

**Honolulu Board of Water Supply
Stakeholder Advisory Group**

Meeting 30 Thursday, April 25, 2019 4:00 – 6:30 pm
Neal S. Blaisdell Center, Hawaii Suites
777 Ward Avenue, Honolulu, Hi.

Meeting Notes

PURPOSE AND ORGANIZATION OF MEETING NOTES

The purpose of these notes is to provide an overview of the Board of Water Supply (BWS) Stakeholder Advisory Group meeting. They are not intended as a transcript or as minutes. Major points of the presentations are summarized herein, primarily for context. Copies of presentation materials were provided to all participants and are available on the BWS website. Participants made many comments and asked many questions during the meeting. These are paraphrased to be more concise.

ATTENDEES

There were 16 stakeholders present, in addition to BWS and CDM Smith staff and members of the public. The stakeholders represent diverse interests and communities island-wide.

The following Stakeholders Advisory Group members attended:

- | | |
|---------------------------|--------------------------------|
| Mark Fox | The Nature Conservancy, Hawaii |
| Will Kane | Mililani Town Association |
| Bob Leinau | Resident of Council District 2 |
| Helen Nakano | Resident of Council District 5 |
| Robbie Nicholas | Resident of Council District 3 |
| Dean Okimoto | Nalo Farms |
| Christine Olah | AARP Hawaii |
| Dick Poirier | Resident of Council District 9 |
| Elizabeth Reilly | Resident of Council District 4 |
| John Reppun | KEY Project |
| Cynthia Rezentes | Resident of Council District 1 |
| Alison (Omura) Richardson | Coca-Cola Bottling Company |
| Chace Shigemasa | Resident of Council District 7 |
| Cruz Vina Jr. | Resident of Council District 8 |
| Guy Yamamoto | YHB Hawaii |
| Suzanne Young | Honolulu Board of Realtors |

WELCOME

Dave Ebersold, meeting facilitator and Vice President of CDM Smith, welcomed the group and outlined the meeting objectives:

- Introduce new stakeholders
- Receive updates regarding the BWS
- Receive informational about Climate Change from the panel

Dave introduced new stakeholder Chace Shigemasa, representative of Council District 7. Dave also acknowledged new stakeholder, Dan Kouchi, who is representing the Chamber of Commerce. Dan could not attend the stakeholder meeting due to his responsibilities at the legislative session. Chace is the current Chair of the Aliamanu-Salt Lake-Foster Village Neighborhood Board Number 18. He told the group that the community he is representing is directly impacted by the Red Hill fuel storage tanks and that he appreciates the opportunity to serve on this stakeholder advisory group, and to provide feedback on behalf of his district.

PUBLIC COMMENTS

None.

BWS UPDATES

Ernie Lau, Manager and Chief Engineer of BWS, welcomed Stakeholder Advisory Group and gave an update about the City Council resolution regarding Red Hill.,

Ernie reviewed a few of the State legislative bills under consideration and/or in progress that involve or affect BWS:

- The House is considering a bill to create a task force to oversee the Red Hill Administrative Order on Consent.
- Two bills under consideration by the Senate would require the State Department of Health to coordinate with water (e.g. Honolulu BWS) and sewage utilities (e.g., Department of Environmental Services / ENV) in its efforts to bring cesspools into compliance.
- Another bill would pursue State funding for drilling an exploratory well in the Kunia area.

Ernest thanked the dedicated the Stakeholder Advisory Group community that has made a difference at the Board of Water Supply. “It's really so important, because water is life, here in our community. And to have folks like this, willing to volunteer their time, for over four years now is something special, so everybody give them a hand, and mahalo and thank you so much.”

BWS CLIMATE CHANGE PANEL DISCUSSION

Dave introduced climate change panelists Dr. Chip Fletcher, Dr. Tom Giambelluca, Josh Stanbro, and Barry Usagawa. Each gave extremely informative and highly detailed presentations on the background of climate change, how climate change affects water in Hawaii, sea level rise, climate change and resiliency planning on Oahu, and BWS research and adaptation planning. The information provided by these panelists has been summarized including critically important details and selected

slides/graphics. Because of their length, summaries of each speaker's presentations are included in an appendix at the end of these notes (see page 9). The presentations were videotaped and have been posted on the BWS website. Links to each of the speakers' presentations are below:

Video Presentation Links (Vimeo)

1. [Presentation by Dr. Charles H. Fletcher, III \(Chip\), UH Manoa, SOEST - Part I](#)
2. [Presentation by Dr. Thomas Giambelluca, UH Manoa, Department of Geography and Environment](#)
3. [Presentation by Dr. Charles H. Fletcher, III \(Chip\), UH Manoa, SOEST - Part II](#)
4. [Presentation by Joshua Stanbro, Honolulu Office of Climate Change, Sustainability and Resiliency](#)
5. [Presentation by Barry Usagawa, Board of Water Supply, Water Resources Division](#)
6. [Climate Change Panel Discussion: Question & Answer](#)

Stakeholders had many questions, which were answered by the presenters. These are below:

QUESTIONS, COMMENTS, AND ANSWERS

Dave invited stakeholders to ask questions panelists about the presentations.

C. Barry talked about preliminary supply adaptation strategies. I'm thinking about how important it is to recharge groundwater and yet we're developing like crazy at higher levels. At one of our meetings we talked about things like reforestation. I think we need to revisit state land use designations and county zonings in a huge way to look at where are the best places to reforest in order to recharge. We just have to be realistic about that.

I look at the Waiahole ditch in a whole different light as a result of these discussions. A tremendous amount of water flows in the Waiahole ditch. We should have a long-range plan for how that water gets deployed. I'm always going to be in favor of stream restoration, but it is important to plan for how that water gets deployed in a time of climate change and extreme weather and disasters. Something like Puerto Rico can happen to us. There's some very high-quality water in that tunnel.

I've been talking to some folks in the State about the tremendous amount of kinetic energy in those ditch systems that needs to be put to use generating electricity.

I want to thank all of you guys for the presentation here. This should be textbook for every man, woman and child growing up in Hawaii here on in. Every school should have some curriculum relating to climate change. We just can't avoid that. It has to be. So anyway, thanks.

Q. It was nice to see that the City Council did a resolution on Red Hill. Is the State also going to do a resolution on Red Hill?

A. Ernie said that the State unanimously passed a similar resolution, very recently. Unfortunately, it didn't make it to a hearing on the House side, but the House did hold an informational briefing.

Q. One of the things discussed was the number of rain gauges being reduced. In terms of metrics, the number of rainfall gauging systems available is important, monitoring streams is important, and so are the monitoring wells. I'm curious who is responsible for monitoring and consolidating the data? If you don't get all three metrics, which one becomes the most significant?

A. Dave said that's a great question. He turned to Tom Giambelluca and mentioned that he heard Tom talk about some mechanisms being brought together to install more rain gauges. He asked Tom to talk about what it is going to take to complete that network.

Tom said that stream gauges have also declined to very, very low numbers. He said he was not as sure about the well monitoring, but that the stakeholder was right that the data has to be integrated. His presentation focused on the rain gauges because that's his expertise and that's where he would like to make a contribution, but it's not the only thing we need to do.

Dave asked Tom what it takes to get that network going. He mentioned that there's some cooperation to try and rebuild it. What else is needed to complete it?

Tom said the first steps are identifying where to use the resources. Resources are used for purchasing and installing equipment, and also for the long term. This includes retrieving the data, screening it, taking care of data quality, analyzing it, archiving it, and making products more useful. To get this started, Tom said they are looking for one person for the field, keeping equipment running, and another person for the data.

Dave asked Tom, in his opinion, is that something that should be a university function, an agency function, a multi-agency function? What does the model for bringing that together look like?

Tom said the university can play a role, but it's something that's going to be multi-agency in the long run. Because there are many stakeholders out there that need this information, and we're trying to develop a hui that can support it. The BWS is stepping up, and we're going try to get started.

Barry added that the BWS also involving our watershed partnerships to install rain gauges up in the mountains because they're up there all the time. It's a matter of funding it, coordinating with the Water Commission, USGS, with NOAA, led by Tom. BWS is helping to implement Tom's idea to get near-real time rainfall data because we need it to know where we're going in terms of water supply.

C. Anybody who has a well on their property has to register it with the State. Agencies involved with wells include the Department of Land and Natural Resources and the Commission on Water Resource Management. Reporting is also required, and there's a big database.

Q. To the panel, thank you very much for a very enlightening presentation. Barry, in East Oahu, there's also a wastewater treatment plant, but it wasn't highlighted in your presentation. Are there any plans to help East Oahu use R1?

A. Barry said the R1 water from that treatment plant is a little too salty. BWS has looked at it for reuse for golf course irrigation. As sea level rises, you're going to have more seawater intrusion into the collection system, and that makes the effluent even saltier. It has to be a low-risk tolerance

facility that has to be able to handle higher levels of sea level rise. Ala Wai and Waianae may also be affected.

Q. What role do you see for State Planning in knitting together all of this? What entity is pulling all of this planning together, looking at land use designations, the application of new planning policy, etc.?

A. Josh said the action right now is at the Climate Change Adaptation and Mitigation Commission. This Commission functions within the DLNR and is focused on climate issues. It's co-chaired by Chair of The Board of Land and Natural Resources and the Director of the Office of Planning. Commission members represent cities and counties, committees of the legislature, and several other key groups on Oahu. He said that's the current thinking on how to respond to this collectively.

Q. So do you not see a role for the State Office of Planning?

A. Tom said that there are about two dozen people serving on the Commission. The Commission formed Permitted Interaction Groups on sea level rise, transportation, social equity, and carbon reduction. Those Permitted Interaction Groups get together every two months and discuss the different planning issues that need to go with their sectors. The State Office of Planning co-chairs this Commission and the Permitted Interaction Groups. They're playing a very important role.

Barry added that he attends the state planning meetings on the Ocean Resources Management Plan, which they're updating. He sees the role of state agencies, like DNLR, the Water Commission, Office of Planning, as providing statewide consistency in planning, so we're all moving in the same direction. But Barry said the process of moving forward together, all in the same direction, could be more difficult for many of the state agencies; collaboration is needed and is something we should work on. Counties are responsible for basic infrastructure planning, water, sewer, drainage and streets. Climate change collaboration among county agencies and with respective State agencies is currently challenging.

Chip said there is a lot of confusion. People don't know what to do. He said that BWS is years ahead of any other agency, federal, state, county. He said that in Barry's presentation, he talked about real concepts that are only a couple steps away from CIP (Capital Improvement Program) decisions.

C. I want to thank you for giving us such updated, complete information that we've heard about, but now you've brought it down to a level that people should be able to understand. In the past month or so, I've talked to a civil engineer, a retired attorney, and a scientist, and the level of their ignorance is really shocking. They don't believe that climate change is happening.

C. Do you remember Dr. Paul Berry, who was a teacher at Punahou? He said to give the children the information to teach the adults, and you will see behavioral change in the parents and grandparents. Barry and I (Helen Nakano) worked on the Kuleana project and used this approach. The best ages are fourth, fifth, and sixth graders because they are still passionate. A third-grade class surveyed their parents and older people in the community, and then explained to them why their answers were wrong. Then the third graders said they would come back again in a month or two, and survey them again. That moved the behavior of their parents and grandparents, based on the fact that their kids were marking their lack of knowledge or knowledge, and their behavior needed to change. One survey question example was: "How many minutes do you shower?" And "how many gallons of

water are you wasting?" Then they said, "We're going to come back to you in a month or two months, and we want to ask you the same questions".

The panelists can provide a survey that will inform as well as promote behavioral change and use the sixth graders or the fifth graders of every public and private school in the island.

The Manoa Kuleana Eco-System Project Community Guidebook can be viewed here:

<https://www.boardofwatersupply.com/bws/media/files/publication-water-warrior-project.pdf>

A. Chip thanked her for her comments. He said he thinks the media has failed us terribly. He said we need Public Service Announcements. PSAs that have changed behaviors taught us not to drink and drive, not to smoke cigarettes, and to wear our seat belt. We need to know about climate change and its local impacts, so PSAs built around climate change will build the information that voter population needs in order to make the correct choices when they go into the voting booth.

Chip added that a Swedish girl named Greta Thunberg has gotten tens of thousands of school kids striking every Friday, refusing to go to school. Their message is: "Why should we go to school when there's no future?" The streets of Europe on Fridays are clogged with protesting children, and it has swept across the world. A month ago, a global strike for climate took place, and it was the first ever global strike for anything. There'll be another one, I think May 2nd, and there's a small group of us who'll gather at the Capitol as part of that strike.

C. That's an indication that people need to know what small changes they need to make in order to affect change. One of the survey questions can be: "How many miles or how much gas do you use every week?"

Q. Speaking about the beaches and allowing them to grow back inland or upland -- I'm wondering if among the agencies, commissions and Permitted Interaction Groups, has there been discussion about more aggressive, "outside of the box" thinking? Think of that North Shore home that's losing its beach. At what point in time do we start looking at legacy land funds or something to take these parcels and allow the beaches to grow back? That action would model what Hilo has done after the tsunami. From a planning standpoint, has the concept of buying land to allow the beach to grow back floated up into the conversation?

A. Chip said yes, and that the Office of Planning published a report about a month ago on strategic retreat. Their initial thinking was that they would come up with some tools and ways to strategically retreat. They found it was a very thorny a problem and that there were no actual tools ready to be implemented, so at this point, the discussion has been more about how difficult strategic retreat is.

Chip said that a group has been discussing possibly identifying which beaches we (Hawaii) really want to keep, and other beaches that maybe we cannot keep. A question they've been considering is: "How do we give an exit strategy to beachfront communities where we really want the beaches to exist in the future?"

C. That's a hot topic, and I think you'll get ground swell support locally if you just start having conversations with people, and then you can bring in other aspects of sea level rise and climate change. I just want to let you know that's a good hook for conversation at a very local level.

A. Josh agreed that strategic retreat is a complex issue. He said there's not enough money "in the kingdom" to buy all the coastal land that's going to be in jeopardy. He said there needs to be a reassessment of risk and where people are choosing to live as risk shifts.

He said we just saw this in action with the volcano on the Big Island. Homes were allowed to be built in an area that, at the time, didn't have the same sort of risk profile that it suddenly had as soon as a rift opened up and those places were inundated with lava. Similar thinking about risk and safety as things change (e.g. sea level rise) is going to slowly transfer to certain coastal areas. Josh said about six months ago, Zillow put out a study that showed that coastal property has stopped increasing in value at the same rate that inland properties have.

C. I've looked at sea level rise. I have two cousins whose homes are right now in the path of erosion at a sea level rise of 3.2 feet. Where I live, I won't be able to get out to the coastal road. We're talking within the family about none of us leaving property to any of our kids, grandkids, nieces, nephews, or anybody else because it doesn't make any sense as legacy for them to pick up those properties.

There are so many people where I live that still haven't gotten the message that sea level rise is coming. They talk about passing property to their kids. I keep thinking: "You're never going to be able to make it to the road again. Or your property is going to be underwater, given the sea level rise viewer predictions."

Are we being too kind to ourselves in not saying: "You're going to be underwater, so think about what you and your family are going to do when that happens"? Why do I want to leave something to my nieces if it's going to be underwater where they can't get to it? Are we not providing the correct picture to people by soft selling it, telling them to look up property on the sea level rise viewer for themselves? Instead, should we be saying: "This is what is happening!"? Are we just not being forthright enough about the seriousness about this situation coming up for the general public because they don't go look at the sea level rise viewer?

A. Chip said he wouldn't make any recommendations about what to do with people's personal assets, but he wanted to make the group aware that people can get a conservation easement and can get money by turning their property over to the public. That property could become a beach park. He said there are financial options to consider, rather than just walk away from your property.

C. The message hasn't gotten to the public that this is beyond serious, especially for those who live on coastlines. I live nine houses in from Farrington Highway, and my house is below sea level. And the only reason I don't have the ocean in my front yard is because Farrington Highway is a raised highway. I don't know if anybody really believes how serious this is except maybe the people on the North Shore who see what's happening to their roadway, which has been happening for the last 50 to 60 years anyway. I'm just not sure the message is getting out and I'm concerned.

A. Josh responded that her concern is absolutely true. However, in Hawaii, we consistently have about 10-12 points higher recognition that "climate change is happening and likely to impact me

personally” than the national average. Although it doesn't feel like it sometimes when you talk to folks, our actual public understanding and acceptance is much higher than in other places. That allows for forums like this to happen, and agencies like the BWS to move forward and help protect us. Josh added that the way that the media has not reported this enough to get the message out there is not by accident. He recommended watching the movie, "Merchants of Doubt." It describes why we have had several decades of inaction. It's not because people don't want to do things. There's been an effort to make sure that there is confusion about this to slow down a response.

He acknowledged that this is really tough stuff. Our brothers and sisters in the South Pacific are now watching, literally, the bones of their ancestors being washed away by the ocean, out of graveyards they dug decades ago and are now being claimed by the sea. There's this sense of loss when you're tied to land the way that folks in Hawaii are tied to land. When you lose that land it's not like losing a piece of dirt or a parcel. You're actually losing your history, culture, and all these other important things. He said that's why we have to grip tight and work twice as hard as anybody else, because the stakes are so high for us. We don't just move to another place or relocate to another state and call it good and move to the mountains. That identity is wrapped up in who we are, and he hopes that motivates us to work twice as hard to protect it.

Chip added that there is a workshop on the first Friday of May on climate change litigation at the capital auditorium.

Dave asked panelists if they had any other final comments.

Barry said he thinks that action is going to come when people have to drive and walk through that floodwater. Right now, this isn't happening enough to bring people to the point of action. With nuisance flooding around mid-century when the roads start getting flooded, people are going to be demanding: "What is government doing about it?" We can't wait until then to start to figure it out. We have a decreasing amount of time, and we need to start now because there's a lot that we can actually do about it. We have to make the hard decisions now, recognizing that even with post-disaster reconstruction, there is an opportunity. We have to be prepared to answer: "Do you let them rebuild, and if they do, then do they build higher?" We have to have those plans in place, because when sea level rise starts to be visible, that's when people are going to be demanding. That's when you can possibly implement additional fees to pay for it, but it's hard to do that now.

Barry said he hopes we can all get together collaboratively and get the plan in place, so we all have a plan of action so when it does come, we know what to do.

Dave thank all of the panelists for an excellent series of presentations and discussions. He thanked stakeholders for their participation, and the folks from the public who came to listen in tonight. He said Stakeholder Advisory Group meetings are always open to the public and always announced on BWS's website. He said the next meeting is at Blaisdell on July 25th from 4:00-6:30. He thanked the group for four fantastic years and for continuing to go forward. Lastly, he thanked the BWS for making all of this possible.

Summaries of Presentations by the Climate Change Panel

Presented at the Board of Water Supply Stakeholder Advisory Group meeting on April 25, 2019 at the Blaisdell Center.

<u>Climate Change Panelists</u>		<u>Page #</u>
Dr. Chip Fletcher	Climate Change 101	Page 10
Dr. Tom Giambelluca	How Climate Change Affects Water in Hawaii	Page 13
Dr. Chip Fletcher	Sea Level Rise	Page 16
Josh Stanbro	Climate Change Adaptation and Resiliency	Page 18
Barry Usagawa	BWS Research and Adaptation Planning	Page 22

CHIP FLETCHER, PhD

Dave introduced the first Climate Change Panel speaker, Dr. Charles (Chip) Fletcher. Chip is the Associate Dean for Academic Affairs and Professor of Earth Sciences at the School of Ocean and Earth Science and Technology at UH Manoa. He serves as the Vice-Chair of the Honolulu Climate Change Commission. His research focuses on understanding reefs, beaches and the impacts of sea level rise on island shorelines. He authored the textbook called *Climate Change: What the Science Tells Us*, which is now in its second edition.

Chip said that the bottom line message of his presentation is that we, as a global community, need to cut our carbon emissions by 50% every decade going forward to the middle of the century, or we will experience 1 ½ degrees C of additional temperature rise to what is natural each decade. There is a strong need to remove carbon dioxide (CO₂) from the atmosphere, but it is still unknown how to scale up such a global engineering system.

There has been a long-term rise in carbon dioxide (CO₂) that has caused a 1.8-degree C rise in temperature over what is normal. CO₂ is a trace gas in the atmosphere and is extremely effective at trapping heat from the earth's surface once warmed by the sun. The warmth created by CO₂ leads to a rise in water vapor and warm air is humid. Water vapor is the most powerful greenhouse gas. With each 1-degree of warming that comes from CO₂, there is an additional degree of warming from water vapor, or humidity in the atmosphere.

Greenhouse gases come from all sectors of our socio-economic activities: Agriculture that involves deforestation, commercial and residential buildings, industrial activities, transportation, and electricity production.

Chip told the group that warming in the Arctic region has occurred twice as fast as the global mean, and that has caused instability of the jet stream. The jet stream is no longer following a straight line around the globe but is meandering. That has pulled down Arctic air creating record-setting cold temperatures. It has also meandered northward, pulling up tropical air, and creating record-setting heatwaves and drought.

Weather disasters have doubled in the last two decades and people all over the world are not prepared for them. Extreme rainfall has increased by 12%. Rain bombs are overwhelming engineered drainage systems. Kauai took the brunt of a rain bomb in April 2018, which yielded a national record of 49.69 inches of rainfall in a 24-hour period. There were 12 landslides; damage was expensive and devastating for homeowners. The Hanalei River overflowed its banks and carved a new channel through the town. On Oahu, channelized streams in Aiea and areas of Eastern South Oahu also jumped their channels and carved through homes and backyards delivering mud and debris.

The Western US fire season is almost a half year longer than it was four decades ago and the number of large fires has tripled. Heatwaves are now the deadliest natural disaster in the US.

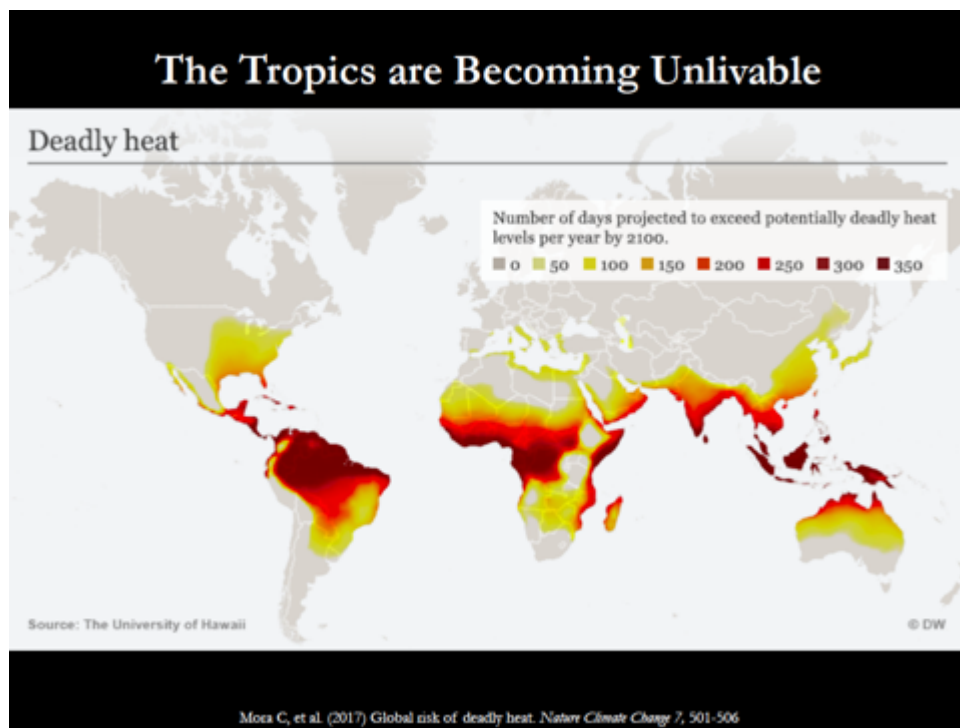
Hurricanes are changing their character: they are larger, wetter, have higher wind speeds, moving slower, and migrating away from the equator towards the poles. When a hurricane or storm is bearing down on Oahu, residents cannot evacuate the island. Chip posed the question: How will we deal with the waste, fresh water needs, human sanitation needs, medical needs, the food, and

shelter for our community? We are ready with emergency responses, but not for long term sustained support for our communities. There are enormous questions as to how we are going to handle this disaster, and then we have a rise of heatwaves around the world, for which we have no preparation whatsoever.

In 10 years, global water requirements will exceed sustainable water supplies around the world by an average of 40%. In the continental US, we pull water out of aquifers 17% greater than nature can replace in a single year. In China, the drawdown is 22%, and in India, it's 52%. The Middle East and North Africa are drawing water from aquifers thousands of percent faster than nature can recharge. This is the very definition of unsustainability.

We are also documenting that food is less nutritious when there is more CO₂ in the atmosphere. Our four primary cereals – soy, maize, wheat and rice – have lower levels of protein, zinc, vitamin B complex and iron. By mid-century, the decline in nutrition could lead to malnutrition for an additional 300 million people and iron deficiency for 1.4 billion women and children. Global wheat currently provides 20% of all human protein. Wheat yield is threatened by drought, flood and the higher CO₂ in the air. By mid-century, demand for wheat is going to increase 60%, but the actual yield will fall by 15%.

The tropics are slowly becoming unlivable; some areas along the equator are projected to have up to 350 days of potentially deadly heat annually by the end of the century (see graphic below). When



regions of the planet become unlivable, people move. Food and water shortages can lead to conflict, and refugees flee conflict. People are driven from their homelands, and currently almost 1% of humanity is seeking asylum and is displaced from their homelands. The refugee and global security crisis is growing.

Chip described the Syria conflict as an example. In the early 2000s, Syria had the worst drought in a thousand years. Farms had widespread crop failure, driving farming families into the urban centers of Aleppo, Damascus, and other inner-city regions. They found a lack of government services, housing, education, medical treatment, food and water, and the young men of these displaced families started a civil war. At the same time, Al Qaeda was pushed out of Iraq and Afghanistan and found safe haven in Syria, where there was already a chaotic mix of rebels and government forces. This led to the rise of ISIS.

Four million people fled from Syria. Smugglers put them in unseaworthy boats. There was enormous human tragedy. Refugees moving into Europe and into England is what led to Brexit. Germany opened its doors to 1.1 million visitors and placed them with a very well-designed government program among communities around the German landscape, but the refugees kept coming, and Germany couldn't support more.

Local neighborhoods resisted the influx of these asylum seekers, and we saw the rise of a new class of politicians who were authoritarian, nationalists, populists, and tribalists. The US military recognizes that there is a global security crisis related to climate change.

Chip said the ocean is hotter, and the PH is lowering as it absorbs carbon dioxide and loses oxygen. There have been four global coral bleaching events since 1998. They are largely associated with a strong Eastern Pacific El Nino. With the discharge of sewage (treated or untreated), there is an invasion of fleshy algae in response to these changed ocean conditions, and it prevents the coral reef from recovering.

Humanity has caused the loss of 83% of all wild mammals and 50% of plants. Today we are deforesting the planet at 30 football fields per minute, largely to grow more food on soil that only lasts for five to eight years. Of all mammals on earth, 96% by biomass are cows and people; 4% of mammals are wild. Of all birds, 70% are chickens. We now have scientific papers with unusual phrases like “sixth mass extinction”, and “biological annihilation”. A paper authored by 15,000 biologists stated that humans have pushed earth's ecosystems to their breaking point and are well on the way to ruining the planet.

After plateauing in 2014, 2015, and 2016, CO₂ emissions rose again in 2017 and 2018. CO₂ emissions rose because climate policy could not overcome economic growth. Developing nations want to enter the middle class just like us, and they demand new energy.

He said that the relationship between world GDP and atmospheric CO₂ has been linear since World War 2. The International Energy Agency says energy demand is set to grow 25% by mid-century, but renewables will make up only two thirds of new capacity. Oil consumption will grow due to rising demand for petrochemicals, trucking, aviation, and energy, and CO₂ emissions continue to increase. To limit global warming to 1.5 degrees C, we need to bend the curve of CO₂ emissions so that, by mid-century, they are reduced to net zero globally, but instead we're proceeding with business-as-usual.

The global carbon law says that **if** each of us cuts our personal carbon footprint by 50% **per decade**, and **if** that scales up to our families, our communities, our businesses, and our countries – we can achieve this. Global warming is accelerating; we're now projected to reach 1 ½ degrees C above the background in 10 years, and 2 degrees C by 2045. This is because of slowing ocean circulation which otherwise would absorb more heat and clean up more emissions. We're currently on a path to reach 4 degrees C by the 2080s.

TOM GIAMBELLUCA, PhD

Dave introduced the next panelist, Dr. Tom Giambelluca. He is a professor in the Department of Geography and Environment at the University of Hawaii, Manoa. His research focuses on land-atmosphere interaction and the changing land cover and global climate. One aspect of his work aims at improving understanding of Hawaii's climate, how it has changed over the past century, how it will likely to change in the future, and how this will affect hydrological processes and terrestrial ecosystems. He also studies the effects of biological invasions in Hawaii, particularly by non-native tree species on water, soils, and carbon storage. And he recently co-authored *Temperature Trends in Hawaii, a Century of Change*.

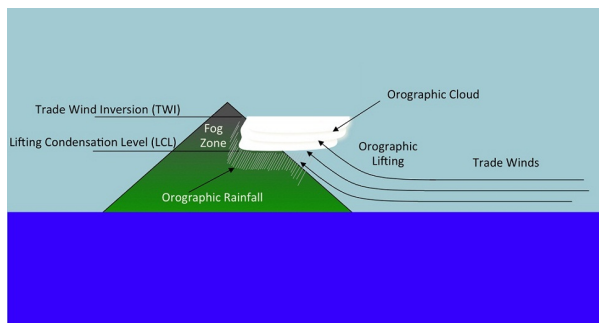
Tom thanked the Board of Water Supply for inviting him to speak and for supporting his research. He said that his presentation focuses on how water is affected in Hawaii. He said that a great deal of his research requires looking back to see how much things have already changed and looking ahead to see how they might change in the future.

Tom mentioned the *Temperature Trends in Hawaii, a Century of Change* handout. It shows the latest analysis of temperatures changes in Hawaii and trends over the last 100 years. Hawaii has gotten warmer by a little less than 1 degree C in the last century, which is about half the global warming rate. Tom said that Hawaii has warmed a bit slower because of the buffering effect of the ocean. In recent decades, Hawaii has been warming at almost the same rate as the rest of the globe, and some parts of the state are warming at an even faster rate. In warmer climates like ours, water evaporates faster, so we simultaneously have less water and also need more water.

Projections show that in the last decades of this century, Hawaii's residential areas will be around 3 degrees C warmer than current if we continue the business-as-usual scenario. This big change in temperature will have harsh effects on human comfort, economic activity, recreation, and water.

For water, change in temperature is important but change in rainfall is even more important. If we look over time, Hawaii was getting wetter to the 1960s, but it has been getting drier since then. Climate has a natural variability. Generally, over the century, our rainfall has followed that natural climate variability, and that makes it more difficult to identify impacts of climate change on rainfall. However, in more recent decades, Hawaii's rainfall has moved away from the trends of natural variability which may indicate that we're seeing the effects of climate change.

The Orographic Cloud



Rain is the main source of water in Hawaii. On Oahu, rainfall is mainly produced by orographic lifting, which occurs when wind encounters a mountain slope. More rain falls on Windward slopes and mountains because of rising air.

This orographic cloud has a definite bottom and top. The bottom of the cloud is called the lifting condensation level (LCL)

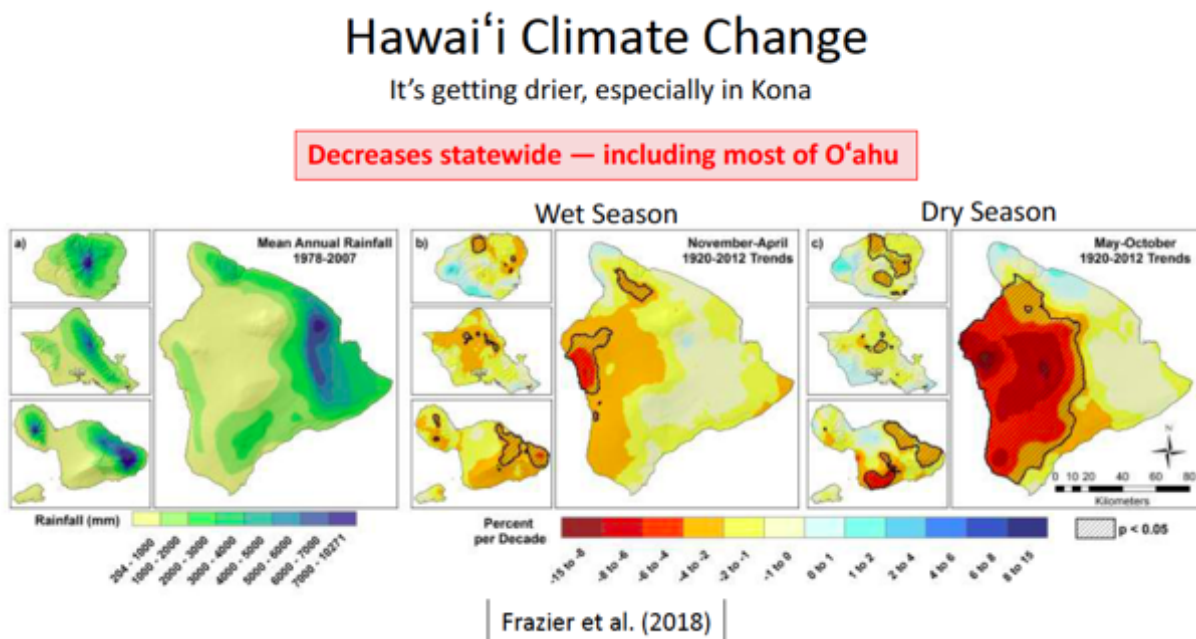
and it's influenced by the humidity of air approaching the islands. The top of the cloud is limited by the trade wind inversion (TWI). This is an important feature of our atmosphere that prevents air from rising higher than 7,000 feet above sea level. The trade wind inversion limits the thickness of clouds and in turn, limits the amount of rainfall produced by the clouds.

Moisture and rising air are the two components that lead to rainfall. Tom said any time air rises it expands because it's moving to areas of lower pressure and that causes the temperature to drop. There are four different ways that air rises naturally in our environment, but the one that is most important to us is orographic lifting.

Tom posed the question: How can climate change affect rainfall here in Hawaii? He explained that researchers are looking at what will make the air more or less moist. They are also looking at what will make it either easier or harder for the air to rise.

Tom said that ocean surface temperature has risen pretty much everywhere on the earth. As the ocean surface temperature rises, the air becomes more humid. We know that the air is getting more moisture in it, and that tends to make things get wetter.

Tom told the group that trade wind inversion used to occur about 70-80% of the year. In the early 1990s, that went up to about 90% of the year. This increase tends to make our climate drier. Recent data make it clear that this pattern has continued. We now have more days of trade wind inversion and we get less rainfall statewide (see Hawaii Climate Change graphic below). He said researchers have also reconstructed rainfall records as far back as 500 years and determined that winter rainfall has been in decline since the mid-1800s. He added that recent decades have been drier than any time in the last 500 years.



Tom said we have seen the effects of this trend on our water system. There are indications of decreases in stream base flow and a decline in groundwater in Hawaii.

What about the future? Tom and his colleagues are working to distill global models of climate change down to figure out what they say about future changes in Hawaii. He emphasized that details of these projections are still highly uncertain, especially when applying them to Hawaii. For this reason, two different groups at the University of Hawaii are doing modeling using different approaches to projecting rainfall in Hawaii. The first group (Tom's) is using statistical downscaling, and the other group is using dynamical downscaling. Both groups are studying how rainfall is going to change in the future. The two different modeling technologies are yielding different results. But there are some similarities – areas that are getting drier tend to predominate in the studies. The dynamic downscaling modeling approach shows a pattern similar to the statistical group, but that everything is wetter. He said that there is more work to be done on the models. Whether the average rainfall increases or decreases, one thing that we do expect to happen is more extreme rainfall.

Tom said we're going to continue to have warming occurring at a faster rate. As a result of that we'll have greater evapotranspiration, loss of water, more heat waves.

Air is becoming more moist which would give us higher rainfall, but lifting is becoming more difficult because we have the trade wind inversion in place more days of the year, which limits rainfall.

Windward areas will either change very little, or perhaps get wetter. Leeward areas where people live and where we have more agriculture are going to get drier and will need more water.

Storms will become less frequent, and more intense, and that has a lot of implications for flooding, but also means that a lower percentage of water that comes in by rainfall will end up in the aquifer. More of it will run off, so we'll get less of the useful water as a percentage of the total.

More droughts, more wildfires, more floods – we're getting more extremes on both sides of our island, and of course with sea level rise, we'll get more coastal flooding which affects water supply.

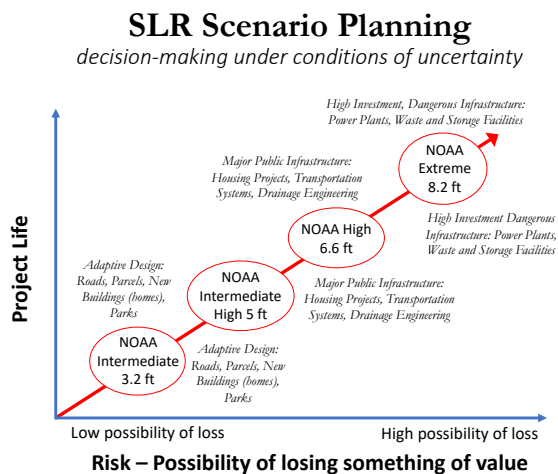
Tom said that Hawaii doesn't have the rainfall monitoring network that is needed. There were almost 1000 rain gauge stations in Hawaii until 1968, mostly at plantations. There are currently 435 stations on Hawaii. Those aren't enough to monitor and track important changes. He said that a new initiative to re-establish those gauges is underway. Tom thanked the Board of Water Supply for being a very big part of this effort. Tom thanked Mark Fox for helping to get the word out and stimulate the conversation to improve the monitoring network.

CHIP FLETCHER, PhD (on Sea Level Rise)

Chip Fletcher returned to the podium and talked to the group about sea level rise. He said the sea level has been rising for over a century. A recent paper concluded that the rate of sea level rise is no longer linear; it's now accelerating, and we global sea level rise will reach a little over 2 feet by the end of the century.

The planet is experiencing 665 billion tons of ice melt each year that flow into the ocean. Antarctica has tripled its rate of melt in the past five years. Western Antarctica has passed the tipping point, and nothing can stop the retreat of ice there. Greenland faces a 66% probability of unstoppable melting once we rise another 0.8 degree C, which is on track before mid-century. Mountain glaciers have contributed 9,625 billion tons of ice melt since 1961 and sea level has risen almost 1 foot as a result. The loss of ice on Antarctica extrapolated to the end of the century, plus the loss of ice on Greenland, plus the loss of the Alpine Glaciers, all add up to 0.8 meter or 80 centimeters. Adding in thermal expansion, we end up with a sea level rise of about one meter by the end of the century.

NOAA has produced sea level rise scenarios for planning purposes. As shown in the graphic below, we will scale our tolerance for risk to the scenario.

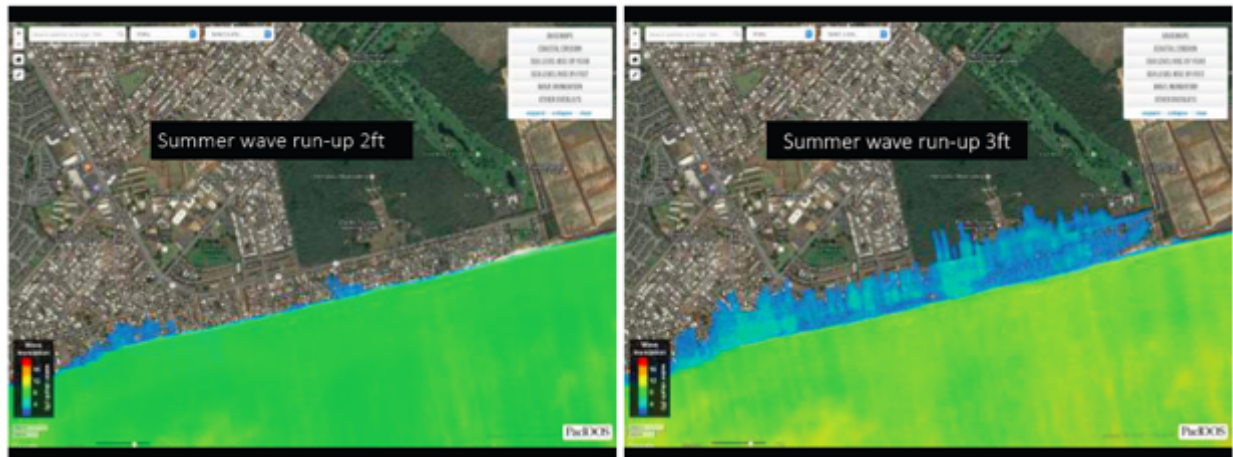


Chip said King tides are extraordinary during certain times of the year, which in Hawaii, tend to be the summer solstice. King tides arrive decades before the permanent inundation. He talked about the water table as being just below the ground surface.

The highest tide in the summertime in Hawaii occurs at about five or six o'clock in the afternoon, which is when we all drive home. With rising sea levels, cars will get stalled on flooded streets. Parents will try to pick up their kids from daycare or school, and teachers can't leave those kids to go to their own families.

Chip then talked about waves and flooding. The elevation of waves on top of the rising sea level will have access to the flat topography of the coastal plain. At two feet of sea level rise (see graphic on the left, below), you can see that several dozen homes will be flooded. At three feet of sea level rise

(see graphic on the right, below), we pass a critical tipping point because the topography of the coastal plain is fixed. At three feet of sea level rise this will happen every summer.



As the ocean rises, our beaches can move landward or die. Instead of allowing them to move landward by getting out of the way, we are armoring the coast with seawalls and revetments and losing miles of beach. Our permitting occurs property by property, and no one is tracking the cumulative impacts which is required by federal law.

Undercutting and erosion are threatening 140 miles of roads and 120 bridges in the state. This is 10-15% of all roads in the state of Hawaii. We have a total of \$15 billion in threatened assets. Communities are tied to these roads. There's a social equity element here – you can't just treat this from a transportation point of view.

Chip said that his team published this data in a journal called *Scientific Reports* that won a prize as one of the top 100 viewed papers in 2018. The data were used in *The Hawaii Sea Level Rise Vulnerability and Adaptation* report by the Hawaii Climate Commission. A major recommendation of that report is that we identify new planning districts. A new planning district would include the storm drain backflow, groundwater inundation, coastal erosion, and wave run up that would occur with 3.2-foot of sea level rise. Every county in Hawaii now uses 3.2-foot sea level rise either for policy guidance or actually mapping where building codes and strategic retreat will be developed.

JOSH STANBRO

Dave introduced Josh Stanbro. Josh is Honolulu's Chief Resilience officer and serves as the Executive Director of the Office of Climate Change, Sustainability and Resiliency. He has a deep background in sustainability and brings a track record of developing cross-sector partnerships in his role in Mayor Caldwell's administration. He served as Director of the Environment and Sustainability program for the Hawaii Community Foundation (HCF) from 2009 to 2017, where he led the Hawaii Freshwater Initiative and the Hawaii Environmental Funders group. Previous to HCF, Josh headed the Trust for Public Lands Hawaii office, where he worked with local communities to permanently protect over 25,000 acres and dedicated over \$200 million in land conservation funds. Josh graduated from Claremont McKenna College and earned a law degree from Berkeley Law. He also visited the William S. Richardson School of Law, University of Hawaii at Manoa, where he earned the Kelly Award in native Hawaiian rights. Josh was an original member of the BWS Stakeholder Advisory Group.

Josh said that businesses thrive on predictability. Climate change is introducing a level of unpredictability and risk that makes it very difficult, not only for our public servants to wrestle with, but also the business community across all sectors. He thanked Ernest Lau for convening this Stakeholder Advisory Group and for doing his job with heart.

Josh said that he was introduced to climate change at an early age. He said the climate change is going to be a challenge but that we will find a way to meet those challenges; we need to do it for the next generation. He said that everyone has to factor in climate change into what they do on a daily basis. This applies whether they're in agriculture and looking at crop yields, or in real estate and looking at vulnerable real estate parcels and flood insurance rates going up. That's the message that Josh said he wants to convey.

Josh focused on bringing the conversation to a local level and on Oahu. He said that the City and County established the Office of Climate Change, Sustainability, and Resiliency in 2016 and we have the voters to thank for that. This is the only office in the entire nation at a municipal level that has the words "climate change" in its name. Climate change is the biggest threat to humanity, but some parts of the country can't even say the word "climate change" because of the politics around it including Florida where sea level rise is already a problem. Josh said that this isn't the case in Hawaii.

As businesses, schools, agencies, and as people, we need to respond to climate change with resilience. He said resilience is the ability to survive, adapt, and thrive no matter what shocks and stresses come our way. Josh explained that "shocks" are temporary yet largely impactful events such as hurricanes, fires. He said that "stressors" happen slowly but can actually sap vitality over time. Examples of stressors are sea level rise, income inequality, and global weather trends.

Josh said that the dynamics around what is happening to our planet and climate change are simple. He gave an example of the temperature inside your car after leaving it in a parking lot with the windows rolled up on a warm day. He said that when people return to their cars an hour later, it is scorching hot inside and people immediately roll down the windows or turn on the air conditioning. This is the dynamic that's happening to us on our planet. Everyone is sitting inside the atmosphere, which is the outside skin of the car. The heat comes in through the transparent atmosphere; light can come in, but heat can't escape. Heat continues to build up slowly and that's exactly what's happening to our globe.

Continuing with the example of the car with rolled up windows, Josh asked if anyone would break the car window if they were walking across the parking lot in Costco and there was a baby in a car? Everyone raised their hands. Josh said we need to look at this example as all of us being in the car, but nobody is breaking any windows and that is a problem. Josh said that we need to change our practices in order to protect ourselves.

He recapped the extreme weather events that are already taking place including the change in trade winds, hurricanes, and rain bombs. Moving forward, it is important to plan ahead to make sure that we bounce back from extreme events in a stronger position rather than weak and unprepared.

Josh talked about a local example, which is Hilo Bay. There are beautiful fields near that water where everyone plays soccer. Hilo got hit by a tsunami in the 1940s and they built it all back. Another tsunami hit in the '60s and instead of building it all back, they decided to plan for the next one by pulling funds together and working together. They collaborated as a community to shift and move to higher ground and turn that whole area into a green space. When Hurricane Lane came and dropped record numbers of a rain four days in a row. The park and gas stations were underwater, but nothing else because they built back in a more resilient way.

Josh said that his presentation focuses on “how to become resilient and breakdown the windows” by changing the status quo and overcoming inertia. It takes time to pivot and shift the direction of a big ship but once momentum builds in one direction, and it's hard to change back.

Josh showed several examples of the early progress that the city is making, including:

- 100% renewable ground transportation goal
- 35% canopy tree commitment
- LED streetlights, bike lanes, Bikis and electric bus trials

Josh said that articles in the newspaper talk about events that are either going to be caused by climate change or are a response to climate change. An example in his newsfeed was "Dramatic weather on the mainland takes five lives." That's climate change. Another article said that Biki has its most successful month ever and is now the eighth largest bike sharing system in the US in its first year. That's a response to climate change. Josh said that if everyone used Bikis, we could drop our carbon footprint by 50% in the next 10 years.

Josh said that, in addition to establishing the Office of Climate Change, Sustainability, and Resiliency, the City Charter also approved the city Climate Change Commission. Chip Fletcher is on that commission. It's been in existence for 13 or 14 months and has already been very productive. In June 2018 they produced *Climate Change brief on Sea Level Rise Guidance* that included recommendations of the Climate Change Commission. On July 16, 2018, the Mayor's Directive on Climate Change was adopted. The directive requires every city department to take the recommendations of the Climate Commission into consideration when preparing budgets.

In response, the Rail Project (HART) has changed the specs on the rail line to build stations higher to meet six feet of sea level rise, the higher standard. Iwilei wants to reconfigure some of the infrastructure for the transit-oriented development to accommodate water in some places and to elevate others. The Sand Island wastewater treatment plant is undergoing a huge reconditioning.

They're trying to get 16 feet of freeboard in that rebuild. These recommendations do make a difference overall and on a fiscal level as well. The Primary Urban Center Development Plan is Hawaii's first development plan to factor in sea level rise and climate change.

Josh emphasized the need for coordination and collaboration across agencies regarding the response to climate change. He said that the federal government and the military are large players but they have a lot of rotation in leadership. That can cause challenges when creating partnerships. Josh is looking for stable points of entry where the state, the city and the federal government can collaborate and share resources to prepare for what's coming.

Josh told stakeholders what they can expect in City investments in climate change response and preparedness: changes to building codes and design guidelines, updated shoreline management, a long-term recovery plan for flood resilience, stormwater solutions, and coastal partnerships.

Josh said that San Francisco is an example of a city who has already adopted new design guidelines based on commission recommendations. The San Francisco Giants followed the guidelines when they brought in fill to elevate the low-lying land where they built their new stadium. This was done to prepare well in advance for rising sea level. Then the neighborhoods around the stadium similarly redeveloped at elevated levels, following the design guidelines and the lead of the SF Giants. That example shows the kind of power of leadership, and what a municipality can do, and that responsible businesses in the community can follow.

Measuring success around climate change and sustainability is important to do over time. It cannot be tackled at one time because climate change is so systemically woven through everything we do as a society. It is important to look at all the different elements.

Josh said the City just released the 2019 Annual Sustainability Report. It includes the data and metrics that can track and measure our progress over time. One of the biggest metrics is the level of air emissions. He said the good news is that carbon pollution emissions have decreased from 2005 to 2016 by 17%, but this is still not enough. We must cut 50% emissions over the next 10 years and that's not the line we're on.

Josh said that the metrics the City is tracking include sustainable city operations, electricity usage, fuel usage, clean and affordable transportation, 100% renewable energy future, water security, green infrastructure, and climate resilience.

Josh said that Oahu is heading in the right direction but must achieve more emissions reduction faster than we ever have in history. When fuel usage is going up, we spend more tax dollars. If we can transition the municipal fleet to run on 100% renewable fuels, under the Mayor's proposal, we will see operating and maintenance expenses actually come down.

How are we doing? Our mantra is, that if we solve climate issues then we can solve equity as well, because when you look at how much people spend on transportation right now, it's 11% of their budget. If we can find alternatives, we can put money in people's pockets.

Josh said more good news is that our renewables are climbing on the grid. Bad news is transportation is lagging. But more good news is that we've got an initiative to plant 100,000 trees across the island by 2025. That is good for carbon sequestration and also good for heat mitigation.

Josh talked about climate change resilience. He said 64% of all single-family homes on Oahu would likely not have remained intact had Hurricane Lane hit. That's two thirds of the homes that we live, breathe, reside in that would have been gone. So where do we go? It's years after Hurricane Maria hit Puerto Rico, and people are still living under blue tarps in many places.

He said we need new codes, but some people don't want to change these things. We know we need to change them for life and safety issues for the public.

His office also tracked how Oahu/Honolulu compares to other communities and cities. There is a lot of amazing innovation happening at the city level in response to the federal government pulling out of the Paris climate accords. Mayors and city councils across the nation are leading many different efforts. We are measuring and comparing the environmental performance of the sustainability performance in climate preparedness of other cities to ours to find out if we're slipping in those categories. This allows us to hold ourselves accountable.

BARRY USAGAWA

Dave introduced the last panelist, Barry Usagawa. He is the Program Administrator for Water Resources Division at the Honolulu Board of Water Supply. He administers water systems planning, water conservation, recycled water, long range planning, hydrology, geology and project review functions of the department. Water Resources conducts long range water resource and capital planning for Oahu to ensure sustainable water resources and dependable water systems for current and future customers. He's worked for over 33 years at Board of Water Supply. He's a licensed professional engineer in Hawaii and has his degree in Civil Engineering from the University of Hawaii at Manoa.

Barry said he appreciated everybody's contributions today. He said he would talk about the mission of the Board of Water Supply, but in terms of climate change.

When we prepared the Water Master Plan, the Long Range Financial Plan, Rate Study, and the 30-year Infrastructure Investment Plan, the Stakeholder Advisory Group drove BWS to expand our water conservation program. Climate change is nested these plans, and especially in the Watershed Management Plans. He said that Josh mentioned that the Primary Urban Area Development Plan has some of the first language on sea level rise. Barry said that the Primary Urban Area Watershed Management Plan will include projects for adaptation against sea level rise and flooding.

He said that the BWS joined the Water Utility Climate Alliance Network. This network is dedicated to provide leadership and collaboration on climate adaptation issues to ensure that water utilities are well positioned to respond to climate change.

In parallel to developing the Water Master Plan, the BWS also partnered with the Water Research Foundation. They're the preeminent research foundation of the nation, and includes wastewater, stormwater, as well as drinking water. BWS co-funded the study of *Impacts of Climate Change on Honolulu Water Supplies and Planning Strategies for Mitigation*. The study is just about ready to be published nationwide.

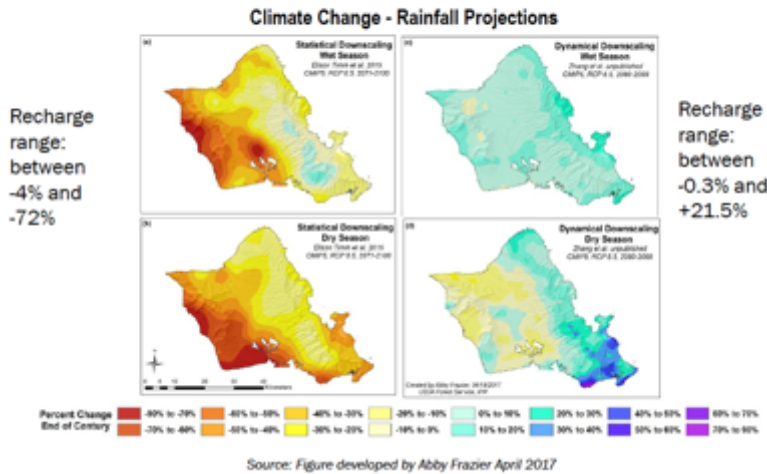
Objectives for this study are to validate climate change impacts on the water system infrastructure as well as the water supply on the island and develop a suite of strategies to address anticipated changes. The study will help provide water utilities with a set of tools to assess their vulnerabilities and develop applicable adaptation strategies.

Adaptive management uses iterative process for flexible decision making in the face of uncertainties. We used the NOAA scenarios described by Chip earlier to consider a range of potential changing conditions to understand where our system and water supplies are vulnerable and how we can adapt. We looked at vulnerability and adaptive management strategies for three timeframes: short (2020 – 2030), mid (2030 – 2050) and long-term (2050 – 2100). Barry said the goal is to develop policies and actions and encourage the “no regret strategy” – be cautious and plan well in advance.

The Vulnerability Assessment Approach took two paths: 1) sea level rise and 2) temperature and rainfall. We evaluated all of our facilities and came up with some options. We incorporated rainfall and temperature forecasts into assessment. If rainfall on Oahu decreases, it will cause decreased

recharge into the aquifers. We looked at what would we do about it if the supply side is dwindling, including the sustainable yield and demands.

Downscaled Climate Models indicate a Range of Rainfall Futures



Rainfall models (see graphic, left) show dry and wet futures. In the dry future scenario, aquifer recharge ranges from -4% to -72%. That's huge. In the wet future scenario, aquifer recharge ranges from -0.3% to +21.5%.

The study used those dry and wet future rainfall forecasts to calculate sustainable yield. A robust analytical model came up with ranges of sustainable yield in the future. The current sustainable yield is 407 million gallons per day (mgd). The model showed a range that drops to

a low of 300 mgd and a high of 443 mgd by the end of the century. Barry said he is not worried about the wet future scenario relative to water supply, although increased flooding could occur from more intense storm events. If we're on that track, we will adjust our planning accordingly.

But if we are on the dry future track:

- In Waianae, the Makaha and Waianae aquifers could drop from three to one mgd.
- In Pearl Harbor, we could see a drop from 165 to 127 mgd.
- In Honolulu, the drop could be from 50 to 43 mgd.

Barry posed the question: “What will we do if the sustainable yield drops from 407 to 300 mgd?” He shared preliminary supply adaptive strategies with the group and provided details about each. (See graphic below.) He said that the easiest to implement are listed first, and most challenging are listed at the bottom.

Preliminary Supply Adaptation Strategies:

Recharge could decrease Oahu sustainable yields by ~27%. Statistical model From 407 mgd to 300 mgd a difference of 107 mgd. Turk, Report #9, B&C.

- Reduce per capita water demand from 155 gpcd to 100 gpcd through aggressive water conservation, like dual plumbing with recycled water
- Storm water capture in Nuuanu and on-site for new development
- Expanded Reuse at Honolulu, Mililani, Wahiawa and Schofield WWTP's
- On-site reuse
- Increase transfers from Wahiawa and Waipahu Wahiawa aquifers to Waianae and Honolulu. Drill more wells in Wahiawa and Waipahu-Waiawa
- Assertion of Public Trust Water Rights for Domestic Use to retain water use permits in a revocation process
- More desalination in Ewa and possibly for Honolulu
- Desalinated reuse in Honolulu, Waianae and Hawaii Kai where wastewater effluent is too salty for irrigation
- Indirect or Direct Potable Reuse with RO desalination and UV/Ozone disinfection

Barry added details for each of these strategies, including:

The first thing is to look at our per capita water demand. This was 155 gallons per capita per day (gpcd) in 2016, and our goal is 145 gpcd by 2045. We would have to decrease water use down to about 100 gpcd. The Watershed Management Plans for the Primary Urban Center, Ewa, Central Oahu, and East Honolulu will include this worst-case scenario to bring the per capita demand down 100 gallons per

capita per day. This is doable. In San Francisco, gcpd is around 85. Australia, New Zealand, and the southwestern United States all have low per capita demand.

We have to get aggressive on water conservation and dual plumbing and recycled water. There's a law that actually all government buildings have to use nonpotable water and use only domestic water only for domestic purposes by 2045. Actions add up, like storm water capture from Nuuanu Reservoirs and onsite capture and reuse for new development.

Another strategy is expanding reuse at Honouliuli, Mililani, Wahiawa, and Schofield. There are currently no plans for Mililani, but it is in an ideal location and maybe one day there will be. The State Agribusiness Development Corp. (ADC) is working with City ENV to provide R-1 recycled water from Wahiawa WWTP to the ADC agricultural lands formerly owned by Galbaith Estate. Schofield is sending their recycled water to the Kunia farms and has plans to irrigate the Army's Leleihua golf course. Honouliuli Water Recycling Facility at 12 mgd, is the largest recycled water system in the state.

For on-site reuse, BWS would have to increase transfers from Wahiawa and Waipahu Wahiawa to Waianae and Honolulu.

A lot of wastewater effluent is too salty to reuse, so in the future, we may have to desalinate the treated effluent for irrigation. On the mainland, cities are implementing indirect potable reuse. R1 water is desalinated, demineralized, disinfected through UV radiation light and then ozone for oxidation, and then put directly into a drinking water reservoir.

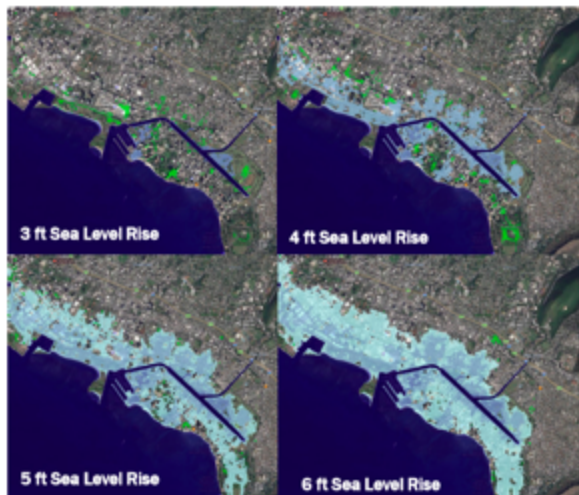
Barry talked about infrastructure impacts from sea level rise. He showed a map of the island with areas that would be impacted by a 3.2-foot rise in sea level, called exposure areas. These include Waialua, Haleiwa, along Kamehameha highway in Hauula and Kaaawa, areas makai of Kalaniana'ole highway in East Oahu, and the hotspots of Honolulu – Waikiki, Iwilei, Kakaako, and Mapunapuna.

Some of BWS's transmission water lines are hung from bridges around Oahu. The study identified 24 vulnerable low-lying bridges where our water pipelines could be at risk because the foundations of the bridges are vulnerable to being undermined by erosion or damage in sea level rise with high storm surge waves. This has already happened in Sunset with the Paumalu stream bridge and our water line had to be temporarily cut while the bridge was repaired.

The study identified about 20 miles of metallic pipelines where corrosion could become a concern from exposure to 3.2-foot sea level rise, through marine water and/or groundwater inundation. This is already happening. BWS has had to repair 5 water main breaks to-date along Ala Aai and Ala Moana boulevards and Nimitz Highway where field crew had to wait until low tide to access the pipeline to make repairs. This has caused repairs to take more than a day, greater traffic impacts and for people to go without water service for longer periods of time. This will only get worse as the sea level rises.

Barry showed a photo of water line repair at Nimitz Highway and Alakawa, where the crew had to deal with free-standing fuel that leaked from old fuel tanks and pipelines into the coastal brackish groundwater. They pumped about 88,000 gallons of groundwater mixed with oil out of the work area and into trucks and disposed of it properly. As sea level rises, the fuel will float higher with the

End-of-Century Sea Level Rise Could be Greater



Source: Habel et al. 2017

also showed a series of maps of how extensively low-lying areas will be impacted by a sea level rise of 3, 4, 5, and 6-foot sea level rise (see graphic, left). These maps were developed by UH under Chip Fletcher's guidance and funded in part by the BWS.

Barry said that the vulnerability study considered the question: "How much do we elevate infrastructure?" He showed a series of photos of dry-day high tide nuisance flooding that is occurring in Miami, similar to what's happening already in Mapunapuna. Miami has elevated public and private infrastructure, made stormwater system retrofits, updated and replaced utilities, and developed green infrastructure.

Barry then talked about what we need to do on Oahu to prepare for sea level rise. He showed stakeholders a table of the Draft Adaptation Framework/Action Plan that was produced as part of the research study. (This table is on page 26 of these notes and was included in stakeholders' handouts.) The adaptation framework plans through the end of the century, but it identifies action steps over a timeline when impacts are expected to occur. UH projects that nuisance flooding 24 times a year will develop by mid-century.

Barry showed stakeholders two areas that were studied for sea level adaptation: West Waikiki and Iwilei in particular which is targeted for major redevelopment tied to transit-oriented development (see graphic below). The study looked at prioritization criteria for where to focus sea level adaptation efforts. Iwilei has the opportunity to incorporate sea level rise adaptation measures the redevelopment proceeds. The City needs to establish policies and regulations for new development in SLR-XA areas. Developers need to know how high to elevate their properties and how to drain their properties. First floors should be built with much higher ceilings in case the floor needs to be elevated further to not impact the building.

water table and contaminate streets and property in the Iwilei area. Similarly, areas like McCully and Makiki have cesspools and are not connected to the sewer system. As the water table reaches ground surface with sea level rise, that will bring micro-biological contaminants to the surface which could be problematic from a public health standpoint.

Barry showed photos of recent King tides, illustrating that sea level rise is already here. He

WRF Study Identified Two Candidate Pilot Areas for Sea Level Rise Adaptation



Possible Selection & Prioritization Criteria:

- Potential severity of social, economic, or environmental impacts
 - Taxable real estate: flood impacts to pedestrians, commercial and recreation activities, tourism, transportation and infrastructure.
- Opportunity to add SLR adaptation measures with proposed improvements
 - Ala Wai Flood Mitigation Project
 - Iwilei Transit Oriented Development Plan

He said we also have to develop stormwater plans. How will we get stormwater off the roadway? Do we lift the system or direct flows to where we may have to build pumps?

There are many things that we need to do now to prepare our infrastructure for mid-century. This includes the different government agencies preparing for how they are going to pay for lifting or relocating their infrastructure because one government agency cannot do it alone.

Draft Adaptation Framework/Action Plan

