Climate Change and Infrastructure Press Briefing

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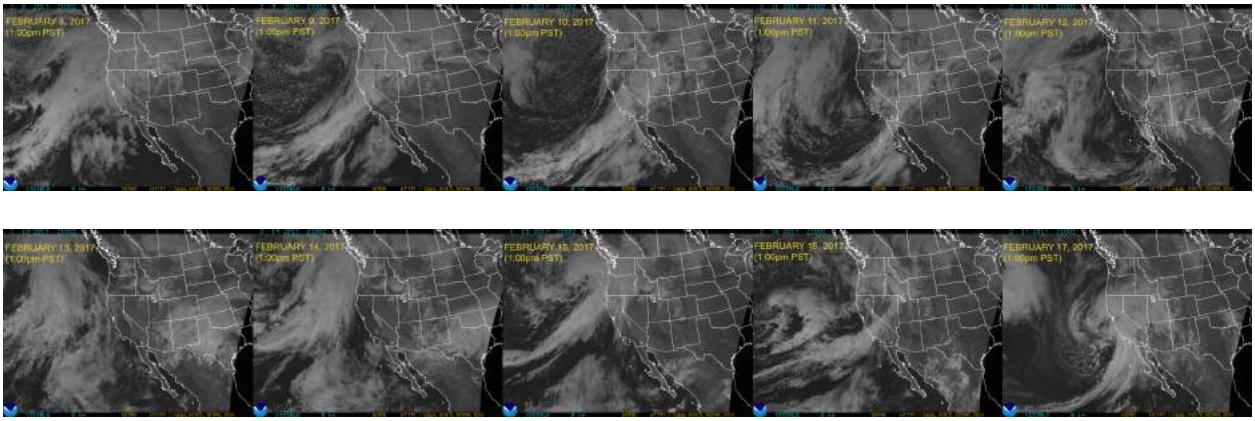
February 24, 2017

Following the Oroville Dam spillway failure in February 2017, Climate Signals hosted a national media briefing to discuss how climate change to date has elevated the risks for aging infrastructure in the United States.

In the discussion below, experts shed light on specific dangers facing state and national infrastructure and measures policymakers can take to prepare for the new weather extremes of the present as well as the coming weather extremes of the future.

Thousands of dams in the US are in need of rehabilitation to meet current design and safety standards. The Association of State Dam Safety Officials listed nearly 2,000 state-regulated dams across the US as “high hazard” in 2015 and estimate it would cost more than $60 billion to repair all potentially hazardous dams. The amplification of extreme weather by climate change has put the country’s infrastructure under additional stress, a trend that is projected to grow in years to come.

In California, climate change has amplified the state's historic drought/flood pattern, pushing conditions past historical norms at both ends of the spectrum as the weather pendulum swings from one extreme to the other in California.



Two rounds of atmospheric river rainstorms hit Northern California from February 8 through 17, as engineers at the Oroville Dam work on overdrive to ensure that the troubled barrier doesn't overflow. Photos: NOAA

Speakers

- **Noah Diffenbaugh**, Senior Fellow at the Stanford Woods Institute for the Environment, expert on climate change and impacts in California

- **Juliet Christian-Smith**, Senior Climate Scientist at the Union of Concerned Scientists, expert on water infrastructure

- **Ethan Elkind**, Director of the Climate Program at the UC-Berkeley Center for Law, Energy and the Environment. Leads the climate change and business research initiative at UC Berkeley and UCLA Schools of Law. Expert on transportation infrastructure.

Moderator

- **Emma Steiglitz,** Co-Director of Communications at Climate Nexus

Briefing

Emma: Okay, good afternoon and good morning to everyone who's joining us from the west coast. This is Emma Stieglitz from Climate Nexus and I want to thank everyone for joining this briefing on climate change and infrastructure. I want to remind everyone that this call is being recorded. An audio file of the call with be available upon request, afterward.

The two spillways of the Oroville Dam during the February 2017 overflow (main at right, auxiliary at left). Photo: DigitalGlobe

So, today we're going to hear from climate change and infrastructure experts from California who can tell us about how climate change has informed the extreme weather they're experiencing and how it's impacted some other states critical infrastructure.

Using recent events in California as an example, they can also speak a bit about aging infrastructure nationally, and how we can build and plan for the future when climate change is making weather patterns unpredictable and extreme. Our panelists are: Noah Diffenbaugh, Senior Fellow at the Stanford Woods Institute for the Environment – he'll be talking about the climate science behind the plains of northern California; Juliet Christian-Smith, Senior Climate Scientist at the Union of Concerned Scientists – she's an expert on water infrastructure; and Ethan Elkind, Director of the Climate Program at the UC Berkeley Center for Law, Energy and the Environment. Ethan will be speaking about transportation infrastructure.

There will be time for Q and A after the speaking portion of the call is over. If you've joined online, you can ask a question by clicking the "Ask a Question" button, which should be at the top of your screen. That will put you in a queue and I can unmute lines one by one so you can ask questions directly. You can also type them in and I can ask them on your behalf.

For those of you who have joined by phone, unfortunately you'll just have to email me your question. I'm Emma Stieglitz, once again. My email address is in the advisory for this briefing and I'll re-prompt your questions toward the end of the speaking order.

Let's jump right in and let's hear from our panel of experts. So we'll start with Noah Diffenbaugh.

Noah: Hi, this is Noah Diffenbaugh at Stanford University. Can everybody hear me okay?

Emma: Loud and clear!

Noah: All right, I think we're certainly in the midst of an extreme event. Both the drought we've been experiencing in California over the last five years, which we know is unprecedented in the historical record, by many measures, and also, the extreme precipitation and runoff flooding that we've been experiencing during this winter season.

I think there are a couple of points of relevance when thinking about this event. The first is that these are the kinds of conditions that climate scientists have predicted for decades for California. They are the conditions we've been seeing emerging in the historical climate record of California and they are the kinds of conditions that are projected to intensify as global warming continues in the future.

So, some of the details of that: one is that we know that the temperature in California has been warming in the long-term mean, pretty similar warming as the global warming, and we know from looking at the historical record of climate in California that when low precipitation coincides with high temperature, it's much more likely to produce drought. So, a low precipitation year that is also warm is about twice as likely to result in drought conditions as a low precipitation year that coincides with cool temperatures. And what's happened as a result of long-term warming in California is when we get low precipitation, we're now about twice as likely to have that co-occur with warm temperature, that low precipitation is now about twice as likely to produce drought as it used to be earlier in California's record. We're experiencing droughts about twice as often as earlier in California's records.

So, that is very much emerging in the historical record. It’s climate change that we're experiencing here and now. Interestingly, the increase in the frequency of conditions that produce severe drought in California has not come along with a decrease in the conditions that produce wet years. In fact, what we're seeing in the historical record in California is not only an increase in the frequency of conditions that produce warm, dry years, but also an increase in the conditions that produce the wettest years in California's history.

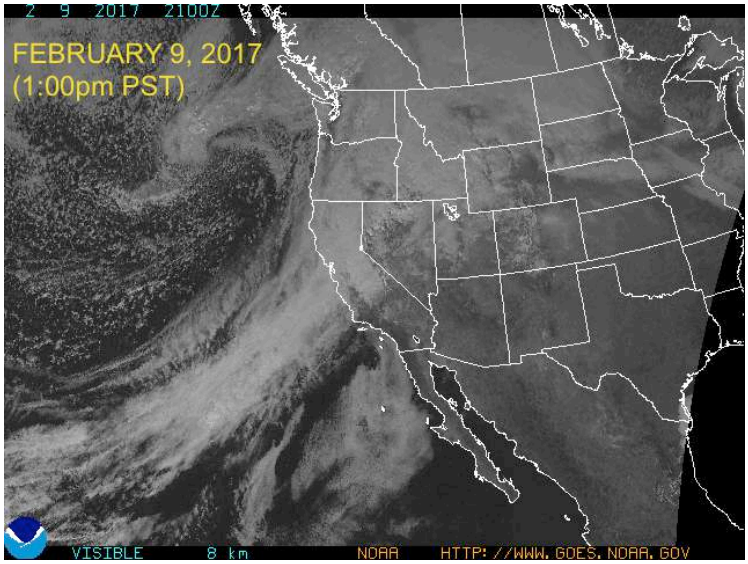
Very much, what we're seeing in historical record is an emergence of a climate characterized by greater frequency of warm, dry conditions punctuated by extremely wet conditions. This has been predicted for decades, it's absolutely being seen in the historical record of California, and it’s clearly projected to intensify should global warming continue in the future.

The other part of the physical climate that we are seeing playing out right now very clearly is the decreasing dependability of our snow pack. In California, and more broadly in the western United States, we rely on snow pack both for water storage and simultaneously for flood control. These are two sides of the same coin, but they're both important. In California, we have a classical Mediterranean climate. We get our precipitation, rainfall, and snowfall during the cool season and we have a very distinct warm, dry summer season where we get very little rainfall throughout the state.

Our water system is built around having snow pack. About 30% of our water supply is dependent on snow pack and what's clearly been happening throughout western North America over the last several decades is that the snow has been melting earlier and earlier in the year. In addition, as the climate warms there's a shift towards more rainfall rather than snow, particularly at lower elevations. And what this means is that not only do we have less reliable water storage from snow pack, but also that we have less reliable flood controls. Because when there's earlier melting of snow, that fills up reservoirs during the rainy season. Likewise, if we have storms that are warmer and deliver relatively more rain than snow, which we've certainly been seeing recently,

that water, rather than being held in the snow pack, runs off and runs into our dams and reservoirs. What this means is that operators, reservoir managers . . . Our whole water system is built around this dual use of dams and reservoirs for both water storage and flood control. With more liquid rather than solid precipitation and earlier melting of the snow that does fall, that puts increased pressure on releasing water out of reservoirs in order to create more room for the next storm.

So even just the role of the changing character of snow pack is a second way in which climate change is putting stress on our water infrastructure, so the last thing I'll say is that what's clear from these climate changes that I've described is that we are now living in a climate that's very different from the climate in which our water system was designed and built. Our water management infrastructure in California is half a century old or older; our rules for managing water within that infrastructure are equally old; and our water rights system, our legal water rights system, goes back even further than that. It goes back more than a century.



An atmospheric river storm brings heavy rainfall to Northern California on Thursday, February 9, 2017. Photo: NOAA

So our water system, the legal rights, the infrastructure, the water management were all designed and built in an old climate. It's clear, from the historical record of climate that we are now in a different climate and it’s one that is characterized by more frequent hot, dry periods punctuated by wet conditions. We are seeing that play out right now and we have a lot of opportunities to catch up with the climate change that's already happened and leap ahead to get ahead of the climate change that we'll face in the future. But being able to do that begins with an acknowledgement that climate has changed and we're now living in a different climate.

Emma: Thank you, Noah. Now, let's hear from Juliet Christian-Smith. Juliet, let me make sure that you are unmuted. Okay, go ahead.

Juliet: Hi, thanks so much. I am going to touch on a couple of similar points as Noah. First, I'm going to discuss briefly how global warming represents a fundamental shift for western modern management. Second, I'm going to talk about how our infrastructure was built for the past. And third, how groundwater can serve to buffer more extreme conditions.

In the first category, a warming world is causing a major shift in California's water supplies, as Noah described. We have to change our approach to water management fundamentally. Adapting to the future of more extreme conditions means we have to rethink how we capture, store, distribute and use our water resources.

As Noah mentioned, for more than a century California and many western states have relied on snow melt to feed our reservoirs. These water supply reservoirs have also served as a flood control system to protect downstream communities. What this really means is that reservoirs can't deliver maximum benefits during drought periods when they are very low, or during rapid onslaughts of water. And that's what we're seeing right now. Rapid onslaughts can occur due to more intense precipitation events; warmer air holds more moisture and it's expected to increase the intensity of the precipitation across the United States and it's been documented in the IPCC Governmental Panel, climate change reports and also the National Climate Assessment.

Rapid onslaughts of water also occur when snow melts earlier and faster. So the abundant amounts of snow that we have now, and that are probably going to be documented in two days, on Wednesday, for the March for Snow Survey - they don't necessarily mean that we'll have plenty of water later this year. Instead of making its way to our faucets, the snow we have now could be washed away into the ocean. Even in heavy snow years like this, even when global warming is really a wild card for our water security.

The second point is infrastructure was built for the past. Nearly two thousand state regulated high-hazard dams have been listed in the United States by the Association of State Dam Safety Officials. By 2020, 70% of our dams will be 50 years old, according to the American Society of Civil Engineers. Not only is our infrastructure old, but it was also constructed and is operated often for past climate conditions. And while we know that the past is no longer a predictor of the future, we continue to plan for the past. It's easier, it seems less expensive, but it has huge-hitting costs. For instance, climate change was ignored during the re-licensing of the Oroville Dam. And we've found that we've focused the vast majority of our effort and funding on surface water systems or above-ground reservoirs, while essentially ignoring the storage available beneath our feet.

That gets to my final point, which is how groundwater can help us buffer more extreme conditions. California is increasingly turning to groundwater to meet its water needs. More than half of our water supply was drawn from groundwater reserves during the

drought. The state's groundwater represents a storage reservoir that's more than three times larger than available surface storage.

Yet at the same time, we have satellite data that shows us that heavy groundwater use has substantially depleted our groundwater savings account, over a hundred million acre-feet cumulative decline in storage, since the 1920s in the Central Valley. Record amounts of rain will not adequately replenish these groundwater supplies. The U.S.G.S. estimates it will take at least 50 years to refill the Central Valley aquifers.

So, it's critical to ensure that effective implementation of the state's new groundwater law takes place. This is called the Sustainable Groundwater Management Act and it requires, for the first time, local groundwater management and has a trigger for the state to step in if locals are not willing or able to comply. Sustainable groundwater management can help protect California from both more severe droughts and more severe floods.

For instance, when it rains, we can slow, sink, and capture runoff in the ground over a much larger area to recharge depleted groundwater aquifers – by redesigning storm water capture and management infrastructure in urban areas, and by developing aquifer recharge systems in rural areas above accessible aquifers. This can help reduce flooding, prepare us for dry periods, and this water can be stored to make up for the loss of snow pack and snow melts in the future.

Finally, just to wrap it up, key takeaways: If you remember anything about what I said, climate change is worsening both droughts and floods; rapid onslaughts of water can't be effectively captured by our existing water systems; our infrastructure is designed and managed for the past. Californians and many others, are shifting to greater exploitation of groundwater. So better groundwater management is key to both more severe droughts and floods.

Emma: Got it. Thank you so much, Juliet. We're going to move on now to Ethan Elkind. Ethan, you should be unmuted. Go ahead.

Ethan: Okay, great. Well thanks so much for having me on. This is Ethan Elkind, I direct the climate program at the Center for Law, Energy, and Environment at UC Berkeley School of Law and I focus on transportation infrastructure in particular. I can touch a bit on water infrastructure, but I think Noah and Juliet have done a great job in summarizing the issues there. I just want to make a few points.

First, I want to describe just the extreme financial need, the number of dollars that are going to need to be applied to bolster and repair our infrastructure, particularly on transportation. I want to talk about the risks in how that money might be spent in ways that might further bad projects over good projects. I just want to conclude with some thoughts about ways we can spend that money more wisely, specifically through performance standards that we place on project spending.

So, first point, in terms of the amount of money needed, just on the transportation side alone, the state of California has estimated that we need $77 billion just to maintain the existing transportation infrastructure here in the state. Nationwide, I've seen estimates as high as $740 billion in terms of backlog of repair needs and again, this is not to build new roads and bridges, this is just to repair what we've already built. We had a big wave of infrastructure investment following World War II and we're really coming to the end of the useful life for a lot of those projects, and we deferred a lot of maintenance. Part of that comes just from the fact that we haven't been able to raise as much public dollars as we need to keep pace with the needs.

For example, the federal gas tax has traditionally supported a lot of our transportation infrastructure but has not been pegged to inflation, so its real purchasing value has decreased over the last twenty, twenty-five years or so. And then you see the same thing happen at the state level. So what's happening is that a lot of local governments are raising sales tax dollars to try to repair bond measures, et cetera, to try to repair the infrastructure, but it’s not keeping pace with backlog. So there's definitely a huge need to have a comprehensive infrastructure spending bill coming out of Congress to deal with the situation.

That's the first point that I want to make, just in terms of the needs, and you know, we're seeing it now with these climate impacts that Noah was describing. You're seeing roads like, in California, Highway 1 now closed because of a bridge that's failed; highway 50 up to the southern part of Lake Tahoe is closed; and we're seeing roads flooded across the state, sinkholes in many communities, mudslides, et cetera. So clearly we're not well positioned to have resilient infrastructure in the face of this new climate era that we're entering in.

The second point I want to make is just that if we do start spending money on projects ,and we're seeing, as I mentioned, local governments trying to take some self-help measures themselves to spend dollars, there's a risk that this money is going to be spent on things that are actually going to exacerbate the problem. An easy example might be spending money to build new highways and induce more traffic, more sprawled development, particularly sprawled development over flood plains that we might need precisely to avoid some of these water impacts.

Flood water crosses over Interstate 5 at Williams, California backing up traffic in both north and southbound lanes for hours. Photo: AP

For example, in California, the success of the Yolo Bypass around Sacramento, which is a giant flood plain. It's really been able to absorb the extra water flow out of the mountains. That's the kind of flood plain that you want to be preserving and you want to make sure that it's not under threat of new sprawled development. But highways out to these areas just encourage development in places that are going to be more sensitive given the environmental impacts. So there is a risk with those bad projects are going to see more dollars. And similarly, more dams. There's been a call with the Oroville Dam Spillway problem to build more dams and in fact, as Juliet has described, there's a lot of other types of infrastructure that we want to prioritize before we start building more surface water storage. So, that's another risk on the water side.

Finally, my last point is that if we want to ensure that these dollars are spent in sensible ways for taxpayers, for the environment, for being resilient in the face of these coming climate impacts and climate impacts that we're dealing with just now, we need some strong performance standards on how the dollars are spent. We don't want these dollars to become, essentially, ways of furthering political goals but not furthering goals related to spending the dollars wisely and sustainably.

I would recommend that we have performance standards related to cost-effectiveness. In terms of transportation infrastructure in particular, how much is that going to cost for the number of people we can move. Looking also at other impacts like greenhouse gas emissions that might be created from, or generated from, these projects.

Looking also again with transportation projects, vehicle miles traveled. How much are these projects going to be encouraging more traffic, more driving miles, rather than building in areas where people already live? Urban areas, where you can focus more on repairing and maintaining existing infrastructure and building new non-automobile type of infrastructure – pedestrian infrastructure, bikeways and transit investments too.

I think we need to have those kinds of metrics to make sure our dollars don't get politicized and spent on things that might satisfy a particular powerful political constituency but aren't in the best interest of taxpayers. But there's no question that as we enter this new climate era that we're in now, we're going into it in a very weakened position because we have this backlog of maintenance already and because we don't have any strong plan to try to repair it and because we've got this moment in time now, where this infrastructure is really at a point where it's starting to break and it's going to cost a lot more money now to try to repair it the longer we wait. It's definitely a critical moment, not just for California, but for the whole country, on a whole host of issues.

The final point I would just like to make is that this is beyond transportation and water; it's also about energy in the state. These water projects also provide a lot of electricity, too. Hydropower in California, depending on available rainfall and water storage, it makes up between six and 12 percent of our entire electricity generation portfolio, so it's a significant energy hit. On top of that, we also have, with sea level rise, a lot of power plants at the coast that are potentially at risk of flooding. I just wanted to make that final point about energy, but when you put it all together, it's definitely a moment where we need to act as a country, because we're facing some critical challenges.

Question & Answer

Emma: Great. Ethan, thank you so much. So, that concludes the panelist portion of the call. Now we're going to move into Q and A. I want to re-prompt our listeners for any questions. Again, to ask a question, just click the "Ask a Question" button on your screen. This is if you've joined online. That will put you into a queue. If you're on the phone, you'll need to email me your question at estieglitz@climatenexus.org.

I'm also going to open up all the panelist lines so that you all can jump in and answer questions freely.

Our first question comes from Matt Kramer, who's a journalist with the Sacramento News and Review. His question is:

What are the biggest flood control issues in the Sacramento region, including the Natomas Basin? What is being done to mitigate these issues?

That wasn't specified for a particular panelist, but Juliet, if you could take a stab at that, or if anyone else wants to jump in that would be great.

Juliet: I'm not that familiar with the Natomas Basin specifically, but I would just take the opportunity to talk about the Sacramento–San Joaquin Bay Delta more generally as being an area that's . . . Historically, it was called an inland sea. It flooded for large parts of the year. Flood controls on fresh water storage, dams were built upstream of that area. Then within the delta, we built a network of levees to protect land that actually has been sinking since then and now much of it is below the elevation of sea level.

We have a situation there where we have had some levee breaks, we've had evacuations, and it’s been listed as one of the more vulnerable areas of the United States having that situation, similar to the areas in New Orleans that were hit by Katrina, where the levees are protecting communities that are below sea level.

We haven't had the infrastructure spending really to do much about it. I think the numbers from the Public Policy Institute in California were around $800 million needed to repair some of these - primarily local - infrastructure systems. That money hasn't made its way to those levees, despite a lot of research to show that they're vulnerable to sea level rise, earthquakes and flooding events.

Emma: Thank you, Juliet. Would anyone else like to speak to that? If not, we can move on to the next question.

Okay, we'll move on. The next question comes from Anthony Cave, who's a reporter with ABC 10 in Sacramento. His question is:

Given the state of infrastructure, is another Oroville type of event possible in the near future?

Noah: This is Noah Diffenbaugh at Stanford. We're certainly seeing the risks playing out in real time. The risk really results from not only the physical conditions like rainfall and snow melt, runoff, but also the intersection of those physical conditions with exposure and vulnerability. I think that Oroville is an illustration of the risks that are increasing as our infrastructure ages and our climate changes.

Certainly, quite a bit of our water infrastructure in the west is old. Maintenance has not been a priority for all of that infrastructure. So, without any climate change at all, the risk of Oroville-type events is increasing as the infrastructure ages and the maintenance gets further and further out of date.

When you add on the changes in climate that are increasing the probability that we encounter a lot of runoff in these episodes of heavy precipitation, those two trends simultaneously . . . the combination of those two increases the risk that we experience the kind of events that we've seen at Oroville and elsewhere in the state during this winter.

Juliet: Can I add to that? Which is just that I think if we don't ask different questions we'll probably get the same results. The questions we've been asking around dam construction and operation have been based on analysis, flood curves from the 1950s and 1960s. We have an opportunity now with a large water bond - it's $2.7 billion to build new water storage infrastructure in this state - to ask different questions about how these system would work under these under more extreme conditions, both droughts and floods.

We've been working closely with the California Water Commission and The Department of Water Resources to try to include not just an analysis of median climate change, or sort of a "middle of the road" scenario, but also a quantitative analysis of extremes. So, when we look at projects and we compare them to each other, that we're making a comparison that includes how these projects will adapt to changing extreme conditions.

The regulations that were passed just this past December by the California Water Commission, actually does not require a quantitative analysis of the extreme scenarios. That's an option for project applicants. So, this is one of the cases where it's really important that we use the right kind of science for the question we're asking.

When we're talking about long-lived infrastructure that's going to cost hundreds of millions if not billions of dollars, we really need to have a higher bar, because we have a lower risk tolerance there when there are human lives at stake and that amount of money being spent.

Ethan: This is Ethan Elkind at Berkeley Law. I just wanted to jump in with another thought. Certainly we've seen some other challenges with dams around the state - Don Pedro comes to mind - but I don't think we should necessarily be alarmists that people need to worry about. Another dam is about to have some major challenges, like the Oroville spillways have had.

I would just point out that this is a kind of a situation where our environmental laws, I think, can be very helpful. We hear a lot of rhetoric out of the Trump Administration that regulations are killing business, driving up costs. But in the case of Oroville in particular, there is a well-publicized case now that, ten years ago, when they were re-licensing the hydropower that comes out of the dam, environmental groups were raising the concerns around not having the auxiliary spillway be paved.

I think it's a great example of where having these environment protections in place provide an opportunity for asking those right type of questions that I think Juliet is referring to. And that we think about safety in a different way and we think about are our public officials really looking at all the potential scenarios that can happen and having the best infrastructure in place.

I think this is the kind of situation where environmental laws can really be helpful. Not just at protecting the environment, but protecting the quality of the infrastructure and the human lives that are potentially at risk.

Emma: Thank you so much. A quick reminder to our panelists just to say your name before you speak so journalists know who to quote if they're pulling quotes from this call.

Our next question comes from Anne Mulkern at E&E. She asks, "Can you talk about any other dams in California beyond Oroville? How at-risk are those reservoirs? Are there any other places in this state, or nationally, that are most at risk from future big storms as the climate changes?"

Juliet: I'll take a first stab at that, but definitely allow others to jump in. The information that I have to rely on primarily comes from California Data Exchange Center. It’s operated by the Department of Water and Resources. The type of data that we're looking at, in terms of reservoir level, shows that we have a number of dams in the state right now that are spilling. So they have reached capacity or they've actually encroached into their conservation space and they're now getting rid of the water to bring down reservoir levels.

This is a point at which there can be problems with spillways and other infrastructure that hasn't been used for many years. Part of this is we went through a very long, severe drought and we haven't . . . I mean the auxiliary spillway was never even used for Oroville until now for over a half century.

So we're testing out infrastructure that's been dormant for many years or not used at all, and the information that's provided publicly is fairly limited. We can only rely on the information that the state reports and, going back to, for instance, Army Corps of Engineers flood curves, to understand how the reservoir might be operated under different conditions.

But day by day, it's really a choice of the reservoir operators and they make their own management decisions about when to spill water, when to maintain water, and how to maintain the systems appropriately. So it can actually be very difficult from the outside

to understand what the risk level is. Clearly, I don't think that anyone was aware of the high risk level associated with the situation at Oroville. The elevation grows so rapidly over just a few days. That was being managed at the local level by the dam manager staff at the time.

The American Society of Civil Engineers does a nationwide review of dam infrastructure and in that review, they've graded many locations as "in need of repair," and The New York Times just released, I think it was last night, a map of all of the dams and their categorization as high-hazard, being particularly risky, or all the way to low-hazard.

Emma: Thank you, Juliet. Does anyone else want to speak to that question?

Okay, we can move onto the next question, which comes from Katy Maher at the Center for Climate and Energy Solutions. She asks, "Are there any good examples of 1) approaches to making infrastructure more resilient, and 2) options for state or local governments in financing resilience improvements?"

Ethan: This is Ethan Elkind at Berkeley Law. I can answer that to some extent. So, examples of resilient type projects . . . Certainly, on the water side, we've heard some examples on the call today: groundwater storage, looking at horizontal levees in coastal areas, wetland areas; also, looking at making sure that we're taking advantage of natural flood plains, so those kinds of infrastructure improvements.

We've seen some of that, certainly here in California, the Bay Area has been interested in wetland protection and building up some of those levees, for examples, horizontal levees, and we have groundwater storage down in Curren County, for example. That's on the water side of things.

Transportation, we've seen some interesting efforts here also in California. The Bay Area just passed a bond measure just to basically upgrade the BART system here. So there's no promise of new extensions that might go out into areas where we don't want to see more development. Instead, it's all about improving and maintaining an existing transit system.

I think focusing on a state of good repair, maintenance of existing infrastructure; those kinds of plans are the most effective. In terms of financing, it has been a challenge. We've seen mostly local governments raising sales taxes to try to pay for some of these improvements and you've seen some bond issues as well.

I think a more promising way to fund some of these, particularly on the transportation side, would be through a mileage fee, instead of paying a gas tax, which is going to be less powerful particularly as cars get more fuel-efficient. And as we switch from petroleum-based fuels to more electric vehicles, we're going to have even more severe challenges trying to fund our transportation infrastructure and keep them in good shape. Oregon and now California have been experimenting with a mileage-based fee to pay for transportation infrastructure and I think we're going to need to see more of that kind of a model because that's based on actual usage rather than just from a gas tax,

which, as I mentioned in the beginning of the call, has been diminishing in terms of purchasing power and likely to become less effective going forward.

Noah: This is Noah Diffenbaugh at Stanford University. In terms of increasing resilience in the context of a changing climate, there are a lot of win-wins. Meaning that there are decisions, investments that can be made to make us more resilient to the climate that we have now. Good choices will improve the safety and security of Americans right now.

That's one half of the win, and then those same decisions and investments will also prepare us for further changes and climate in the future. That's the second half of the win.

In order to create those win-win solutions, those decisions start with an acknowledgement that the climate has changed. If investments are made that assume the old climate – so sort of reinvesting in the assumptions that went into our infrastructure half a century, or in some cases, a century ago – then those investments will not help to build resilience for the climate we have now or for the climate we'll have over the decadal lifetimes of that infrastructure.

In terms of specifics, on the water supply side:

In addition to groundwater recharge, there's also potential for capturing, storing, and cleaning more storm water runoff in urban areas. We also have real opportunities with wastewater recycling, where technology has gotten to the point where not only can clean, safe water be produced from wastewater but the energy intensity has really dropped. There are technologies that actually can produce energy from wastewater by using the organic matter in wastewater as a source of energy.

The last point I would like to make on resilience is that in California, we have a lot of constituencies that demand water. We have a large population, we have a vibrant agriculture sector, we have very diverse and highly valued ecosystems. And even within our human population, we have both urban and rural; we have a tremendous range of wealth and access across the state. To build a truly resilient water system is going to require looking out for and preserving all of these different important sources, important demands on our water. We're going to need to do that with the knowledge that we have a different climate than we used to.

Emma: Thank you. Any last thoughts on that question?

Okay, I will re-prompt once more. There's no active questions in the queue but if anybody has a question and you've joined online, please just submit it through the "Ask a Question" prompt. And then if you're on the phone and you need to ask a question, you can email me. It's estieglitz@climatenexus.org. So I'll give that a few seconds to load and if there's nothing else, then I'll ask for any closing thoughts from the panelists.

We have one more question. Matt Kramer again, from the Sacramento newspaper asks, "How can I get access to the audio recording of this session?"

Thank you, Matt. I will be able to send that out to anyone who asks for it after this call. But folks will have to email me if you want the recording.

All right, I think that closes it out for questions. Do any of the panelists have closing thoughts?

Noah: This is Noah Diffenbaugh at Stanford. I guess the brief closing is that there is a lot of discussion of the potential for infrastructure investment over the next few years here in the United States. In California, we have a lot of opportunities for improving our water system, both the infrastructure and the management. Certainly, an investment in infrastructure in California can help to improve the safety and security of Americans right now and also prepare us for continued climate change that is likely to occur over the next several decades.

Ethan: This is Ethan Elkind at Berkeley Law. I could echo some of those themes. We do have an opportunity now . . . Trump and Hillary Clinton, they both campaigned on an infrastructure build to some extent or infrastructure needs. And obviously, Barack Obama wanted to get an infrastructure bill passed. It was stymied by Congress and I think the politics at the federal level are going to come into play again here. Republicans may be more willing to do some deficit spending to fund infrastructure now that they have a member of their own party in the White House.

I think those politics are really going to affect how we're able to deal with this issue, not just in California, but across the country, so that's something to keep an eye out. But the fact is that we've got really low interest rates now; it's exactly the time where you would want to be borrowing to pay for these needed infrastructure investments.

My hope is just that if an infrastructure bill does come out, that it’s not used to just further spend money on bad projects or come with a lot of strings to weaken environmental protections that might go along with it, as we've seen. As I mentioned, with Oroville Spillway, that these environmental protections are actually ways that can really improve the effectiveness of the infrastructure.

I would hope that any bill that comes out has some strong performance standards and doesn't come with a lot of strings that can ultimately undermine the effectiveness, if those dollars even do come about. Again, that's a big political question so that's kind of where a lot of this is going to end up lying. Or else we'll have to just see more states try to take it upon themselves to fund their needs on their own if they're not going to get help from the federal government.

Emma: Go ahead, Juliet.

Juliet: Just a final thought on the financing piece. This is Juliet Christian-Smith from the Union of Concerned Scientists. I think this importance of performance measures for criteria to help prioritize resilient projects is really key. I also just want to point out that it’s an area of growth. An area where there aren't a lot of sure bets or agreed-upon approaches.

Really thinking through, what does resilience mean on the ground? How do we measure it? What science do we use? . . . is an area that I think we need to work more on and specifically talk to policy-makers that we want more out of our infrastructure than infrastructure that's designed for the past. We want infrastructure that's designed for the future so that it can actually deliver benefits for generations to come.

Emma: Thank you, Juliet. I apologize, we actually did get one more question during the closing thoughts portion. I'd like to ask it quickly and this will be the last question. And it comes again from Anne Mulkern at E&E. She says, "What conflicts or concerns, if any, do you have with a Trump proposal on infrastructure and concerns about climate change that extend beyond freeways?"

Juliet: This is Juliet. I think my response, it kind of was just related to what I was saying. The idea that we have a transparent process to look at a series of criteria that ensures that the benefits that the public pays for actually materialize.

Ethan: This is Ethan Elkind at Berkeley Law. It's highways, new highways that we wouldn't necessarily want to see that undermines our resilience efforts; more dams at the expense of other more cost-effective ways at dealing with our water infrastructure . . . those are definitely types of projects.

If the Trump Administration follows through with its desire to fund infrastructure with tax credits rather than just sort of direct spending . . . that could really skew the types of projects, too. That's going to tend to benefit projects that have their own revenue streams, like toll roads. And they're probably going to be in certain areas of the country that can provide that revenue stream and maybe less in more rural areas that may not have the economic ability to have those types of private investors in those projects but we may need them in those rural areas, when it's things like water infrastructure that can really affect urban areas, too.

My hope is that, in addition to these strong performance standards, this is done in a traditional spending kind of way, rather than a tax credit, privately financed type of way, which is what the Trump Administration has given some indications of.

Noah: This is Noah Diffenbaugh at Stanford. I'll just say, as a general example of ways in which a given investment infrastructure can either help to build resilience in a changing climate or not, the Water in the West Program here at Stanford has looked at the economic cost of increasing water supply through either increasing groundwater recharge or raising dams or desalination. In their analysis the most cost-effective is increasing groundwater recharge.

For a given amount of dollars invested, the most cost-effective investment is for groundwater recharge. From a climate perspective, that has the added benefit of separating water storage and flood control, which we're seeing right now in California. Relying on dams and reservoirs for both of those creates a lot of risk, particularly in the context of a warming climate.

So the added benefit of not only being cost-effective, but also being more appropriate for the climate that we have now, with less reliable snow pack . . . that's an example of where there's a possible decision of how to invest dollars that would increase resilience for the current climate and in the future, rather than assuming the climate of the past.

Emma: All right. Well that concludes the Q and A. I'd like to remind anyone who has joined either on the phone or online that if you do have follow-up questions after the call, you can email them to me. Again, estieglitz@climatenexus.org. I'd be happy to try to get you new information or follow up with you to help with your reporting. If anyone wants a recording of the brief, please email me and I can get you a recording as well.

Huge thanks to our panelists for their time and expertise and thanks so much to the listeners for joining. This concludes the call and I hope everyone has a great weekend.

Noah: Thanks everyone.

Emma: Thanks.

Ethan: Thank you.