the purse strings on water innovation.

So without directly answering your question of long-term federal involvement in big projects, you can get a good project financed if it’s worthy. I think it’s harder to get innovation financing.

MALE SPEAKER: Yes. Right now I don't know whether you can rely on the Federal Government for anything. I think we’d have a lot better chance at (inaudible) 43:17. I’ve identified a considerable chunk of money to be able to go (inaudible) 43:28 water infrastructure with the same needs. And I don't know that we need to be totally reliant on Sacramento either. I think there’s an obligation to the local agencies to build the infrastructure (inaudible) 43:40 also and to finance it.

MALE SPEAKER: Okay. Thank you. One other thing (inaudible) 43:49, we have a Department of Energy but we don’t have a Department of Water, and we might think about that. And we have water actually fragmented across multiple agencies (inaudible) 43:54 and the Department of Defense.

We have EPA and it’s spread across many agencies with no single entity or person thinking particularly about water, and that's why we have to look to the states and local agencies for innovation because that's where it’s happening. But they are strapped with having to deal with refurbishing and renovating our water systems and there’s not much left over either in people or money to think about innovation or investing in the measurement revocation of these new technologies. They are out there but there are not very many opportunities to go out and test them, evaluate them and really take the risk off the table for water utility managers.

You know, they are having to provide this reliable low-cost supplied water, which they’re doing

very well, to do, but there's not a lot of willingness or risk-taking in (inaudible) 44:47 to do that. But we can help change that by providing other mechanisms to provide outlook 44:53 for early stage investments and the measurement verification to (inaudible) 44:58 risk investment into new technologies.

MR. ALTMAN: All right. Let's turn to the audience and take some questions for the panel from the audience. I know there are microphones. Ma'am, in the middle here.

MS. REEVE: Thank you. My name is Carol Reeve. I'm from the (inaudible) 45:25 Incision down in Monterey with Stanford University. I'm a research scientist. We talk a lot about the cost of innovation but we don't talk much about the cost of the environmental impacts of that innovation, and specifically, I refer to ocean desalination.

(Inaudible) 45:41 and I have done a little bit of research on market squid, which is California's number one fishery currently (inaudible) 45:48 discharged onto the seafloor from desal. It actually

impact our number one fishery much like Salmons, the seafloor is a nursery (inaudible) 45:59 water from rivers. We destroyed a major commercial fishery, (inaudible) 46:03. And I would also say that, hopefully one day on the panel there will be fisheries people up here and not just (inaudible) 46:11.

MR. ALTMAN: By the way, if I could point out, the most recent Hamilton Project forum before this one was on fisheries and commercial fishing and were forums that could protect and promote commercial fishing. So we just recently covered that. Who would like to take --

MALE SPEAKER: No, I think there was a question in there and the answer is yes. I mean, particularly, desal has a whole variety of problems in addition to the cost, and one of them is what do you do with the salt grind 46:43 after you finished desalting the water. And that is a significant problem where, again, I think that science and technology can help solve the problem by looking to see how we might be able to dispose of that in a way

which is safe as possible for the fish. But you have to have the actual money there looking at how you can address that particular problem but it is definitely a serious problem.

MS. REEVE: May I just add that salt is actually a energy (inaudible) 47:10. It’s a C02 free energy source (inaudible) 47:5 electricity. (Inaudible) 47:15

MALE SPEAKER: Let me add on to that about the, in fact, in the environment, what water mainders 47:19 can do. Efficiency is really important. Right here in California we actually divert the same amount of water today as we did back in the 1980s, that's all because we’ve become more productive with the water we’re using. Right? And so we have to continue to dote along that efficiency curve in using technology. So the more we can do that, the more we can become more efficient and leave more water in our rivers, lakes and (inaudible) 47:41.

MALE SPEAKER: And I think the one thing you heard in other presentations as well -- and, again, I

agree with your 47:49 conservation, recycling, desalination. We have a tremendous opportunity to continue to recycle water and save California. We just got 1.3 billion gallons per day off the coast of Southern California, don't have the number for Northern California, so there is that opportunity.

And I think we're -- we talked about technology. We're trying to develop technologies to go beyond indirect local reuse into something called direct potable reuse where we would have these advanced treatment facilities that take waste water, treat into the spilled water quality and then put it into a pipeline upstream of a water treatment plant. There's tremendous opportunity there.

In fact, there is a bill that was passed a few years ago, SB-918, Senator Pavley, that says that the -- I guess it's not a -- the Department of Drinking Water has to establish a framework for direct potable reuse by the end of 2016. So that's something the government will be able to do this next term.

MR. ALTMAN: Which one of its next terms?

Who's next? Yes, sir?

MR. WILLIAMS: Peter Williams from IBM. One of the things that I thought (inaudible) 49:10 just to compare my county, the UK, there's 24 water companies for 70 million people. In the United States there are 55,000 separate water systems filtering out to 50,000 million people. 30,000 of those have fewer than 500 customers. So the result of that is each one of these systems is run by one person (inaudible) 49:30. There is no money to innovate. There is no time to innovate. There is no skill to innovate. There is only interest in doing what they've already done because that's what we know.

But one of the things you could talk about -- you talked about financing charges (inaudible) 49:43. Orange County is a big water district. It's actually relatively usual. You have to think about that proverbial long-term. If you're going to get innovation across the water sector, it seems to me you have to think about that long-term kind of consolidator.

MALE SPEAKER: I totally agree with you. I think there are far too many special districts and there is a need to consolidate. We have tremendous economies of scale in doing so. I think I heard the argument that they like to have local control. Well you're not giving up that much local control if you consolidate a few of them (inaudible) 50:18 water in geographic areas.

Although, the one thing also is that I don't see any reason why you shouldn't have waste water water agencies consolidated. (inaudible) 50:28 water agency overseeing, perhaps, (inaudible) 50:30. Because, there again, we need to start looking holistically at water, whether it's waste water or whether it's ground water or whether we're purifying waste water (inaudible) 50:44 water pure enough to put it back into the ground. So yes, I definitely think we should continue (inaudible) 50:49.

MALE SPEAKER: If I could just add really quickly on that. I mean I do think that fragmentation both geographically and also by function is a serious

obstacle to new innovation in the water area. There are various ways of dealing with it. I think one is to imagine having more agencies like the Orange County water district or like the metropolitan water district of Southern California that bring together multiple agencies and permit them to think more broadly.

And then the other reason why we suggested having an Office of Water Innovation at the state level was a notion that it could act as a consolidator and actually have each of the individual water suppliers serve as investors in that particular office or stakeholders in that office, and then you could have a state-wide office that would actually look at some of these innovations, test them and get the information out very much like EPRI.

Those of you who are involved in the energy area know that the Electric Power Research Institute, EPRI, plays a major role as a major researcher for the energy investor. We need an EPRI basically for water, and having a state-wide water office might serve that function.

MALE SPEAKER: And I totally agree with what Buzz and your comment there that the smaller agencies don't have the time or the money to devote to innovation. So obviously a department like that would be terrific. There are also some other examples that exist today that can be used more fully.

So one of the great examples is (inaudible) 52:14 Imagine H20 (inaudible) 52:17. So one out of six metro dollars actually goes through or, two, (inaudible) 52:22 come out of that program, which Water Smart is one, so that's great.

There are also some other agencies and organizations that do a lot of innovation. Take the (inaudible) 52:31 small agencies like the American Water Works Association and the Water Research Foundation. There are also innovation (inaudible) 52:37 around water that EPA is supporting in Fresno, for example, and Austin and in Milwaukee. So those are some examples.

One other one I want to mention -- I just returned from Australia yesterday and southeast water

in Victoria actually has created its own (inaudible) 52:53 subsidiary called IODA 52:55. So they're out looking for new technologies and testing them separate from outside, the operators of that utility, which I think is a really innovative model. It takes away sort of the low-risk mentality that's within the operation of the utility and puts it aside into a higher risk new technology, new innovation segment, so I think that's an interesting example to look at.

MALE SPEAKER: And I think one other thing is we need to try to encourage the private sector and the public sector to work together on new technologies. In other words, if a private sector comes up with a certain technology, they can use the public sector to help maybe implement it and test it for them to make sure that the results are what they think they should be.

Then again, an example, we're working with a company called Trevi on forward osmosis which could be used to concentrate grind for recycled water and other applications. And we have a partnership. We applied

for a grant. We got the grant together and we'll be testing that system out. So there is an opportunity I think certainly within the private sector to work together in that respect.

MR. ALTMAN: Let's have another question. Yes, ma'am, way in the back?

FEMALE SPEAKER: Thank you. I'm actually from EPRI and we work on the water energy nexus a lot. And one of the things I wanted to comment about the consolidation is -- sometimes there's talk about -- well from the other point of view, when you are looking at pumping, the energy perspective. So sometimes the prospective is to do the processing right at the local unit so that you don't have to pump the water back and forth. So that's one point to just look at, point of view.

And we have worked with some of the water research related organizations like Water Research Foundation, which is sort of EPRI but for the water sector. So that's another organization I wanted to point out. Thank you.

MALE SPEAKER: I'm glad you did that because I'm the president of WaterReuse California and I remised not to have mentioned that.

MR. ALTMAN: Question? Yes, sir?

MALE SPEAKER: The last four of the questions you looked up, water transportation through pipelines. And I think one of the questions was or one of the statements was that the (inaudible) 55:42 and major government sponsored infrastructure is over. No more big dams. No more major innovation or infrastructure improvements of that nature.

It seems to me like the water transport (inaudible) 55:55 possibly come from maybe Washington or Oregon and possibly other sources is just as important as (inaudible) 56:01 as the railroads are and other major infrastructures that the government has sponsored and funded. So is the government now incapable of doing any infrastructure development that's critical to the development of the country?

MALE SPEAKER: Well I'll jump on the infrastructure point more broadly and just say that I

think the concept of what happens to a drop of water and where can you take that drop of water from its existing source to where it's beneficially used is the right way of thinking about things. But there is so much opportunity for improvement within existing pipelines within one utility system to reduce leakage and waste, and even on the sewer side, sewer overflows and intrusion from when it rains, the storm water that creates all sorts of problems in the system.

But I think there's a far better opportunity to improve our water and sewer systems, thinking that way than thinking about how to transport water from very far away to a place where it can be used.

MALE SPEAKER: Well I was just going to say, just in the state of California, moving water from Northern California to Southern California takes a tremendous amount of energy.

MALE SPEAKER: But we do it because it's necessary.

MALE SPEAKER: Well, but there's other ways. Water recycling is an example (inaudible) 57:20 that

it takes to move water from the north to the south. So just to follow-up on the point that was previously made, I think we have to look for that local water supply reliability and that's what these water damages are doing in the state of California.

MALE SPEAKER: Just one more thought on that. In order to make any of this happen, in order to get innovation (inaudible) 57:41, someone has to want to buy it in one form or another. And the problem with our pipes and transportation is one where there is an additional value proposition of doing things right, which is when water gets out of the pipe that it’s supposed to be in, there are problems. There is a huge industry of private industry around where mediation leaks and leak detection both on the water and wastewater side.

So there is some financial private market incentive to improve our existing infrastructure without relying on government to do it all. And part of the reason that that's so important is half the mileage of most cities occurs on private land. It’s

underneath your yard, the pipe that takes the city pipe to your house and back, which the city doesn't have any control over.

MR. ALTMAN: Well let's just take one or two more questions to give folks a chance. Ma'am over here to the far right?

FEMALE SPEAKER: Hi. In looking at the future of water infrastructure, we've been talking about pipes and big dams. Technology brings in a whole new set of possibilities around onsite technology and local systems that are remote monitored. Where do you see that fitting into the picture when finance is completely different if you talk about it that way?

MALE SPEAKER: So I'll just say I think we are moving just as the energy area in direction towards more distributed water development and water supply.

One of the questions from the woman from EPRI a moment ago dealt with actually having to move the water around for recycling purposes. Frequently

recycling plants are built at the lowest possible point of city because, historically, that's where you collected your waste water and you've gotten rid of your waste water.

And so that means that we actually collect all of this waste water at this one point and then we have to pump it back out again frequently uphill among all the people who are utilizing it. So it'll probably make a lot more sense in the future to have smaller recycling facilities that might be neighborhood-based where you don't have to worry about pumping the water all over the city again and so that you are reducing your overall energy costs. And I think that's just one other really important point when you think about new innovations in the water field, which is that water/energy nexus.

More and more we are having to think not only about the water implications of what we are doing but also the energy implications of our water technology.

MR. ALTMAN: Yes, sir?

MALE SPEAKER: Dan Isher. A lot of

discussion about pricing in the (inaudible) 1:00:27 stimulating innovation, and we've been talking about lessons from the energy sector. And I'm afraid that, you know, there's another class in the energy sector that we haven't talked as much about is that pricing is important but it's not enough in a lot of these cases. And the (inaudible) 1:00:38 paper talks about the regulation. And I'm wondering if we can have a little bit more discussion because if we look at making energy innovations and (inaudible) 1:00:48 power, energy efficiency, pricing played some role there but the big private home utilities played a minor role. Smart performance-based regulation played -- and where are the opportunities for innovation in regulation in the water sector?

MR. ALTMAN: Buzz, you might want to take that because that's the second one of your two recommendations.

MR. THOMPSON: Yes. You know, again, I think a lot of the things that we saw is that you don't have -- except in the area of clean water, you don't have

the same type of regulatory drivers in the water field that you do in the energy area.

There are some state laws around the United States that have pushed for the use of recycling either (inaudible) 1:01:34, for example, new public buildings to have the plumb for recycled water or to ban the use of fresh water for various purposes like golf courses. I think we could be doing a lot more to think about how we could establish performance-based regulations just like you suggested that actually would push new technology.

In addition to that, the other problem is that frequently you have a lot of regulations at the local level which, very tremendously from one jurisdiction to another jurisdiction on, for example, recycling that require new technologies to actually have to meet different regulatory requirements in different jurisdictions, and that just makes it a lot more difficult to move that technology out.

MALE SPEAKER: One of the performance standards that was instrumental in getting Water

Smarts (inaudible) 1:02:29 state of California is the standard of -- achieving a 20 percent reduction in (inaudible) 1:02:33 and consumption, and that's (inaudible) 1:02:35 by Governor Brown. Thank you for that.

I think (inaudible) 1:02:39 20/30, which I think is completely reasonable. When we look at what Australia did. They (inaudible) 1:02:48 by 43 percent during our 14-year (inaudible) 1:02:50 drought. So I think 20 percent is achievable, as we've shown that it is. We can go beyond it. So I also want to talk about pricing structure, which we talked about creating prices but not about rate structure. So I think that, you know, we should (inaudible) 1:03:04 rates today and we could even go beyond that and think about allocation (inaudible) 1:03:09 rates where we actually apply a water rate on each individual customer as customized to their particular water use. And that's been happening in Orange County very successfully over the last 20 years.

MR. ALTMAN: Well ladies and gentlemen, that

concludes our panel. I want to thank our panelists for a great job.

(Applause)

MR. RUBIN: My sole function in this instance is to introduce the moderator and facilitator of the panel, Tom Steyer. I first met Tom more than 25 years ago. We worked together at Goldman Sachs, and Steve Denning, the chairman of the board at the university just told me that Tom worked for him before he worked for me, which is interesting, because Tom came to us with a lot of bad habits that we had to undo.

In any event, when I left Treasury, Tom and I used to talk a lot about business matters and economic policy, whatever. And then one day Tom said to me --he had reached a conclusion that climate change was the issue of our age and that he was going to work to change the conversation in America about climate change to create a sense of commitment and a sense of urgency to act. Then about two years ago, Tom stepped down from Farallon, the investment firm

that he ran, and for the last couple of years, Tom devoted himself to being one of America's leaders with respect to climate change policy and advocacy for us to act and to act now.

And largely, I think because of what Tom had to say to me over time, I reached the conclusion that climate change and addressing climate change is really the existential issue of our age and that if we don't address climate change it will severely affect, and ultimately perhaps catastrophically affect life on earth as we know it.

So with that, I am delighted to introduce an individual who has become a really important citizen of our country with respect to this critical issue, and also my friend, Tom Steyer, who will moderate the next panel.

Tom.

(Applause)

MR. STEYER: Can you guys hear me? Okay.

I want to say thank you to Bob. There are two people here who I used to work for, Bob and Steve

Denning. They both underpaid me dramatically, and the bitterness has not gone away. Let me say that.

I also want to thank you guys for sticking around. I know we're not scheduled to be done until 1:20, so that's pretty late, and I very much appreciate you staying here. But when I introduce the panel, you'll know that it's definitely worth it; not for me, but for them.

Noah Diffenbaugh, the associate professor of Environmental Earth Science System at the Stanford Woods Institute for the Environment. Peter Gleick is the president and co-founder of The Pacific Institute. Wade Crowfoot is the deputy cabinet secretary and senior advisor in the Office of California Governor Jerry Brown. So his boss is here, so he's under a ton of pressure. I want a lot of applause for Wade when he talks so he'll look good in front of his boss. And Sol Hsiang is the assistant professor of Public Policy at The Goldman School of Public Policy at the University of California Berkeley.

So as Bob said, we're looking at water

policy today, and we're looking at it in the context of a time when the world is undergoing climate change. And in particular, we're all sitting in the middle of California and we're undergoing a historic drought. We've always had droughts and wildfires in the state of California, but right now 100 percent of California is experiencing "severe drought." 2013 was the driest year in California's 119-year recorded history and the latest 12 months are the driest on record as well.

So we know that we're under a severe water situation. I'm not sure in my own mind how much of that is cyclical? We've had droughts before. How much of it is secular? So we have a group of experts here to talk about the interaction of what naturally occurs and what's happening in this specific time as a result of changing climate.

And in particular, when we're talking about water policy, we're talking about it in a place that is in crisis, and we need to get -- we can use California as an example of understanding the crisis itself -- talking about the impacts, and then talking

about what the right policies are going forward.

So that is really -- we're going to take this discussion this hour in those three parts. We're going to ask the scientists first how much of what is going on here relates to climate change? How much of it is just the normal cyclical droughts that Californians have experienced forever? Then we're going to talk -- and Wade is here -- about what is the impact on Californians? How is it manifesting itself for the citizens of our state? What are the impacts? And then thirdly, we've heard a lot of talk in the previous two panels about innovation. We've heard a lot of talk about markets. But hopefully we can step back a second from the specific focus and try and put the policy solutions in a framework so we understand how we're dealing with them. You know, should we be dealing with them from a mitigation standpoint? Should we be adapting? Let's try and understand a little better how the system itself works and what we're trying to do in the long term.

So with that, let's start by asking Peter

the basic question, which is, what are the broad impacts of climate change on our water systems in California? How are the two systems linked? And what is the latest data telling us?

MR. GLEICK: Well, thank you, Tom. And thanks to all of you.

Probably like many of you, I've been to a lot of water meetings. It's great to see this level of interest and the quality of the conversation. It's great to see that the governor is interested in this issue. But not only that, he sat through this whole thing. And again, like many of you, I've been --

(Applause)

MR. GLEICK: -- I've been to meetings where politicians come and they open a meeting and then they leave, and it's a sign of his commitment to these issues. So thank you, Governor.

And it's raining. Don't go home. It does not mean the drought is over. I promise you that.

(Laughter)

MR. GLEICK: So I'm going to try and do four

quick things to frame this as Tom has described.

The first is to say that the climate is changing. We know that. We know that the climate is changing because of human activities. We know that. There's a long history of the science of this, and I'll come back to a little bit of that in a second.

The second point is that among the worst impacts of climate change are going to be on water resources. The hydrologic cycle is the climate cycle. As we change the climate, we're going to affect water. And not just the natural system but we're going to affect the infrastructure and the massive institutions that we put in place to manage water as well. So that's the second point.

The third is the impacts of climate change on water systems, I think, shine a spotlight on the false dichotomy between mitigation and adaptation on climate. Now, maybe if we had had this level of conversation 30 or 40 years ago we could have really focused on mitigation, but the truth is that ship has sailed and we're now in a world in which we have to

mitigate by reducing greenhouse gas emissions, but we have no choice but to deal with unavoidable impacts of climate change on our water systems, and many other things as well. So set aside that dichotomy. You may prefer mitigation. You may prefer adaptation. But we have to do both.

The fourth, and the panelists will come back to this, is what do we do about it on the technology side? On the economic side? On the policy side? On the communication side? All of this is wrapped up. On the impacts of climate change on water, this is a big topic because water is connected to everything we care about. It's connected to energy and human health and ecosystems and our economy and food and agriculture. And as the climate changes, it's going to affect all of the pieces of that. Temperatures are going up. It's not only the driest year on record, 2013. In fact, the last 36 months, from October 1 going back 36 months in California, have been the 36 driest months on record in California, and the 36 hottest months in California's 120 years of recorded

instrumental record. It's not only been dry; it's been hot. And that's part of the debate here. As temperature goes up, the demand for water goes up. It takes more water to do the things that we want. If you want to grow a green lawn -- maybe we'll comment on that later -- it's going to take more water under a hotter climate. So temperature alone is important.

Precipitation is going to change. And precipitation is a little tougher. The models are a little bit ambiguous about California because we're in a geographically kind of a strange place. Our water comes in big events off the Pacific. We have to understand storm patterns and so on. Noah is going to talk about the work that he's been doing linking precipitation patterns in California and drought. It's complicated. But we do know that the science suggests we're going to get more extreme events on both ends of the tail of the spectrum, wet and dry. We do know with much less uncertainty about precipitation. Uncertainty to a scientist means there's a range of outcomes. Uncertainty to the

public means you guys don't know what you're talking about.

(Laughter)

MR. GLEICK: So when I say uncertainty, there's a range of outcomes.

We do know with very little uncertainty that we're going to lose snow pack in California, and frankly, this was my dissertation 30 years ago. It gets hotter. The snowline moves up. We're going to lose snow pack. It may rain the same amount. It may precipitate the same amount, but we're going to get more rain, less snow. What falls as snow is going to melt faster and runoff earlier, and we already see changes in the timing of runoff in California.

Extreme events we'll talk about more.

Sea level rise. The governor mentioned sea level rise. Sea level rise -- here's an impact probably most of you haven't thought about. There are 22 wastewater treatment plants in the Bay Area alone at risk of a one-meter sea level rise, which is well within what we expect over the coming decades. They

discharge wastewater, which maybe we shouldn't do as Orange County has shown us, and we can come back and talk about that. But sea level rise is going to affect all sorts of things that we don't typically think about. Coastal aquifers will be affected by sea level rise. Ecosystems. Systems operations. How we choose to operate the dams and reservoirs that we've built will be affected by climate change, by sea level rise, by changes in the timing of runoff. So it's not just the hydrology; it's the systems as well.

And the final point I want to make is that despite the fact that we've been talking about this stuff for a long time, and I participated in 1991 in a conversation among climate scientists and water managers in California in Sacramento. Our water managers are still not sure what to do about this. They're not sure how to integrate the coming changes that we now are pretty confident about into management. And in the broader discussion about all of the difficult things that we talk about -- water rights, water laws, institutions, the pricing -- we

now have this additional complication that the climate is no longer static. And we'll come back to that.

So I'll stop there.

MR. STEYER: Okay. Since you introduced it, Noah, why don't you talk a little bit about how you see the connection? I know there's been some controversy about whether this drought is directly related to climate change, and I know that Stanford has done a bunch of work on it. But I'm not sure that some of the people here aren't as familiar as you are with that work that you've been doing. So why don't you explain a little bit about how the current drought is affected by climate change and what we can expect going forward in terms of as the climate changes, what is that going to mean for us in terms of water?

MR. DIFFENBAUGH: Absolutely. Yes, I think this is really a question about risk, and Chris Field is co-chair of working group 2 of the IPCC, and this is one of the big messages coming out of the IPCC reports that have been released over the last year is that it's really about the risk. The probability of a

physical hazard, like a heatwave or a drought or a severe storm and how that interactions with ecosystems, how it interacts with people, the exposure and vulnerability of different systems. And I think the current drought in California is a great example of climate risk. We know that it's a rare event. We heard that. We know it's rare in terms of how extremely low the precipitation has been. We know that the -- we understand really well the atmospheric causes, why it hasn't been raining. This ridiculously resilient ridge, my grad student Daniel Swain has coined this atmospheric feature over the Pacific. And you can think about it as it's a ridge of high pressure. It's basically a boulder that's been plopped into a stream and the storms that normally would come to California have been diverted pole ward, towards Canada and Alaska. And it's just sort of been parked there for a long time.

So we know it's a rare event. Both the causes are rare. How extremely dry it's been is rare. And really, the question is about risk. And part of

the question is how rare are these atmospheric conditions and our recent paper, we've concluded that the global warming has very likely increased the probability of those atmospheric conditions by about a factor of three. So it's still rare, but from the perspective of risk, if we say we've having the most severe drought in terms of low precipitation and in terms of impact and it's three times more likely because of global warming, that's not saying that the CO2 that came out of my minivan caused the drought, but it is saying that we're experiencing increased risk of this kind of event.

The second thing we've been working on, which hasn't been published yet but that we're writing up now relates to what Peter was talking about, about temperature. And we know that when it's warm, snow melts earlier, more precipitation comes as rain rather than snow. We know that soils dry out faster when it's hotter. And what we've been doing over the last several months in my lab is we've been looking back at new data that have been released by the National

Climate Data Center, and we now have access to observations going back 120 years of temperature and precipitation and drought.

And so we've been looking back at the frequency of low precipitation in California, the frequency of warm temperatures, and I've actually been quite surprised to find that back earlier in the record, in the early 20th century, the mid-20th century, temperature and precipitation were pretty uncoupled as we say scientifically. So it really was like flipping two coins separately. And we had about 50 percent chance of getting a warm year, and 50 percent chance of getting a cool year. We had about 50 percent chance of getting a wet year, and 50 percent chance of getting a dry year. And they were pretty independent. We flipped the two coins together. About a quarter of them turned out to be warm and dry; about a quarter of them turned out to be cool and dry.

And what's happened is that because of global warning, which we know with high confidence, the temperatures in California have been increasing.

California has been getting warmer. And this has really changed the probability of the state being warm or even hot when we have the bad luck of it being dry. And we know that looking back at these long records that are warm and drier, it's much more likely to produce a severe drought. In fact, it's about twice as likely when we look back at the whole 120 year record.

So what's happened is, even though precipitation is noisy, even though climate models have some uncertainty about precipitation, we know with very high confidence that when we get low precipitation in California, we're about twice as likely to have a severe drought if it's also warm when the precipitation is low. And we know that over the last 20 years that global warming has substantially increased the probability of years being warm, and now we're at the point where we essentially have 100 percent chance of having a warm or even hot year in California. And so we're approaching -- it's going to sound hyperbolic, but we're essentially approaching

100 percent risk of kind of drought-inducing conditions because of this increase in temperature.

Tom mentioned there's been debate in the media about the connection between climate change and drought in California. I think a lot of this is kind of spurious debate about precipitation, and really we have such high confidence in the effect of global warming on temperature in California that we really do have high confidence just because of that temperature effect, that we're substantially increasing the risk of severe drought just because of the odds of having high temperatures, wind precipitation is low.

MR. STEYER: So you've been talking about risk and the risk of outcomes, and I want to ask Sol a question about what it is we have at risk in terms of the economy. So when we think about undergoing this severe drought, what are the things we're trying to protect? I mean, we obviously have fires. Obviously, people mentioned the ski industry. The agriculture is 80 percent of our water use. When you think about the risks to the economy, the risks to the people of

California, how do you categorize what we should be worried about?

MR. HSIANG: That's an excellent question.

The way to think about the economic risk of climate change and the drought is to think about how it projects onto the economy. And the economy is made out of a bunch of building blocks -- people, crops, buildings and infrastructure -- and we see the drought and climate change affects the productivity of those individual building blocks. And when you turn the lever on the productivity of every little person working or every field in the economy, it aggregates up to have really large economic effects nationally. And so in some very new work that we're just completing, we're actually seeing, for example, that on very hot days, counties lose basically $20 per person. So a day above 86 degrees Fahrenheit costs each county a $20 bill per person. And now, if you add that up over 300 million Americans across, like many, many days in a year, and in the Risky Business report that we did together, we saw that in the

future, the number of these extreme events is going to go up dramatically to be 20, 30, 50 of these a year in some locations. These aggregate up to be very large economics costs, and it's entering through sort of its individual effects on people, but predominantly on agriculture. So agriculture is one of the most vulnerable sectors.

This ends up manifesting in the price of land in the economy. So if land is expected to be very productive for agriculture, it's going to cost a lot in the marketplace. And as people see the productivity of that land decline because it's expected to experience more hot days. It's going to have weaker rights to water perhaps or it's going to have less rainfall, people are going to be willing to pay less for that land. And so the people who own that land are the real losers. They're the ones who are losing a valuable asset in real time as the climate deteriorates.

And so one way we've dealt with that in the past is to build a lot of infrastructure that helps

supplement and smooth out these types of fluctuations. These are all the things we've been talking about -- the massive water infrastructure projects over the last century. Now, those are all distributed across the state and across the country in such a way so that the water that falls in places far away from the consumer, it can be transported to the consumer in an efficient manner. But as these climate patterns change, the quality of that infrastructure in terms of being an efficient transportation network is going to change because the precipitation is no longer going to fall where it used to fall, and the demand is going to be growing simultaneously like we were talking about before. And so you have these simultaneous problems of infrastructure that's now not allocated in the optimum way. At the same time that the climate is also reducing the productivity of individual locations, and that's causing the value of land to depreciate even faster. And so these are some of the biggest risks to the economy directly.

Now, what we should do is we should think

about how do we plan going forward, but the problem is climate change also makes the future more uncertain. So coming up with long-term plans is going to become increasingly difficult because as the climate changes, we are forced to rely more and more on models, projections of the future, less and less on historical data because that historical data is no longer valid. But because of that we are now not sure what the right course of action is. And so that uncertainty also creates an additional economic burden on planners and on government in terms of thinking about sort of what should we do moving forward?

So these are the different angles in which the economy is extremely vulnerable and sort of the challenges that I pose to policymakers trying to make new investments, new long-term investments in this highly uncertain environment.

MR. STEYER: So fortunately we have the government sitting directly to your right.

Wade, let me ask you two questions. One -- and they're connected -- one is can you just tell us

the impacts that you're seeing in California, that people are coming to you and saying help, in effect? And secondly, I'm sure that especially the out-of-state people are intimately familiar with prop one, but in any case, just to refresh their memory of some of the details, maybe you'd explain a little bit what the current proposition to ameliorate some of the long-term problems that we're looking at.

MR. CROWFOOT: Sure. So it's been a sobering summer in the work that I do. If any of you got in your car after this conference and drove three hours east of here and went to Madera County or Tulare County, Kings County, you would encounter thousands of people that live in homes that don't have any water. They turn on the tap and they don't have water for drinking. They don't have water for washing themselves, much less washing their dishes or their clothes.

A few weeks ago, a letter came across my desk from a woman named Jean Wilson in Madera County. And you can't obviously respond to all of the sort of

requests from constituents, but this one caught my attention, and I actually spent an hour on the phone with this woman, Mrs. Wilson, and she lives in Madera County. And she literally has elderly neighbors of hers coming up to her doorstep with jugs of water who don't look like they've taken a shower in days, asking where they can find water. This is California in 2014, and you're seeing this level of desperation.

It should be noted that beginning this spring, our emergency drinking water program at the state started hearing from communities, some very small -- some communities you've heard of or visited, like Willets or Healdsburg or Cloverdale -- that basically indicated they were in danger of running out of water in 90 to 120 days. These are groundwater tables, and these are places that don't experience frequent cyclical water shortages. In the case of Tulare County, many of the folks that don't have water have been in these homes for 50 years and never thought they would encounter this problem.

So drinking water is probably the most

severe and sort of alarming impact of climate-driven drought that we're seeing. Agriculture is perhaps more well-known. We, and the state, contracted with the UC Davis Watershed Science Center to do a model of what are the economic impacts to agriculture from the drought. And their model, which has actually borne out to be very accurate, suggested California agriculture will be short about 6.7 million acre feet of water this year. It will make up for that shortage with about 5 million acre feet of groundwater pumping. So over two-thirds gets made up -- about two-thirds gets made up by groundwater pumping. The resulting shortage of 1.7 million acre feet has an economic impact of about $1.5 billion. A billion in reduced crop yield and about 500 million in increased groundwater pumping costs. That translates to about 20,000 lost jobs, which, of course, has economic impacts, particularly severe in poor farming communities in the central valley where we're literally shipping hundreds of thousands of boxes of emergency food to people that are without food and

facing hunger.

An area of impact that is certainly drought-related has to do with wildfires, of course, and our state wildfire fighting agency called Cal Fire has reported that fires are burning faster and further than they ever have before. There was a fire a few weeks ago that many of you read about east of Sacramento called the King Fire. Cal Fire experienced that fire moving 15 miles in one day, something that really went far beyond their modeling. In fact, the rate of speed of growth was so alarming that firefighters had to use emergency shelters and shelter in place and let the fire pass over them. That combustibility this summer has had a human impact on communities like Weed in Siskiyou County, one of our furthest north communities, where almost 200 homes were burned to the ground. It looked like an explosion hit Weed. Again, alarming because the combustible nature of vegetation made that fire act like it never had before.

Those are just probably what I consider to

be the most alarming and impactful impacts of the drought this summer. And if you accept what Noah and Peter explained to us, that essentially, climate change is loading the dice on this extreme weather, and these are climate-driven events, one could argue that these are really victims of climate change in our state. We so often have heard about victims of climate change in the lowlands of Bangladesh or northern Africa with the droughts. This is impact in our state right now. And so to me, working on climate change and emergency management, this has connected the dots like never before.

MR. STEYER: So, Peter, I was going to ask you a question, but do you want to make a comment before I do?

MR. GLEICK: Yeah. There are a couple more impacts I think we ought to at least raise. One is on fisheries. You know, we see the fallowed ag land. We see the fires. We don't see very well impacts on fisheries, and fisheries are already under stress because of our water conflicts and the allocation of

water. In the last drought, which wasn't that long ago, some of the worst impacts were on some of the local fisheries and local fishing communities. So that's one thing that I think we need to add.

Another more obvious one is hydropower. And this connects to the climate issue. So in a normal year now we get about 15 percent of our electricity from hydropower -- not that we get a normal year anymore. This year, it will be closer to 6 or 7 percent. The numbers aren't in yet. The Pacific Institute is just about to release an analysis of this, and our estimate is that probably over the last three years of drought, ratepayers have had to pay an additional $2 billion or so for additional natural gas primarily to replace lost hydropower. And obviously, there's a climate connection there because it's increased our greenhouse gas emissions. It's increased other air quality challenges. So that's another consequence. And I think all of these things together have to be evaluated.

MR. STEYER: Now, I know we're going to

spend, in terms of the public policy part, most of the time talking about adaptation just as Peter said because in terms of mitigation versus adaptation, we're at the point where we're going to have to be doing serious adaptation. But before we get there, I wanted to ask Noah where we're going on this path? You were talking about the fact that in effect we've gone from a time when it was 50 percent it was going to be dry and 50 percent it was going to be hot, to it's going to be hot and we're going to have a lot of years that are hot and dry. On the path we're on, how is that actually going to change the actual circumstances of Californians? It's going to be hotter, but what is that really going to mean for us over the next 25 years?

MR. DIFFENBAUGH: Well, I think there's, I guess, a couple ways to think about that question. One is what do we know about projections of the next 25 years? And certainly with temperature increasing in western North America we have a good understanding of what that means for snow water. We know sort of

the melting point of water quite well. If it's colder, it's solid; if it's warmer, it's liquid. And so we know that in much of western North America we're already seeing trends towards more liquid water earlier in the year. This actually was one of the first impacts of climate change that was very conclusively attributed to human emissions of greenhouse gases. There was a paper in 2008 that was one of the first impact attribution papers. So this is something that the scientific community has had high confidence in, and so we're already seeing that and we're likely to see more of it with snow melting earlier and earlier in the year, more of the water that's falling out of the sky coming as rain rather than snow, which has implications for our water infrastructure and management.

So I think certainly over the next three-decade timescale that you're talking about, scientifically we're seeing a likelihood of an imminent shift towards this more liquid-dominated water delivery from the atmosphere in the western

United States.

I think the other way to think about your question, where are we headed over the next 30 years, is to think about this current event and think about the vulnerabilities and impacts that we've been hearing about in this current event and how often would these conditions occur in terms of the climate? And so that's what we've been doing in our research, is asking when we look at climate models after we've sort of done the screening for how good are they -- and I'm happy to answer any questions about that. Once we identify what we have confidence in and the climate model is asking how often do those climate models give a result that looks like this year. And getting back to this co-occurrence of dry years and hot years, that is something we're seeing that probably over the next two to three decades where there will be enough warming to pretty much guarantee that when one of these really low precipitation years happens, that it happens in the context of a record high temperature. Over the next three decades we're

pretty likely in the western United States to move outside of the historical envelope of temperature where we're really seeing pretty much every year being the warmest on record.

MR. STEYER: So, Peter, that brings us to the framework in terms of thinking about adapting. And I have a two-part question. The first one is someone said earlier today there's plenty of water available in the system, which implies it's just a question of allocation. That's the first part of the question.

And the second part of the question is this. Water isn't just a resource the way other resources are resources. At some level, water is a public resource. So when you think about water as a public resource and then you put it in the context of markets and you put it in the context of innovation, should we be thinking -- how should we think about allocating water given that the current system is basically a legal system giving rights to people and protecting the status quo going back as far as 1850?

Simple questions, right?

MR. GLEICK: Wasn't it Taman who said that was a simple question?

So first of all, plenty of water. In some ways, California has plenty of water. It's sort of ironic. I've done some work in the Middle East. I have friends who have come from the Middle East to California. They don't understand why we have a water problem. They have a water problem.

So plenty of water in a sense, but not enough water to do everything that everybody wants. And I would modify that to say not enough water to do everything that everybody wants as inefficiently as we're doing it today.

So we have to make some decisions. We're at what we call "peak water." You might want more water out of the Colorado River, but you can't have any more because we take it all already. You might want more water out of the Sacramento San Joaquin Basin, but the truth is we're taking more water out than we ought to be from -- if we care about some of these public

benefits, the ecosystems which we know now in the 21st century that we ought to be protecting.

So part of the question is how do we allocate the water that we already have? And I wish I could say there was an easy answer to that. And if we were redesigning the system today from scratch, it would look a lot different, but we're not. And this gets back to some of the earlier conversations about water markets and water rights. Academically, I sort of like the idea of water markets, but I also understand that we have a water rights structure that has a serious dispute right now about who really has rights to do what? Are they property rights versus use rights? Can you really sell a water right when it's a public good? How do ecosystems participate in that?

So I'm not sure I can answer the question except to say that water is a public good, and yet there are economic benefits and private benefits as well that we want to support, and we have to do a better job of balancing them than we've done.

I'll leave it at that.

MR. STEYER: Okay. Well, then let me ask Sol the follow-up question, which is this. When we look around the world, when we look at -- we, obviously, are not starting at square one, but people have come at this from a variety -- we heard about Australia earlier -- if you were going to point to a water system that seemed to bring out the best benefits broadly in society, what one or ones would you point to? And which of those would be adaptive to the western United States?

MR. HSIANG: So I don't know everyone's water systems, but I'll point out a few interesting points.

So the issue that happened in Australia is actually a terrific example because -- well, a few things happened. I actually visited Australia around 2008, just in the middle of the drought when all this was happening, and Australia has a tremendous amount of highly productive agriculture in the southeastern portion of the country for a river basin that crosses

three or four states -- equivalent to their states. And so they had had all sorts of different allocated rights issues and different states had given permission to different people to withdraw water. And then there was a drought and everyone was pulling out all the water. And basically, the government created a new organization to oversee the entire watershed that crossed and superseded state legitimacy.

They said, the way we've been managing this didn't recognize sort of the natural features of the environment. There's a normal pattern for how the water flows from one state to the next, but it's being managed, and the guy upstream doesn't care what happens to the guy downstream. And we should think about this holistically. And so they've created -- they basically have started from scratch. They totally reengineered the whole system, created water markets, and now they have something that people point to as a highly effective trading regime. So I think that's a great example.

When I visited, no one thought that that was

going to happen. So people said that's impossible. But people found a way to make it happen, and initially, some states were more reticent than others, but they were eventually convinced and brought onboard. And once people saw how it functioned, and it could actually function in their favor, people were more willing to buy into it.

In another case -- so that's on the market end. Actually, I also recently visited Israel, and they actually conduct agriculture in a fantastically dry environment. And so the technology that they use in terms of getting more crop for drop is really remarkable. They have irrigation systems where they are -- instead of -- in contrast to floor irrigation where you basically just douse a field, they have little tubes that carry water right to the base of the plant and deliver water directly to the roots of each individual drop. So tremendous water efficiency. A huge amount of value delivered per drop. And so thinking about sort of what types of technology they employ and what can we transplant to this context, I

think could be extremely profitable.

MR. STEYER: So we've talked a lot about the policy. I'd like to ask Wade about the politics, because obviously, you can't really design a policy in a vacuum, and there are interested parties who have current rights and have current interests and would like to see those protected and enhanced. So when you think about California water policy or western water policy in the context of water rights, who are the biggest players? Who are the people who are pushing the hardest? And how is that reflected in the way that you have to deal in the real world?

MR. CROWFOOT: Another easy question.

You know, I think the conventional wisdom, or the sound byte that would describe the historical understanding of water in California is this model or paradigm of farms versus fish; cities versus agriculture. This zero sum game where powerful interests are banging up each other and what results is not a lot of systemic improvement to increasing reliability, resilience, ecological sustainability;

right? So that's the script. And probably everybody in the room knows that that script exists.

I think we're in a very interesting time now because the crisis of the drought has brought opportunity. And as the governor mentioned, you know, many folks would argue, and I would say correctly, that we might not have gotten groundwater reform legislation over the finish line if there had not been a drought. Public opinion polls of the water bond prior to this winter suggested it wasn't largely supported. This water action plan that we put together again, you know, got everyone's attention because I think all of these interests understand we have to do something differently.

So I don't want to be Pollyanna, but I think the stars have sort of aligned for -- yeah, knock on wood -- for a new approach, and I'm not presupposing proposition one passes, but the stars have aligned for this new approach, and I think when the governor's water action plan was released, it had over 100 groups, the same groups that I mentioned, you know,

commenting on it. The end result was actually largely embraced by groups because it didn't take sides. It didn't suggest there was a silver bullet. It really took this portfolio approach, which is an overused term but it is true. The water action plan says, yes, we need more storage, but it needs to be smart storage. Underground storage with some surface storage and conjunctive use. Yes, we need robust habitat restoration, but we also need to be much more efficient in the water that we use. We need to maximize water recycling, stormwater runoff, et cetera. And so the water bond, to answer part of your previous question, is really a down payment on that portfolio approach. If it passes, it actually invests in the infrastructure, because some of this is about policy and innovation. Some of this is about getting infrastructure to enable that policy innovation.

So I actually think while there are strong political forces with strong opinions around what we should do, we've got an opportunity over the next four years to actually make changes that both provide

reliability for water users but also help restore the ecological habitat and prepare us for climate change. So I'm actually, despite my fairly depressing answer to the impacts of climate change, I'm fairly optimistic about what we can do politically.

MR. STEYER: So I want you guys to think of questions to ask. I'll ask one more question so you get a chance to really think about it. But Peter, let me ask you, take you back to an earlier answer you gave, which had to do about the dichotomy between adaptation and mitigation.

In California, we have very progressive energy laws designed to deal within the confines of California with mitigation, and we're also dealing, I mean, the water bond is a perfect example of us also trying to deal with adaptation. As you look around, can you see -- when you think about society trying to deal with both of those things simultaneously, do you see the pressure on adaptation that everybody obviously feels is a local human pressure pretty much regardless of where you are? Can you conceive of

society being able to deal with both at the same time? I mean, the energy laws are from 2006 to some extent and before, and in a lot of places they're dealing with specific problems the way we are, on an adaptation basis that are expensive, real, and immediate. Does that make mitigation go to the backburner?

MR. GLEICK: Yeah, so I think the good news here is that we're already doing some remarkable things. I think we're making a lot of progress. Agriculture is making the kinds of changes that Solomon talked about. We have drip irrigation, although we could have a lot more. All of our sectors could be more efficient. The kinds of wastewater treatment and reuse that was described earlier is an adaptation to a climate where there's not enough water to go around. Stormwater capture is an adaptation. The groundwater work that we're talking about. I think those are the right things that we want to do in the context of climate change, with or without climate change. In a normal year in California, there's not

enough water to go around. This isn't just a drought climate change issue.

But the other connection is that there's a very strong link between our energy use and our water use. There's been a lot of discussion about the water requirements for our energy systems. Power plants take a lot of water. That's true. But the flipside of that is it takes a tremendous amount of energy to run our water systems. The biggest single consumer power in the state of California is the pumps that lift water over the Tehachapi Mountains in the Los Angeles Basin, which is part of the reason why the earliest question about why aren't we pumping water from Canada or the Mississippi River isn't going to happen. It's hugely energy intensive. Saving a gallon in the Los Angeles Basin is a smarter idea than saving the same gallon of water in San Francisco, not that that's a bad idea either, because it takes more energy to get it there and more greenhouse gases.

So if we think about energy and water together, there are all sorts of opportunities to

improve the efficiency of our system, meet our water needs, cut our energy use, reduce our greenhouse gas emissions. That's the mitigation adaptation link. That's why we have a tremendous opportunity to do both at a time when we had no choice but to do both.

MR. STEYER: Okay. I have a question right there.

MR. MASHI: John Mashi, Tech Riser.

So I have a question actually for all five of you -- you get one, too. And this is about the effect on handling of climate change from the fairly well-organized political machinery that would rather not have any mitigation and obscure the cost of adaptation. In particular, seems to want to keep science out of public policy. And I know Tom has done some wonderful stuff in funding action in the political area, and I know Peter has jousted with some of the same think tanks I chase -- we know them well -- that try to help this.

So the question for you is to what extent do you see this both in California and nationally, since

that matters? And what can the rest of us do to make sure that science informs public policy?

MR. HSIANG: Well, I think what we're doing right now, today, is a great example of that communication here in the room and on the World Wide Web broadcast and all that. So I think this kind of forum is really critical.

I also think that, to get back to what Peter was saying about what some people all win-wins. There's a lot that we can do to improve our resilience to extreme events, for example, in the current climate, and that's going to -- those are actions that we can take that are going to also improve our resilience to climate change. So I think anything that we can do that's going to be a good idea now -- in the U.S. over the last decade, we've had something on the order of 70 individual extreme weather and climate disasters that have each had at least a billion dollars in losses, and a number of them much more than one billion. So that's an indication that we're not adapted to the climate that we have right

now, and so we can improve without -- hopefully without there being a lot of debate about whether mitigation versus adaptation. If it's a good idea now and it's going to give us increasing resilience in the future, then it seems like a relatively clear path forward.

MR. CROWFOOT: I think part of the answer lies in continuing to build the model of what we've been able to build in California. We have the eighth largest economy in the world. Our economic recovery has outpaced the rest of the country while we've reduced emissions, and we're going to meet our AB32 goal and then with the governor's leadership, go beyond that while we're bringing on a third of our energy system will be renewable, while we're plugging in 100,000 cars (electric vehicles), while our energy footprint is half of the rest of the country. So part of it is this is not a boutique economy. This is a large, robust economy that's showing we can actually grow and reduce climate emissions or carbon emissions.

The second piece is what the governor is

doing in terms of spreading this message. The governor and our administration are deeply involved with China, India, Mexico. The governor spoke at the United Nations last month. He may be in Lima for the next conference of parties, and then in Parish in 2015. He's talked about that publicly. So a part of it, from our standpoint, is showing we can continue to reduce emissions in California while growing our economy, and then part of that is sharing that with the rest of the world and finding those other exemplary climate leaders to help move our nation states towards international agreement on climate.

MR. STEYER: But obviously, we're not talking about -- you're not talking about deep blue states like California; you're talking about states where the politicians who understand that there are human immediate needs and problems that they'd like taken care of. They'd like billions of dollars of federal aid, but they really don't want to spend any time or conversation on mitigation because they really aren't sure if climate change is happening, and

they're not scientists, and that's above their pay grade.

MR. HSIANG: Scientists that are above their pay grade?

(Laughter)

MR. STEYER: Let me say, it's a confused statement at the best of times.

And so the question is how is that line of argument, which isn't much of a line of argument, going to be countered so that they eventually have to come in and deal with the realities and the scientific research? And, you know, that's an ongoing process of trying to counter those statements and do exactly what Peter is talking about, which is to combine the two. We know we have to deal with adaptation, but we also have to deal with mitigation, because if you really listen to what Noah is saying, if we continue on this path, our current adaptation plans become mute. And so the question is what do you say to someone who says I am not a scientist? Well, they're also not a doctor or an architect. So there are a number of other

policy issues where they don't have a Ph.D., and by that line of argument shouldn't have anything to say either.

So I think over time this is going to be kind of a question of do Americans see through that? And do they see it not so much in terms of the scientific argument but do they see that as an unacceptable answer for someone holding a really high office of trust and making decisions on their behalf on the most essential questions? That's really going to be the question.

Yes, ma'am?

MS. LEKEL: I know we mentioned population is a tough --

MR. STEYER: Hang on one second.

MS. LEKEL: I know talking about population -- hi, I'm Joanne Lekel and I call myself the "business surgeon," helping companies improve their processes and systems. I'm here because I want to get involved in this industry. And we're talking about population changes, one of the variables we can't talk

about. If we look at history, some of our strength came to urbanization. What about -- and Peter, you mentioned that we can't just look at one variable here, we have to look at energy and water. There's a capacity to some cities. I know we heard it might not be an issue, but do we need to rethink about how we're going to live in the future, where we're going to live? Is there a way that we can move businesses around so that there's -- I mean, if they dry up, we're going to have to look at migration patterns and new ways of living. So how do we factor that into this whole equation that we know is very difficult to talk about?

MR. STEYER: Peter, do you want to take a shot?

MR. GLEICK: Yeah. So I talk about population all the time. I don't think it's off the table. It certainly shouldn't be. I agree with that. But really, part of that is we obviously have to meet the water needs and the resource needs of the populations we have, which we're not doing a great job

of, again, even in a wet year some of these disadvantaged communities don't have safe drinking water, and that's just ridiculous in a state like California.

But it raises the question about land use planning and urban planning and the design of our cities. And there was some conversation in the earlier panels about rethinking our wastewater or infrastructure and moving away from the centralized approaches we've used. And whether we want lawns. You know, there's a whole series of questions that come up embedded in your question about the design of the way we live. And I think part of the answer is going to be over time we're changing those things; we will inevitably change those things.

I would like to think that in 50 years people are going to look back and think green lawns, what were we thinking? Flushing toilets with potable drinking water? What were we thinking? And of course, what we were thinking was water was unlimited and we could do anything we wanted. But that's

changing. And I think part of the question you're asking is a fundamental change in the way we think about the way we live.

MR. DIFFENBAUGH: So a couple of things. One is that my 13-year-old daughter just two weeks ago asked me, why are we flushing our toilet with potable drinking water? So people are already, at least in my house, asking.

But more seriously, I think it's important that we look outside of California at the global scale because really -- and again, this is something that came out in the latest IPCC report, that the difference between the two degree world that the United Nations has identified as a target and the four degree world that is really the business is usual that the world is on, it's really the difference between the whole global population more or less progressing towards looking like I do in terms of my energy consumption and my carbon-based lifestyle times billions of people, or this two degree world that the U.N. has identified is really a world where carbon

emissions go to zero and then eventually negative. I mean, it's a carbon-free global economy. That's what's required to get to that two degree world. And this is really -- to me this makes it very obvious that it's not a mitigation or an adaptation question. The two degree world requires a lot of mitigation and it's a world in which we still need adaptation.

MR. STEYER: Absolutely.

MR. GLEICK: You know, in a four degree world, we're going to see people moving out of the southwest back to the cooler climates. We're going to see population migration in the U.S. in reverse of what we've seen in the past century. We're going to have conversations in a four degree world that we're not having today about crop type in California and about how much land really ought to be under irrigation, which we don't want to talk about now because the political questions are much more difficult than just improving efficiency or wastewater reuse or building new storage. So climate change could -- will change the nature of the conversation as

well.

MR. STEYER: Go ahead.

MR. HAYES: Quick question. I'm David Hayes, a former fed, now refugee here, visiting professor at the law school.

Quick question, specific question on adaptation. You guys made a very strong case about the loss of snow pack. One of the immediate reactions is more storage. Storage is part of the bond. I notice that Lake Meade and Lake Powell are not filling up. What's the situation now in terms of a large off stream reservoir potentially in California and whether that makes sense given the difference in hydraulic cycles? Will we be able to essentially replicate the Sierra snowpack with conventional storage or not? Is there a relationship here between the climate science and the cost effectiveness of the traditional reservoir answer, or are we going to look for more modern storage answers than the traditional one?

MR. GLEICK: If I could tackle that one, at least to start. The easy response to the "we're

losing snow pack storage" is build more storage. But we don't live in that world anymore. I'm sorry, but we can never replace the loss of snow pack storage with new storage in California, because we built on all the good dam sites, and some not so good dam sites. We might build a couple more reservoirs. There might be one off stream storage site reservoir. That's not going to solve our problem. There is enormous potential for groundwater storage, and I think rethinking what we mean by storage is the answer. It's not to say yes storage, no storage; it's what kind of storage? We over pump groundwater even in a good year, and as Wade noted, enormously in a bad year. But if we can recharge groundwater really effectively, at the same time as we're restoring ecosystems because we're spread water more, we're restoring wetlands that permit recharge, that storage could really be the climate -- could help with the climate management problem. But even that may not be enough. We may have to change the way we think about seasonal management overall.

MR. STEYER: So you guys, I got about one minute ago, I got the high sign that there was one minute to go.

So I want to say thank you very much to these four panelists.

(Applause)

MR. STEYER: I think they were even better than they were advertised.

(Recess)

MR. DENNING: It was a great example of what Stanford is all about, and that is really in interdisciplinary collaborative culture represented by The Woods Institute, as indicative of what goes on across all seven schools at the university. But I think it was also one where the forum was very much one that was in the mission statement from the Hamilton Project, which is really encouraging and promoting a public discourse on an issue that is so critical to all of us. And I think we all realize we're in a very major transition point from where water was something that was readily available and

less concerning to what, as Buzz said, could be the critical resource issue of the 21st century.

And when you think about it, it's one that not only as many people said here today was a critical input into our economy, but it's also essential in terms of our ecosystem, our environment, and in life that water is such an essential element of life in and of itself.

Let me just say a couple thank yous, first to Governor Brown, not only for his thoughtful and insightful remarks and to his exemplary leadership in addressing water as an issue in California's drought, but as was mentioned earlier, participating throughout the forum. So thank you very much.

(Applause)

MR. DENNING: To Sheryl Sandburg for her encouraging and optimistic remarks, which as we were talking about last night, is something that when you go back and forth between the two coasts, you realize there is a lot more of that out here than there is back there. But it was also, I think, quite

interesting to hear her very warm and personal remarks to having a mentor such as Bob Rubin, so you've done a great job, Bob.

But I'd like to also thank Bob Rubin and Roger Altman for their leadership in the Hamilton Project and to what they've done at Brookings to get this underway, because I think this second collaborative forum with Stanford is something that is very much what we all need. We need great public discourse and debate and discussion on topics that are so critical to us. Our mutual expectation is that we can continue to build this symbiotic relationship between Stanford and Brookings and the Hamilton Project and continue to develop and enhance the cross country collaboration between these two institutions that are so important to our shared dialogue on issues of national importance.

Thanks to Buzz Thompson and Karen Anderson for their leadership at Woods and Hamilton for organizing this water forum, but I also want to thank the Hamilton Project because it was then that actually

catalyzed this forum and were very instrumental in us having the very forum that we're having today.

I would like to especially express our sincere appreciation to all the panelists and the two prior panelists for their expertise, their insights, and the time they shared with us today. We were very privileged to hear from them.

Thank you, too, for all of you, for participating and recognizing the importance of water issues in the west and for recognizing how important the efficient allocation of our water resources are to our overall economic growth.

We heard a lot today, big ideas, facts, insights in innovation, so I will briefly just recap a few. Our focus today has been on directions for U.S. water policy, as water in the west reaches a very critical point. We heard that many of our current water challenges could be addressed through doable solutions, such as better management of our highly fragmented water system and innovative market-based pricing and regulatory reform.

We covered three main topics in the panel. Let me first talk about the first panel. It discussed how market mechanism can be used to build resilience in our country's water management system. In particular, use market tools to reallocate water to meet the demands of the changing economies of water. And despite the fact that we had some comment about getting government out of the way, I think there was a general consensus that we need to examine how to better share responsibility among federal, state, and local agencies. And lastly, to develop further managing and regulating ground water as has been done here in California.

The second panel discussed the need to promote and incentivize innovation to the water sector and the need to increase investment materially, as has been done and as was noted in clean energy. With a focus on solution, they talked about policy responses to overcome the current obstacles to innovation, including the discussion of new frontier technology. Both panels emphasized that viable markets and

efficient pricing are perquisites to achieving real conservation, significant innovation, and material new investment.

The final panel put the water crisis in the context of the pattern we were seeing in climate change, and as a result, the challenges water resource managers and all of us will face in the future. They focused on how to mitigate the effects of climate change with an emphasis on effective policy avenues. The bottom-line is that with an increasing population that was referred to many times today, and with increasing needs for water, for food, for energy, and for our city, and with increasing impacts of climate change, the challenges are significant and require new thinking, new technologies, new market mechanisms, new managerial approaches, and new governmental framework. Today's forum has outlined a range of innovative options and opportunities as we explored new direction in U.S. water policy, and we need to continue the dialogue going forward.

But before we leave the topic of water and

its importance here in the United States, I would like to make a few comments about the global scope of this problem. The water crisis as we all know is global in scope and in scale. In fact, the American West could be characterized as a canary in the coal mine for the challenges global society faces as water resources become more severely constrained around the world. Water impacts are now appearing in more than one-third of the planet's watershed, prompting the World Economic Forum to list water supply crises among its three critical risks to global prosperity. Nearly one-fifth -- yes, one-fifth of the world's population live in areas of physical scarcity, and one-quarter live in areas where the infrastructure is inadequate to take water from rivers and aquifers.

Meanwhile, water use globally has been growing at more than twice the rate of population increase in the last century. Without action, global water demand could outstrip supply by an estimated 40 percent by the year 2030, and we sometimes think 2030 is a long ways off, but when you think about it, it's

only around 15 years.

The term that is frequently used to sum it up is the water energy food nexus. We heard about the water energy nexus today but you've got to add in that third element. This is an issue that defines our time with broad implications for basic human health environmental sustainability and the underlying fabric of our global economy and our societal future.

However, just as we have heard about California, the American West and U.S. water policy, there are many things that we discussed today that can be applied globally to address the increasing challenges of water scarcity and water security. We, here in the U.S., not only have an opportunity to solve our water issues, but we have both the responsibility and an enormous opportunity to apply our technologies, our expertise, our intellectual property globally so as to have an even greater collective input.

So in closing, let me thank all of you for your participation today, with special thanks to the

panel, the Brookings Institution, Hamilton Project, the Stanford Woods Institute for the Environment, and in particular, Roger Altman, Bob Rubin, Karen Anderson, Barbara Katz, Buzz Thompson, for their leadership and hard work in bringing us all together.

Thank you.

(Applause)

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CERTIFICATE OF NOTARY PUBLIC

I, Carleton J. Anderson, III do hereby certify that the forgoing electronic file when originally transmitted was reduced to text at my direction; that said transcript is a true record of the proceedings therein referenced; that I am neither counsel for, related to, nor employed by any of the parties to the action in which these proceedings were taken; and, furthermore, that I am neither a relative or employee of any attorney or counsel employed by the parties hereto, nor financially or otherwise interested in the outcome of this action.

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