SNEP Symposium – Science Bringing Solutions Delivering Environmental Improvement to Southeastern Coastal New England

Room 1, Morning Session 1

May 18, 2022

Zanetta: I think we'll just get started good morning everyone I know some people are still joining but I think we'll just move along good morning my name is Zanetta Purnell I am a community involvement coordinator in EPA Region One and I'll be your facilitator for this session, this session is based this room this in this session one is based on nature-based solutions for climate resilience and resource protection so we're really glad that you guys were all able to be a part of this SNEP symposium this morning and we hope that you enjoy all of the presenters that we have so I will get started with introducing our first presenter. so the presentation title for this one is make research that guides nature-based solutions to nutrient removal and coastal resiliency an urgent SNEP priority our presenter for this session will be Christopher Neal he's with woodwall climate research center I'm just going to go over Chris' bio thank you Chris, Chris are you on?

Chris: Yes, all right.

Zanetta: Awesome, all right so Chris Neil is a senior scientist with expertise in watershed nutrient dynamics and management and restoration of northeastern US coastal grasslands and wetlands so Chris we thank you so much for joining the session on this morning and I guess I will just pass the floor over to you.

Christopher: Alright, I'm gonna share my screen here, can you see that?

Zanetta: Yes, awesome thank you Chris.

Chris: All right well thank you everybody so what I'd like to do today is sort of make two main points. I guess the first one is that investments in nature-based solutions to environmental problems of the kind that SNEP makes a priority; that is nutrient removal, coastal resiliency, and climate change, should be a major investment of society but SNEP has a unique role to play here I think as a catalyst or a multiplier in doing work that actually allows as administrator [cash] said the sums of money that need to flow to these things to go to the right places and I think having a program like SNEP is great and I just sort of want to talk about the way to think about the role of SNEP in promoting these nature-based solutions and solving some of these major problems.

All right so what are nature-based solutions? we hear that a lot we hear about natural climate solutions that kind of think of them as the same thing they are and I like the explanation given in this article that was in the New York Times last year by Paul Greenberg and Carl Safina and the headline of this was "we don't need more life crushing steel and concrete" but the subtitle really was "what nature needs is for us to get out of the way and let its systems function in the manner that billions of years of evolution enabled them to do" that is sort of setting up nature to solve the problems that of nutrient pollution and climate change and habitat loss. And so I think you know in terms of what we need as a society we need to do more of these projects

and I just want to sort of set the stage for the need for nature-based solutions as a whole right so recent analysis done by Bronson Griscom of the nature conservancy and others colleagues who did it for the world and for the united states nature-based solutions that is you know things like regrowing forests, preventing deforestation, improving agricultural soils, restoring wetlands, saving wetlands, have the potential to offset 20 to 22 percent of fossil emissions now we're not going to get to solving climate change with nature-based solutions alone but there is no pathway to any climate solution that doesn't

involve large amounts of these nature-based solutions. any pathway requires that so these require large societal investments.

And they have extra benefits right. i think nature-based solutions come with these enormous co-benefits so as opposed to even great things like switching to wind or switching to land-based solar for our energy supply, those come with enormous trade-offs right. you're going to use up land you're going to cut down forests you're going to have environmental impacts of wind farms we're going to accept those trade-offs. but the nice thing about these nature-based solutions they come with these co-benefits right and I think the co-benefits are right in SNEP's wheelhouse; water quality protection biodiversity and habitat protection and climate resilience. and the things that rise to the top in terms of the top priorities the things that have the most climate benefits and the greatest co-benefits that is water quality protection biodiversity benefits are things like reforestation avoiding forest loss and in our region in particular I think we need to think about avoided peatland impacts and that is how do we save wetlands how do we preserve marshes, restore marshes, and not just salt marshes but inland marshes that are peat based systems, as well because these have enormous potential but if you look at any global analysis this just happens to be one that i contributed to last year for the world economic forum that you look at the literature you look at where the potential is and these are the places where the most co-benefits are and we need to think about implementing them and I'm going to argue studying the heck out of them in our SNEP region.

so the other thing that administrator cash just made this point for me is that society needs to put large investments into these kinds of projects and here's just in some digging to try to trace well how much money is actually potentially flowing to these to these kinds of projects. there's money within the mass MVP program the Rhode Island municipal resilience program many millions of dollars land water conservation fund just got re-upped that's going to be for land protection this mass covid recovery alone has 15 million flowing to open space protection which is nowhere near what's needed but it's a significant amount of money. and then if we could get the build back better climate portion of the administration's program passed that would be an enormous investment. but the point is that money needs to flow to these projects and I'm going to argue that SNEP has a major role in determining sort of where that money goes.

if SNEP plays its cards right it can have what I'm going to argue as a work gate or a multiplier function. so any of you who can think back to the work of Howard Odum, a great systems ecologist and sort of one of the one of the key founders of system thinking, he created this idea of a work gate and to me this is critical this little symbol he had lots of symbols and he could diagram ecosystems with these symbols, he created this idea of a work gate. and this idea is you can by some action and it needs an expenditure of energy or in this case I'm going to argue money here this little symbol here like this takes work but by doing work you can have a really large influence on the flow in a system and I'm going to argue that SNEP needs to think of its role in that way by doing innovative projects, by doing the science around those innovative projects, it can quantify the ecosystem services provided by these nature-based solutions that need to be part of what we do and that by doing that it can have an outsized influence on these other larger flows of money. SNEP will not be able to do these programs itself obviously but it can play this this big role. So what are the key places where these investments in science and understanding can make the biggest difference?

I'm going to argue one of them is how you set the stage for the survival and resilience of coastal salt marshes. and by setting the stage I think I mean two things one is sort of how do you preserve these critical coastal habitats and peat-based carbon storage locations you know in the short run and then how do you how do you set them up for long-term survival in a world where sea level is rising you know faster than it has in ages and ages.

So one of the things I think here's a place where I think SNEP plays exactly this role. this was a Reynolds project as an idea that came out of Rhode Island and has been tested in a SNEP project and that is, if you can, salt mars are disappearing. we're documenting that around buzzard's bay. there are lots of

places, people are coming to us all the time saying you know my marsh is falling apart well one of the reasons is falling apart is water is sea levels higher more inundation is occurring, water is ponding on sections of the marsh where it didn't pond before by creating these small little runnel channels with a fairly modest investment in action one could simulate the revegetation of areas like this. but you know do we want to multiply this across salt marshes across new England? where's the best place? you know which marshes are the best candidate? that takes science. So investments in coupling the doing of the SNEP projects with the science that allows you to make the claims that this is going to work under these circumstances and have these benefits, it's just absolutely critical. because these this is how you have a multiplier effect.

And the other way i think is this idea of where are these marshes going to go? this is a picture of saltwater you know flooding in on the eastern shore of Maryland a corn field places that are now agriculture but the question is you know how do you set up landscapes for salt marshes to move? what do you need to do? do you need to worry about what the configuration of that edge is? do you have to do something different if it's a forest versus if it's an agricultural field? how do you set up, how do you set the stage for these things to happen? you have to protect the land, you have to get rid of the quirks of topography that might prevent something from happening; like roads or berms. maybe there are some vegetation effects that you could manipulate in some ways that prevent invasion of phragmites for example or other things. we need to study those things. we need big projects we need to do these projects not just in one place not just as one-offs as SNEP projects I hate to say sometimes often are, but systematically think about how do we solve these big problems set up networks of these problems, study the heck out of them, because if communities could be convinced that these things work they will multiply right.

All right this is you know so here's the stage right it plays out this is in south Dartmouth this is by Allens Pond this these things are going to play out over these landscapes we need to study them and understand how they're going to how they're going to work and SNEP can play a major role in that.

All right the other place i think SNEP can have a major role and is having an important effect and could amplify that effect, is this question of how do you rewild watersheds for these multiple benefits? and obviously one of them is nutrient removal, right. so rather than sort of re-engineering systems with wood chips or injecting the vegetable oil or things like that which require these constant investments they may have local applications and i think they're important but what you're really aiming for in the long term is rewilding to let nature you know get out of the way and let nature do its thing. and I'm going to argue that here there are some great opportunities in rewilding of watersheds right now and this is one of them. so this picture is upper eel river and it used to look like this right

So Massachusetts right now has an enormous opportunity for rewilding of watersheds associated with changes in the cranberry industry that make this style a flow-through bog kind of an anachronism and create lots of opportunities for rebuilding wetlands in those cranberry systems.

And this was just an analysis that I had a hand in, in trying to understand, well here's the Wareham River watershed and here are the blue bogs or the flow-through bogs that are going out of business and being retired the red or retired bogs and that number will increase and the purple is traditional bogs that sort of depending on where they are how productive they are what cultivars they're planted to might go to restoration or might go down. the other the green pathway here are the renovated bogs that will be there for a long time where the yields are higher and Massachusetts farmers can kind of make money. So the enormous opportunities in this in this in this area right now but there's are a lot we don't know.

Like how do you do this? we need to study how you do it. how do you get the maximum benefits? these systems have enormous potential for nitrogen removal, we know wetlands play that role, but is the nitrogen removal in the old bog surface? is it in the stream channels? there's a lot we don't know, and if we knew that, towns, municipalities, the state, DER, could make a much more cogent case for doing more of these projects, and they're more on the drawing board. and they're the perfect setup for doing science, because some of these projects now could be sort of studied before and after but we've done six or so of

These projects so far without the real good before and after in terms of nutrient dynamics or habitat or any of these long-term studies that that would allow towns to jump on these as part of their long-term solutions to nutrient problems. So there are various things that that you could get down into the details of how you do these projects but I think that's an important part of the defining and quantifying these ecosystem services.

All right here's another you know another little thing, do you build in little denitrifying features into these projects as part of the rewinding? and i think the answer might be yes, in some circumstances. what do these look like? my argument is we need to invest in not just building the projects, patting ourselves on the back and saying we rewilded a little part of this you know watershed X, but we need to study those to get this multiplier effect. just make a bigger investment in that research. I think we could say the same thing about dam removals.

This is the lower dam on the river the Horseshoe Dam, and it came out you know and there was some monitoring involved but not what it could have been and I think that's the key is; are there trade-offs involved in some of these rewilding projects? and I think there very well might be we just don't know what they are to be able to prioritize.

And if we look across the landscape this is just from mass GIS you know lots of these culverts, dams some of them in red are major risks, some of them in yellow are lower risks, but there are lots and lots of potential to do these things. increase connectivity, increase climate resilience, take away barriers to storm surge, and that kind of thing. we're just not doing enough science around that.

And I would argue that this applies to urban watersheds as well and this issue of could we improve the environment while addressing some historic injustices and i think these projects like that I'm involved in a pilot SNEP project that I think is really exciting in do new Bedford along a stream corridor and a very urbanized stream corridor in new Bedford but here again a lot of the project is documenting the problem, thinking about projects in trying to implement a few restoration projects but then we need the science on the back end. did that work can we multiply these into the future? and i think again we need we need more of that

So I guess just in sort of making my final point again is that SNEP has a unique role here to be a multiplier of these projects and a lot of these cranberry bog restoration projects for example you know one pilot project can have lots of benefits because if towns could argue that they would save tens of millions of dollars of engineered wastewater removal by doing restoration then more towns will do restoration and more money will flow to restoration. but it requires that very strong argument that we have the science to do this I think the same with marshes if we can do some of these projects and get the data and then through the outreach programs like SNEP has, multiply that across the landscape. and remember, we all know we're in New England where what gets decided in one town often is based on very hyper local view of the world so I think these local projects, the regional projects are great, but we need the regional data. SNEP is in a unique position to provide that. So I'm going to end there and thank you.

ZaNetta: All right, awesome thank you so much Chris for taking the time to present. I know that there was some before I did my original introduction that some people joined after so I just wanted to just reintroduce myself my name is Zanetta Purnell and I'll be your facilitator for today I work in EPA Region One Boston. This session today is focused on its focus on nature based solutions for climate resilience and resource protection, so our next two speakers, I'm gonna go over their bios and just give you a little bit of background on them I did just want to mention that at the end when all of the presenters have spoken we will have a question and answer opportunity so i will you know if you want to add questions in the chat now that's completely fine but when we get to that part you can either use the chat or use the raise your hand feature and if you have any questions on how to use the raise your hand feature you can always add that in the chat so I can help you but it's right near the chat button where it says reaction. so all right our next speaker we have Pallavi Mande with tamraparni.org. and then we also have Anjali Joshi with Design LLC. Are you guys both on the call?

Pallavi: Yes .

ZaNetta: All right awesome all right thank you so Pallavi Mande founder and director of tamraparni.org has been involved with water-centric environmental restoration work in the Boston metropolitan area for the last two decades. while serving as the director of blue cities in watershed resilience at CRWA, she was deeply involved in public education and outreach on urban restoration through engaging a variety of stakeholders; ranging from state and local public agencies, institutions, advocacy groups with resident communities at large. Pallavi received her bachelor's degree in architecture in India, a master's in philosophy and environment and development at Cambridge university in England, and a masters in architect and urban design at Washington university in saint louis. in 2016 she was selected to be a fellow at the Harvard graduate school of design GSD, where she currently serves as a design critic and studio instructor.

And Anjali Joshi, principal at Anjali Joshi design, a landscape architecture firm based in providence, striving to incorporate green infrastructure and climate resiliency goals within the traditional practice of landscape architecture. the firm is on the technical assistant list for SNEP grant recipients, and currently working with several non-profits with development of major and minor land development in Rhode Island. Anjali serves on the capital center design review committee in the city of providence and is a sites ap. Anjali received her bachelor's degree in architecture in India, masters in landscape architect at Rhode Island school of design. She is a licensed landscape architect in Rhode Island and in Massachusetts. So we thank you both for joining today to speak to everyone I will pass the floor over to you.

Pallavi: sorry can you hear me I'm just trying to share my screen and I don't see the option.

ZaNetta: So in your hotbar right next to your microphone see the share button?

Parker Gassett: Anjali, if you have two screens open, will you mute one so there's no feedback?

Pallavi: my apologies. Anjali do you happen to have my presentation

Anjali: I do but I'm also just facing the same challenge, I'm gonna try that.

Pallavi: Okay because it's not giving me the option of sharing screen for some reason.

Anjali: Do you see my screen?

ZaNetta: Yep, I see yours yep

Anjali: Okay, perfect.

ZaNetta: all right awesome.

Anjali: I'm just gonna turn it into a slideshow, just give me one second.

Pallavi: Sure, thank you so much.

ZaNetta: All right, awesome thanks.

Anjali: Here you go.

Pallavi: Great, sorry about that but good morning. as was indicated before Anjali and I are doing this joint presentation and the two of us are located in Massachusetts and Rhode Island, so this gives us a really great opportunity to showcase the kinds of resilience projects that are happening in both states. of course, we talk about it from different points of view as well as at different scales. So I worked in the watershed planning and design field for the last 16 years with Charles River Watershed Association, so a lot of this work actually is what I did as the director of watershed resilience at CRWA. Can you go to the next slide Anjali? Thanks.

So as you all know and this is not anything that's a surprise you know. the last on the left are two pictures of what the Charles used to look like when it was tidal and there was no control in terms of what was being discharged. as we developed our cities we definitely did a good job of putting in a lot of polluted storm water, as well as other pollutants in the Charles and now we are kind of facing the impacts of that. the picture on the middle bottom shows the issues with cyanobacteria which is being seen in a lot of urban rivers, so Charles not an exception. and of course the flooding with intense rainfall is also a huge impact. next slide.

So as you probably know this too so I'm going to go quickly over this so what has happened is that we have changed the natural hydrology in our developed watershed so in the diagram on the right you see the on the natural ground cover side there was only 10 percent runoff that is the storm water runoff from the rainfall we received. which actually is hugely increased to about 55 percent, and in parallel to that the infiltration use which used to be about 50 percent of rainwater is down to 15. so that's a huge alteration in natural hydrology and what we are trying to do is replicate that natural hydrology but in an urban context. as you see in Massachusetts, the average annual rainfall has increased from 4.2 to 23 inches and the groundwater recharge has decreased from 21 inches to 6.3, which is a substantial difference when you look at the natural as well as the urban watershed. next slide please.

So what we are trying to do is restore the watershed as a way of cleaning up our water resources. as you can see, when we have the water come through the downspouts, we are trying to make that a visible part of the landscape so people understand you know where the water goes it's not just entering a catch basin and disappearing from sight. So we are using both plants and soil based approaches to not only clean the water in terms of water quality but also recharge the groundwater levels. next slide. can you go to the next slide.

Great, and just keep clicking this. So as I mentioned the stormwater war run off -if you can keep clicking Anjali please thanks- brings not only pollution with it but also a lot of discharges -can you click that further. okay- it also brings a lot of phosphorus that has been discharged as a pollutant to storm water and that is in fact making the water quality much more harmful for being interacted with whether you're swimming or having boating interaction with the water. cyanobacteria is a huge health hazard. So how do we go about retrofitting this watershed? and it's not just a matter of designing and implementing different green infrastructure technologies, we've had to do this as part of our education and outreach efforts to actually make residents understand what these BMPs are doing. of course, what you see on the other two slides, look at visualizing what green infrastructure looks like. and then actually constructing it to understand you know how effective it is for both pollutant removal but also recharge of groundwater. next slide.

so as I said you know I've been working with a lot of communities across Boston metro area. this happens to be in north Allston. we did a green street guide for three streets in Allston Brighton, and that was a very much community embedded process. we had you know residents along those streets work with us to identify what kind of best management practices they'd like to see. you know of course there was a canopy cover that was a main part of this this guidelines document but also understanding you know where there might be opportunities for traffic calming as well as rain gardens. next slide.

these also just show the various site scale, Anjali is gonna talk a lot more about the site scale so i just wanted to kind of breeze through this these examples to just show what kind of variation can exist in terms of what the BMPs that are designed for a particular slide. So the images on the top, if you hit one more slide, thanks. those two images are on a privately owned site the walt watch factory which was really kind of designed with the aesthetic sensibility that that was you know new at that point and it has been a huge success story and the pictures below come from a housing project in Chelsea which is in the mystic river watershed and the middle is Peabody square which is in the watershed and last but not the least we also installed porous pavement in downtown Boston in the south end. So these are just a different kind of variety of BMPs that we have constructed and monitored over time. next slide please. Go to the next slide, can you go to the next slide Anjali sorry.

Anjali: All right, so I'm already on the next slide, I don't know.

Pallavi: Okay yeah, I see it now thank you. So these just show you know different points at which community involvement occurred not only in the design phase that I talked about before but even during construction and planting we made sure that there was enough investment from the neighboring residents to this kind of project being implemented. this was the school that was retrofitted with rain gardens, street trenches, etc., but it was important for us to not only educate the school kids who were using this area as an outdoor classroom, but also residents around the site so that they could take on maintenance if needed and just use the space as a community space. Next slide. It seems to be a little lag. Is it gone to the next one?

Anjali: Yes.

Pallavi: Okay I don't see it on my screen that's interesting.

Anjali: Does anybody else see it? I don't know.

ZaNetta: You may want to try, I don't know if you want to click back and then go forward again.

Pallavi: Yeah I think it's kind of stuck. oh gosh sorry about that.

Anjali: Do you see it?

ZaNetta: No worries. so I'm seeing the watershed approach to climate resilient images.

Pallavi: Images of the school right? German International school? yeah it doesn't seem to be progressing from that.

ZaNetta: Maybe Anjali I don't know if you want to just click out of the presentation and go back in.

Anjali: Do you not see it also?

ZaNetta: Yeah I see you clicking out yeah if you want to go back to the slide show and then click back on that slide. Yeah it's progressing now, do you see that?

Pallavi: Yeah all right, awesome, just the next slide Anjali thank you. Great so this is also just a bunch of images showing the before and after of those sites that I mentioned in Allston, Brighton and also Chelsea housing complex where the central island was retrofitted into a bioretention area and it treated the storm water that was going into the creek that you see behind the site and again it involved educating the youth on not only the science behind the design but also making them stewards of the project that would kind of would have a vested interest and stewardship being built at the same time. next slide. I don't see the next slide.

Anjali: Do you see it?

Pallavi: No.

ZaNetta: I'm seeing the amazing housing complex in Chelsea.

Pallavi: Yeah it's kind of stuck there maybe yeah just come out of the presentation mode actually I can just, okay, this kind of is better. Okay yeah so this is almost my last slide so just wanted to talk about how these approaches have not only worked and had some really good traction in the last few decades at a site scale, but we are seeing a huge push in Massachusetts to look at watershed-scale interventions and regional infrastructure projects. as I pointed out most of the work that I was involved with was in the Charles River, the Mystic, and a little bit in the Neponset but -next slide please

The state has really taken a leadership role and created the program called municipal vulnerability preparedness program which has in some ways just jump started a whole array of investments by

municipalities in green infrastructure not only retrofitting the different sites for storm water pollution treatment but actually looking at regional approaches to climate resilience, whether it's creating or restoring wetlands or other green street efforts. So I just wanted to end here and hand it over to Anjali to talk about the case studies that she's been working on in Rhode Island and again, apologies for the technical difficulties, thank you Anjali.

Anjali: Thank you. You see my screen?

Pallavi: Yes.

Anjali: Hi everyone. Thank you Pallavi, that was a great presentation. I'm going to jump in scale and go to Rhode Island. I've been working on a very micro scale of small urban sites and neighborhoods and the general providence area and I'm going to walk you through some of the projects that some of them are still on the drawing board some are implemented and some are still in permitting stages. so just to sort of look at what I could do at this micro stage in terms of the design approach towards designing a landscape that incorporates strategies with storm water and climate resiliency in mind.

I'm going to start with the slide which we've seen so much in the news about almost half the country facing extreme drought conditions and dangerous heat conditions like never before. a lot of global news on the heat waves especially for my family back home in India and also the dramatic photos that we've seen of Lake Shasta just in the last three four years of the water levels diminishing. So bringing all of that to a scale of a project of an urban site, some of the challenges I have seen are you know regulatory challenges with the public right-of-way or sidewalk space if you will. our construction and engineering practices that don't always allow us to pick the right materials that will help us with climate change. traditional construction and architectural A&E budgets do not have a green infrastructure budget or you know they're not prioritized. And also our maintenance equipment for our DPW departments and others they're still using equipment that does not provide the support that some of our green infrastructure projects need.

I'm going to just jump right into the sites as I inherit them this is a school in providence and urban some of them are existing buildings that are being retrofitted others are open sites like the one on the top left. which is just an asphalt parking lot where a new building is being designed. The bottom left, it's a client that already owns the yellow dotted parcel, if you can see it, and are trying to develop the site, which is shown in blue. and so trying to think about how to bring these highly built sort of mesh of concrete, asphalt, lack of tree canopies, and also lack of pedestrian friendly paths or shade into creating something that is more comfortable and people-oriented.

So these are some of the three opportunities that sort of I focus on in some of my projects. one is to find ways to build water storage capacity, whether it is through permeable paving, green roofs, or especially using the recycled storm water for irrigation and grey water use for toilets. Also looking at landscape as an opportunity for not just any plants, but looking at it as an ecological opportunity. Can we build a stream's edge? Can we build a woodland garden? Can we create some typologies that occur in nature within the small site? and just by the plant associations and creating the right environment, create a much more holistic landscape. and also looking at how we can connect every small site with existing neighborhood parks and resources, so they become this sort of continuous chain of spaces that we can experience and also benefit from.

This is the project that I showed earlier, it's a school project based in a small neighborhood in providence. you can see some of the ideas and it's a very small site and it's a complete asphalt parking lot and we've repurposed it to create storage opportunities for water. There's a raised retaining wall that has a backfill of gravel that literally becomes the reservoir for rain water, permeable paving, and we negotiated a larger expanded tree belt along the street side with the with the city to allow us to have that expanded sense of green space to allow trees and also to invite the community to use some of these seating nooks and spaces along with outdoor classrooms.

A similar opportunity for an existing building at the diamond hills park, this was an old ski lodge that needed to be repurposed, a one-story building. and we looked at opportunities to use the roof deck, which has beautiful views of the diamond hill area, and it is in an area where there's a stream that flows through the site. And so to think about adding entrance canopies to capture rain water that then gets captured in these green roofs and converting the asphalt parking lot into a woodland garden.

This is the same project looking at it from the other side. where there were open large gathering spaces for the community for events that would be open even when the community center is not open. So after hours.

Another building water storage capacity is looking at underground tanks. where new buildings are planned or even where we are retrofitting into existing buildings small fiberglass tanks are both cost effective as well as great ways to capture the storm water that does not end up going back into any of our natural systems. it allows, this is a calculation for a school project where we calculated the rainfall in the wettest and the driest months and trying to figure out what kind of a gallon tank would fit and how we could fit it in this very tight site and use it as gray water for toilet flushing as well as for irrigation. and as part of the new the sewer abatement water meter is used, by the Narragansett Bay Commission, which allows a client to file for an abatement form. which means that instead of the water that does not make it into the sanitary sewers is given as a credit to the clients for not adding to the stormwater system.

This is a community music workshop, a charity that has music lessons for the underprivileged children and is now building a new building. and the idea that we don't have to look at just site as the property boundaries but water does not see, water and people don't really see boundaries in the same way. so how could we activate the sidewalks to create pollinator gardens and plants that would actually contribute to our ecology and carbon footprint. And so instead of using traditional grasses, using some of these pollinator plants can have deep carbon sequestration benefits. We had to negotiate with the city to turn this eight-foot-wide sidewalk into a five-foot concrete sidewalk and the remaining is our sort of plan, these expanded planting pits for pollinators as well as some permeable paving. The client had to sign off a liability waiver to the city for the use of permeable pavers and these planting pockets, as the city does not love anything except the concrete standard sidewalks. The equipment does not handle permeable pavers and other surfacing, so we negotiated a 5-foot-wide sidewalk which will be still concrete but the remaining areas will be permeable.

These are two projects this is the same project, the community music workshop. The bio retention areas behind the building will be converted into this sort of stream edge wetland garden with plants that were characteristic of our native stream edges. and on the top left is a woodland garden that is planned for a new courtyard building. A courtyard for an apartment building for crossroads; another non-profit, that houses people who are victims of domestic abuse and homelessness. And the idea is that this woodland garden would be another room that they can have and have healing benefits from.

These are some of the implemented projects, this is the school project with this big rain garden component, permeable pavers, all the drain spouts and the roof rain water it gets captured in these areas and these expanded sidewalks. You can see some of the seating nooks and this is an outdoor classroom, also permeable with stabilized soils.

This is the view of the new building for community music workshop where we're planning on the right bottom you can see the underground tank will be incorporated into the permeable paving areas and create the stream edge garden we talked about and then the expanded sidewalk components are shown in the slide on the left.

Here's a small library project in east Cambridge. Also a very small site and is envisioned as an outdoor park, wi-fi stations. this library has an interesting history, it was closed mostly and open only two days a week, was very beloved neighborhood library used by a lot of older folks and young children. So a non-profit group called east Cambridge open space trust came forward and wanted to develop the outdoor

space. as a result of their efforts the building received funding and we also were able to create this garden slash park. it has become a great amenity for the community, especially during covid. it has outdoor wi-fi stations, a story time place, and all of this is with permeable- there was only grass, tough grass, here and we were able to add permeable paving, a small woodland garden for the children again using the sweet bay magnolia and some of these native species to both educate and it'll make people aware that even the smallest of spaces could be great opportunities for adding green infrastructure opportunities, recharging, as well as a social space for people to enjoy and educate.

ZaNetta: All right awesome thank you so much Pallavi and Anjali, we appreciate you guys for taking the time to present today and so we're going to move on to our last presenter. This presentation title is canoe river aquifer protection through regional application of nature-based solutions. Our speaker for this session is Kimberly Groff with the SNEP network and I'll just read Kimberly's bio very quickly. I think I see you on, Kimberly?

Kimberly: Yeah.

ZaNetta: All right awesome thank you so much.

Kimberly: Are you able to see my screen?

ZaNetta: Yeah. I don't see it yet. I'll just go over your bio and you can work on that, and then if we can figure it out together. Yep all right so Kimberly Groff has dedicated 30 plus years to her career advancing water quality at a project, state, Massachusetts, and regional scale. She is currently working as the Massachusetts liaison for the SNEP network, that is administered by the New England environmental finance center. In this role she works with the communities to address stormwater management and climate resilience. I will pass the floor over to you, Kimberly.

Kimberly: Thank you very much. I am having trouble sharing my screen for some reason and I'm not sure why. Should I stop sharing?

ZaNetta: Kim we can see your screen, oh, we could. Yeah, we could.

Kimberly: Okay, let me try this again. You see it now?

ZaNetta: Yeah I see it now, yes okay awesome perfect.

Kimberly: Thank you and am I in presenter mode?

ZaNetta: Yup you are everything looks great. Thanks.

Kimberly: Thank you. Thank you so much for the introduction and I'm really happy to be here today to talk about the canoe river aquifer resilience project and I couldn't have had a better introduction from Chris and Pallavi and Anjali and the benefit of nature-based solutions. And so, this talk sort of comes at it from a little bit different perspective of how do we start to identify those types of opportunities and work with communities to advance projects. but before I get into the talk i just want to acknowledge the support from EPA, the SNEP network, the New England Environmental Finance Center, as well as our partners at The Nature Conservancy, Mass Audubon, and SRPEDD (Southeast Regional Planning and Economic Development District). As well as Horsley and Witten, our consultant, and the five towns that we worked with Sharon, Mansfield, Norton, Foxborough, and Easton.

So, what I'd like to cover in the next 20 minutes is to talk a little bit about how this project got started, the approach that we took to working with communities to identify opportunities to implement nature-based solutions, and then some results in terms of a short list of projects and observations and opportunities.

So first off why are we here? Why did we decide to focus on the canoe river aquifer resilience project? The Taunton river watershed is a very unique watershed in the state of Massachusetts and then it has the longest undammed river in the state. it's also a federal federally designated as wild and scenic. and it's an

area that's experiencing rapid change from development and that development is compounded by climate. and you saw in the previous speaker's talk, a lot of examples of the results of more frequent intense storms flooding and higher temperatures. and why the canoe river aquifer is so unique is it's the sole source aquifer for about 50,000 people in the area and it's co-located within the boundaries of five towns. it was designated as an ECEC 20 years ago by the state of Massachusetts; however, the protection of the aquifer really falls to the local communities. And so we decided to focus on this project to assist the communities and looking at opportunities to enhance aquifer recharge and provide adequate supply of clean drinking water.

And Pallavi mentioned the mass vulnerability preparedness program so in at the outset of the project we worked with the Resilient Taunton Watershed Alliance also known as RTWN to think about how can we set up a pilot project that would build off of EPA's strategic goals and serve as a model for other communities. And what we found was through our interactions with RTWN is that these five communities had all been either completed mass vulnerability preparedness plans or with were in the process of completing those plans. and that process as Pallavi mentioned earlier is really to explore natural hazards, look at its strengths and vulnerabilities, and to identify potential actions. So when the SNEP network got involved in this project, there was an aggregate of about 300 projects around the five towns and what we really wanted to do was evaluate the intersection between built infrastructure and opportunities for nature-based solutions to help those communities advance those priority actions, and most importantly at the end of the day connect them with the resources and funding that are coming into the state.

And we spent a lot of time earlier talking about nature-based solutions, but it's the perfect intersection for this project because really what the whole goal is to minimize impervious services and to help stormwater become more of a resource to the area, and that can be done through conservation restoration and improvements and retrofits.

So with that background in mind the goals of the project were to build off the mass vulnerability preparedness plans and other planning activities that the five communities had conducted, to conduct facilitated planning for the five communities, to employ nature-based solutions for watershed resilience, and to prioritize up to 10 nature-based solutions projects for implementation. and we were hopeful that through this process we would also gain insight into common barriers to the implementation of nature-based solutions and look for ways to overcome those obstacles and encourage more widespread application of these practices.

So at the beginning of the project which was right around 2020 communities were pretty distracted by the pandemic and this was not a focus point for many of the communities. And as you can imagine with 300 projects and five communities it's hard to set up an organizational structure that allows for that collaboration and information exchange. So it's a pretty overwhelming task and many in feedback that we've gotten from communities is that this project probably wouldn't have happened in this manner without the support of the network and its partners. So first I'd like to just talk a little bit about how we approach this and the principles were talked about in the prior talks but I'll run through this quickly. so first off scientific analysis; which nature-based solutions had the greatest ecological impact? Hydrologic impact? Which solutions could result in positive impacts across multiple towns? Which projects did the towns have interest in advancing? Where were there overlap with vulnerable populations and environmental justice communities? And last but not least, which nature-based solutions were going to best address the issues that the residents cared most about?

So this slide is just a schematic of the approach that we took and as you can see on the left hand side of the slide, community engagement really was so vital and so important on this process and it started at the beginning of the project. In fact, we met with many of the leaders from the towns and had them actually help us develop the project and how it was going to be organized and how it was going to run. And so we got a lot of feedback at the beginning, but most importantly community engagement has been ongoing throughout this entire process. So with that in mind we also went through an analysis series of steps shown in step one through four, where we developed a geo reference database with all the projects. We

filtered those projects based on community priorities. we did a second set of filters to look at the intersect between built infrastructure and nature-based solutions opportunities. and then a fourth step which really included a detailed analysis and deeper dive of a series of map overlays that sorted projects based on multiple benefits; including hydrologic, ecologic, and social.

so just a quick review of what's been done to date. As I said most of the towns had were either in the process or had completed the MVP, all five towns have now completed their MVP plans, we formed a steering committee in January of 2021 and we had representatives up from each town on that as well as interested citizens and other state agency representatives and planning agency representatives. we began outreach in 2021, we developed a public participation plan, we set up a project website and feel free to visit our website in the lower right-hand corner. you can google canoe river aquifer resilience pilot project and you'll go to our website and story map. we held a public workshop early in the project in September to educate the public about nature-based solutions and to talk about the project itself. we held listening stations at each local library in the fall of 2021. we developed an online questionnaire hosted by the southeast regional planning and economic development district. and once we had a short list of projects we circled back not only through the members of the steering committee but also a cohort of representatives from town planning, DPW, natural resources, and reviewed our findings to make sure that the selection of the projects was grounded in what the town cared about. and then we also just recently held a second public workshop where we shared our results.

And these are just some pictures of the community engagement; our public meeting and training events, zoom meetings, so multiple opportunities to connect with people throughout the process.

So this slide what I'd like to do is just go through the process that we use to whittle down the number of projects, which was a bit overwhelming. We had, as I said set up a project database so first off we looked at projects that were co-located or in close proximity to the canoe river aquifer and the aquifer would benefit from. we looked at projects co-located along major streams and surface water bodies as well as major roads. and we also categorized each project in the database in one of four categories. So category one was water supply and drought resilience, category two was flooding stormwater dams and culverts, category three was forests habitats and invasive species, and category four was public health and emergency preparedness.

We also worked with our steering committee and a second screening process to identify which of the categories were most important to the communities. and through our steering committee what we identified was that category one and category two were the most important, the highest priority of all the communities. So with that we screened those out and we ended up with 198 unique projects and you can see the distribution amongst the towns at the bottom of the slide and 212 features.

The third step was to start to look at how we could look at the overlay between built infrastructure and opportunities to employ nature-based solutions to address water supply, water quality, flooding, and drought resilience. And what you can see on the right-hand side of this slide is that what we're really looking at is how can we retrofit built infrastructure like collection systems and piping to encourage the infiltration of water and filtering of water into the ground, as you can see at the top of the slide.

The third step oh, so the results of that were that we ended up with 95 candidate projects remaining in our database where we had opportunities, and you can see the distribution of those projects with culvert pipe and dam and bridge at the top of the list, but also numerous opportunities to address flooding water quality, stormwater management, and conservation.

The fourth step was to do a deeper dive, so once we had that candidate list of 95 projects was to really hone in on what are the local characteristics and potential benefits that could be achieved through the implementation of nature-based solutions and retrofits. and we looked at three different areas. ecological value, so we looked at the potential benefits in terms of hydraulic restoration and aquatic connectivity ecosystem services. we looked at culverts and dams for ecological values and hydrologic relationships,

and we also looked at socioeconomic values such as the public input that we received, vulnerable populations, environmental justice neighborhoods, flooding on roads and neighborhoods.

And this just shows an example of how the analysis stacked up. We used the nature conservancy's mapping layer, as well as other GIS resources. and this slide just shows the TNC layers of habitat and good recharge and what you can see is that as you work with GIS and you layer in the projects with all these different multiple benefits you can start to hone in on great areas to focus in and primarily what areas of the landscape have the ability to absorb and filter water.

So this shows the results of that filtering, and what you can see on this slide is a map that was created. this is a screenshot from an interactive map that Horsley and Witten prepared and each unique color-coded dot on this represents a cluster of projects. So we're really working on a sub watershed scale here, and if you're interested you can access this map through the SNEP network web page. so we have clusters of projects or single projects that are located in each of the towns. We have a distribution of projects; one in Sharon, three in Easton, two in Norton, two in Mansfield, five in Foxborough, and then two regional projects. and what's circled here in the red is an area that we've been focused on in the last couple of years in Easton called near Mulberry Meadow Brook and I'd like to just spend a little bit of time talking about that project to give you a feel for more of the detail and granularity of this the map also has a-

ZaNetta: Sorry to interrupt Kim I just know we're just heading into our question-and-answer portion so I just wanted to just give a friendly reminder.

Kimberly: Okay yeah I'll wrap up in a couple minutes is that okay?

ZaNetta: All right yeah I think if we have like two or so that would be great.

Kimberly: Perfect, thank you. So with Mulberry Meadow Brook we identified the hazards of local flooding dam failure drought water quality and many of the solutions that were identified addressed removing impervious cover and increasing wetland storage capacity.

This slide just shows some of the interventions that are being looked at, and i won't go into a lot of detail here, but they include replacing culverts evaluating dams and enhancing the ability of the landscape to absorb water. and then also conserving land. Item six is a thousand acres of wheat and farm that was preserved a couple decades ago.

These are just some slides showing the new south street culvert that was replaced already and the aging highland street culvert.

This is some of the work that's going on at Sam Wright Field the area in black is impervious cover that's being removed from former farm structures the area in red is also wetland area that's being expanded re-graded re-seeded and then the installation of nomosomes along riparian corridors.

So the next steps are to work with the communities to identify projects that they have interest in advancing, to provide ongoing technical assistance to further develop the project priorities, to identify the needs for training workshops to support the communities, and then continue to engage.

Some of the observations from the projects are that five communities each had capacity limitations in setting priorities and positioning themselves for funding. they really struggle with competing demands for their time, which is a challenge to find meaningful engagement. And the immediate demands often negate their ability to look at projects from the perspective of multiple benefits. There's competition for consulting services out there and we've had a couple of projects that have advanced out of this group to applying for grants and others that just weren't able to get the resources they needed to pull the information together that they needed to advance the project. and then also the work with the public is that they don't always understand the connection between their involvement and implementation, and there's really a need for more resources to translate the benefits of nature-based solutions to the public.

And then just this is the last slide. Some of the opportunities are that we realize that working with the communities and focused community assistance really does help build momentum, local champions are vital to the success, and as Ian said in his opening talk you know finding those projects that serve as regional models and working on a watershed scale really have the opportunity to for multiple benefits and also to save time and resources. thank you very much.

ZaNetta: I was on, I was on mute. Thank you so much Kim, we appreciate it. Thank you to all the presenters that took the time to speak today we really appreciate your efforts and all the information that you were able to provide to folks that are on.

SNEP Symposium – Science Bringing Solutions Delivering Environmental Improvement to Southeastern Coastal New England

Room 1, Morning Session 2

May 18, 2022

Sara: I'm the moderator for our second session in room one so I'm gonna move this along. Thank you to everyone for a wonderful, a wonderful first session thank you thank you to Zanetta for an exceptional job facilitating. So welcome everyone to session two in room one, I will give folks just a minute to kind of move around because that conversation sounded incredibly robust so we'll give folks a minute to filter to where they're going for the second session and then we will get started thanks so much.

Attendee: Great thank you very much for your patience.

Sara: Absolutely here for the discussions that's what this is all about. Okay well actually looks like our attendance number isn't changing much so I'm going to go ahead and get us started because we've got three great presentations to hear from today and if the last session was any indication we'll have some great discussion at the end of it so welcome everyone I hope that you're enjoying your morning so far my name is Sara Sinslow I use she her pronouns and I'm delighted to help moderate this session on wastewater policy and design if that is not the session that you intended to join will only be a little offended if you drop off and go to a different one but again we've got three great presentations lined up so we do hope that you stick around I know Adam went over some of the basic housekeeping at the top of the symposium but just a quick reminder that if you run into any technical difficulties you can leave the team's meeting and either join the main meeting room for assistance or sometimes with teams if you leave and come back they should resolve itself. You can access the links to all of the meeting rooms through the virtual agenda on the SNEP symposium website and if you need the link for that I can toss it in the chat. I'm excited to be joined by Nicole Hagerty in the session as our meeting host and our notetaker, thank you so much Nicole. The session's going to have the same run of show as the last one we'll have three presentations from our distinguished speakers followed by Q&A. Speakers will present for 20 minutes each and they're going to control their own slides so Dr. Alissa cox I see you up there, if I could just ask you to go ahead and get your slides loaded up that would be excellent. Before I officially introduce Alissa I'm gonna remind folks to please mute your lines if you are not presenting. If I need to mute people I will do so I know that Nicole will also assist with that. And in terms of being able to engage with our speakers we have our chat feature which we encourage everyone to use you can put questions into the chat at any time during any of the presentations although we do ask that you specify who your question is for I'm not savvy enough to go back and read time stamps and try to map what question was for who so please specify in your question who it's directed towards I'll read out those questions at the end during our Q&A session and you can also use the hand raise feature to be called on to verbally ask a question at that time at the end so with that unless there are any questions about run of show or logistics, Alissa has her slides ready for us so please allow me to introduce Dr. Alissa Cox who is a researcher and educator in the natural resources science department at the university of Rhode Island and directs the New England on-site wastewater training program her interdisciplinary and collaborative research explores the myriad impacts of climate change on on-site wastewater treatment infrastructure and treatment processes and how to engage and empower communities to use these findings to plan holistically for a resilient future so here to discuss with us imagining the future of robust on-site wastewater treatment infrastructure, Dr. Alissa Cox, take it away.

Alissa: Thank you. Hopefully you can hear me okay.

Sara: We can, thank you so much.

Alissa: Fabulous, okay so thank you everybody I'm excited to talk to you a little bit about today some ideas that have been kicking around various my brain and some of my colleagues in response to or as a result of some of the research that's gone on here at the university of Rhode Island relating to on-site wastewater treatment systems aka septic systems here at the University of Rhode Island and so here are some thoughts to kind of putting together and some of the integral folks are Matthew Dowling from the town of Charlestown George Loomis and Jose Amador who are also part of the university of Rhode Island here.

So I think it's not news to anybody that centralized wastewater infrastructure meaning like wastewater treatment plants are vulnerable to climate change right here in Rhode island in we had the epic flood the West Warwick wastewater treatment plant flooded you know, hurricane Harvey in flooded Texas, I could have pulled like 900 other photos that showed basically the same thing.

And so there are also tons of resources for centralized wastewater treatment infrastructure to plan for resilience in response to climate change so there's all these different publications and funds and suggestions and ways and reports that have looked at how climate change is affecting these.

And there are money and you know the epa is involved some of this and suggestions for how to adapt to climate change for these different centralized utilities so there's lots of different examples of that, there's maps, there's mapping infrastructure initiatives, there's all kinds of things happening for centralized wastewater treatment, both resource wise and financially and this is sort of a thing that's on people's radars.

What I've found in the past is that on-site wastewater treatment systems aren't getting the same kind of attention even though they are really important infrastructure in the same token right. So there was an article in the Washington Post about a month ago that talked about how climate change is affecting septic systems but that our story mostly focused on sort of the mid-Atlantic and southern Atlantic coasts, so here in the northeast this hasn't been a huge thing that we've talked about necessarily, but our on-site wastewater treatment systems which are abbreviated owts or right this is the same thing with septic systems are vulnerable to threats from hydrologic cycle changes and weather pattern changes that result from climate change so things like sea level rise, extreme precipitation events that happen you know more frequently, storms, different hurricanes, flood events inland or on the coast and so when we look at what these images look like again you could pull about different images for each one of these what does this water mean for our below ground infrastructure in a non-centralized community? Which is common in much of sort of the SNEP purview and is common in Rhode Island and coastal communities and inland communities as well as in Massachusetts.

So some of my research focused on coastal septic systems and I like to think of them as the systems sort of along the coast or between a rock and a hard place. On the one hand you need to think about sort of long-term sea level rise and related groundwater table changes and potential rises but you also have these unpredictable sort of intermittent potentially catastrophic storm events that are also going to affect systems.

And so if we imagine a coastal septic system, you know, there are plenty in Rhode Island that are still sort of the conventional gravity-fed type that are still in place along the coast so usually a septic tank collects all the wastewater from the households sends that somehow into the drain field usually there's some sort of distribution box and this is all gravity fed. Some systems have been upgraded to advanced systems that have extra sort of treatment steps in between and so those are becoming more common in these coastal areas, but we still have in Rhode Island a number of these conventional systems in place. And so one of the things that I looked at for my PhD research was trying to understand if we look at a cross section of this drain field, we just take a slice across and look, at it you know the way where this drain field infrastructure below ground ends we call that the infiltrative surface and the distance between the bottom of that infrastructure and the season high water table is something referred to as separation distance and so you want sort of this dry soil in between the bottom of our wastewater infrastructure and

the seasonal high water table so that it can treat wastewater. But our coastal water tables are connected to the ocean so as sea level rise it drives up coastal groundwater tables as well and if you add to that sort of changes in precipitation patterns more frequent or extreme bits of events of precipitation you'll end up with raised seasonal high water tables which means you're now going to end up with inadequate separation distance so one of my research projects try to look at how common is this is this sort of inadequate separation distance anxiety justified and that's a story for another day but the short version is that about 20 percent of the systems that we looked at along the southern Rhode Island coast had plenty of separation distance all throughout the year it wasn't an issue. Half the systems we looked at intermittently had inadequate separation distance sometimes about half the year they had enough and the other half they didn't and then there were a number of system that never had adequate separation distance they were always in sort of this inadequate or repaired separation distance and during individual storm events or extreme precipitation events sometimes the groundwater table made it all the way up to that drain field infrastructure which means that untreated raw wastewater is potentially mixing with those groundwaters so that was mildly alarming. And something though that we need to start thinking about as we know our seasonal high water tables are going to continue to change over time.

From the other perspective, right, these storms that happen along the coast are also going to affect our systems and so in the aftermath of superstorm Sandy when you walked along the beach you saw here these are examples of concrete galleys which are a form of drain field infrastructure that are common in Rhode Island especially older venture systems, old cesspools are just you know washed away and so, you know, various if you look carefully and you're a wastewater nerd like I am you can see all of these examples of how the wastewater infrastructure has also been damaged never mind the above ground sort of structural components.

And so we did a little bit of modeling to kind of figure out can we predict or understand what are the likely storm impacts should another storm of a particular size hit the southern Rhode island coast for example and the idea is that during the storm you're going to have flooding, you're going to have storm surge and some of that water is going to move pretty quickly and some of it may linger so you may have sort of quick moving sort of aggressive storm surge near the oceanfront properties and then you're going to have flooding for some period of time on our for our properties that are sort of on the lower elevations along our landscape. And so after the storm recedes it's possible or likely that some of these septic systems are going to face severe damage from this flood and probably need significant repairs if not complete replacements and that's going to be more though this is the oceanfront properties are going to be at a greater risk compared to sort of the more inland ones that might have just been sort of ephemerally affected and have minor or not any effects once the storm retrieves and then you'll have some systems that are somewhere in the middle or they'll probably need some minor repairs a little bit of tinkering to get them back into full compliance and normal operation. So based on a little bit of information that was gathered by the town of Charlestown after Sandy struck the coast in 2012. We did a little bit of modeling and model comparison and adjustment and in southern Rhode Island which is a small area right, based on our modeling conservatively at least 200 systems are going to likely face significant damage they will be seriously affected by the storm. Another 65ish, plus or minus, will probably require some moderate repairs and then all the other systems that might be flooded that can range from anywhere to 2000 from 2000 to 5000 depending on the type of storm will also be sort of affected during the storm but likely not to have faced long-term issues and so it's important to think about so you know it's maybe 300 systems which doesn't sound like that many and this is a conservative estimate so potentially it could be more but some professional’s going to need to go out and assess these systems and then figure out and schedule and implement whatever the repairs are and that's not something that maybe we have the bandwidth for at this time.

And so one of the things that came out of my research is that we realize that we don't really know what we don't know, so we don't actually have a count in Rhode island about how many systems were actually destroyed and or damaged and repaired after 2012 and like there is no plan as far as I can tell to do anything differently after whatever the next event is which is surely coming. We don't know how long it

takes for a system to get back to normal operation and regain its full functioning as a way to mitigate nutrient and pathogen pollution after there is a flood. We don't have a lot of information on coastal groundwater tables and how they behave and what the impacts of floods and sea level rise or large precipitation events and therefore it's hard for us to predict what this might look like in the next 30, 50, 100 years. When we do look at some of the data from we know that some advanced systems which have these extra engineer components that help aerate water in some capacity to provide advanced treatment before the wastewater is discharged to the drain field to the ground. A lot of them are electrical driven they have sometimes airfield components and those systems are a lot more vulnerable to severe damage in these coastal waterfront properties and yet this is the technology that we are relying on and requiring to protect our coastal ecosystems from nutrient and pathogen pollution. And so we also don't know if there's no physical damage, again how long does it take for that microbial population to get back into performing and renovating wastewater the way it's supposed to, that's assuming we even know what it's doing in the first place which is another ball of wax but we'll get to that. And we don't have a good sense and there are no rules and no standards about systems that are at risk for being affected by extreme events being designed or installed in a particular manner to make them more resilient.

So wastewater treatment systems, on-site wastewater treatments, are not necessarily a priority the way they're dealt with at scale now as there is some sort of permitting process typically at the state or county level, your mileage will vary wildly on what that looks like, management and financing approaches also super variable, typically again this is managed at the town or county level here in the northeastern US like once these systems are in the ground what about them? The personnel that are in charge of managing the systems are typically underfunded and or overextended and that level of management can vary from like there's a person that supposedly managed them but doesn't actually to actually going out and collecting samples from individual systems and seeing if they're doing what they're supposed to be doing and o what level they're treating wastewater. And the funding options are also really variable mostly it's the property owner's money somehow that's going to fund a repair or an upgrade or a new system. In some cases some communities have programs where they can tap into some component of state revolving funds and as a part of the community septic system loan program but in the end that's really still homeowner money because they have to pay that back over time, it's a low interest loan, but still a loan. In some cases especially in areas in Suffolk county down on long island New York there are grants locally but they're also sometimes state and federal grants like the SNEP program that will provide subsidies or cost chairs to install or upgrade systems. And then in theory after a major disaster we might have some disaster recovery funds that we could use but that is unpredictable and you know its own separate issue. So these are kind of issues that I see that keep me up at night.

And so what are some ways that we might be able to address these things? So the water utility climate alliance which is actually focused on centralized system has some advice and I would say that this is solid advice that also applies to on-site wastewater treatment systems. So one of them that they talk about is that warming is here now and so we need to start thinking about how can we docent the current performance of our septic systems and what the impacts of various climate change event like derived events do to that performance, so can we docent what's happening now? Knowing our system and understanding its vulnerabilities can we use past data like and then use that to identify patterns and vulnerabilities? And then do something with that information like planning for the future given this past information. how can we start planning so that our systems are going to behave themselves and serve us in the long term in light of climate change individual flood, events long-term sea level rise, storm events and can we manage them proactively aside from designing and installing them to be resilient so that they continue to function and perform the critical important thing that they do for us which is treat our wastewater? And then capacity building is part of it right so how do we engage and train professionals and stakeholders that interact with on-site wastewater treatment systems? How to develop systems to address and mitigate these climate change derived risks?

They have sort of this idea of leading practices this the same water utility climate alliance and again if I adapt their words to look at on-site systems, so how can we engage and motivate stakeholders? So it’s

like the end users and then all of the professionals that root that are related so the service providers the installers the designers the regulators. How can we help or start to understand what systems are doing now and what their relationship to climate change is? What's the plan to manage systems and make them more resilient and build capacity within the sort of professional community? What is it we're going to require and how do we implement management and data collection and failure analysis to help us inform some of this planning? And then how do we make sure that once we figure out what works to keep going and then adjust as we need it because this is going to be a learning process?

So one thing that we could do an easy way to catalog to know our system is to catalog all of the systems statewide or at least at large scale so that could include GPS coordinates of the various components of the system so drain fields distribution boxes advanced, treatment components, drainfields links in this database that's geo-referenced to the most recent permit or certificate instructions so that you can actually look at the plan and see what the system is, having information that's easily accessible about design flow the type of technology when it was less inspected or pumped or maintained, is the property relying on a private well or community well or some other kind of thing? What's the separation distance according to the plan? And what is the depth to the groundwater table from the ground surface and can we go and verify that is this property in the flood plain or a coastal zone, is it owner occupied in year round? If we have a centralized database that as best as we can documents as many things about this we have information we can start collecting information. So the town of Charlestown Rhode island they have a pretty active on-site wastewater management program it's one of the most proactive ones in the state and so they do a number of these things already in various capacities so there are…

Sara: You've got about four minutes left.

Alissa: Okay.

Once you know your system you can track things like performance and maintenance and age and start looking at which systems are vulnerable and high risk, you can do failure analysis and then if you create some sort of standardized damage assessment protocol after a system has been affected by one of these disasters, you can then integrate and use this information again in terms of looking forward. If you have a centralized statewide system you can actually run analyses the scientists and various people can crunch numbers but if you have all these individual systems it's really hard to integrate that information and this might help us identify best practices and then guide and inform sort of moving forward. And this would basically be in line with how we treat and manage centralized wastewater treatment systems where we know where all of the pipes and all of the things are so let's treat on-site systems the same way. Again, the Town of Charlestown does a number of these things already.

We don't know right now how much climate change is going to influence the systems in the ground and so we need to start collecting performance data. I know Barnstable County does this and so do parts of Suffolk but this is not a common practice in Rhode Island we know based on the research here at URI that systems that are monitored for performance end up performing better. We know that oftentimes in embarrassment for example we rely on lab testing which is expensive and it's not timely because you've got to wait for the results so we actually here at the university of Rhode Island a number of research projects of documented and identified accurate and inexpensive field-based rapid tests that you can do while you're at the site as the service provider and understand how the system is behaving in terms of how much total nitrogen it's putting out, what the ph and dissolved oxygen are, so that you can triage systems and start figuring out how to get bring them back into a compliance. Again, we are starting to do this on some of the projects and then some of the systems that were installed under SNEP and previous funded grants. The other thing that we can do is start understanding our groundwater better and start monitoring that, so can we track elevation and variations and impacts of precipitation event? And then can we cross check that information once we have a network with when new systems are designed or redesigned, does that information jive? We can use these groundwater monitoring os to assess changes or just water quality in general which could then be used to alert local folks that we and our monitoring wells are showing X. This might also be an opportunity to leverage the community members to be

engaged with their water quality and help with the data collection and involve them so that they understand what the stakes are. And then establishing post-flood protocols would be really important so that we know what happens and how could to communicate and collect data after the fact, in some cases the town of Charleston does that.

And so lastly you know how can we involve stakeholders how can we co-integrate the things that people know in various places and turn these systems into risk a robust and sustainable infrastructure, how can we then make sure that our designs and installations are better how can we make them sexy for end users so that they're motivated to be interested and I'm excited to hear for from Alexa Redmond next and then again big picture, how do we involve folks? The town does this it's expensive and difficult blah blah blah but the end note is that this is infrastructure that protects public and environmental health and it shouldn't be the sole responsibility of a property owner to be in charge of and so if we manage these systems like we do centralized systems that's going to be protective of our communities and ecosystems around us. Thanks.

Sarah: Thank you so much, that was excellent.

Alissa: Gotta figure out how to share stop sharing, there we go.

Sarah: And again, any questions for Dr. Cox you can either type them into the chat now or save them to ask verbally during our Q&A session. And with that I'm going to invite Alexie Rudman who Dr. Cox gave us a teaser for you can go ahead and begin sharing your slides, that'd be excellent. Alexie Rudman is an Oakridge institute of science and education fellow this ORISE fellow at EPA's office of research and development in Narragansett Rhode Island, where she studies the human dimensions of coastal water quality and contributes to communication planning for a stakeholder-centric nutrient reduction research pilot on cape cod Massachusetts. she has a master's of environmental management from duke university and a bachelor's of arts in international development from McGill university. we're thrilled to have Alexie share with us and continue this conversation. Take it away Alexie.

Alexie: Thanks Sarah and thanks everyone. I'm just loading up my slides they seem to be a little bit slow today. I wanted to thank SNEP, NCEI, and Adam and everyone for putting the symposium together and today I'll be talking to you about some of the social science that our lab has done around the adoption of innovative and alternative septic systems. I'll also talk a little bit about how findings from focus groups that we conducted could be used in conjunction with behavior change strategies to potentially incentivize wider spread adoption of these systems. and it looks like my slideshow is finally cooperating.

Okay, so many of you are familiar with the nitrogen loading problems that we've been struggling with now for several decades in the region. here in red we see imperative embayments that are primarily impaired from nitrogen. a lot of the controllable load of this nitrogen comes from septic systems and this is a map of cape cod where the social science research is primarily taking place. this social science research is a part of a larger stakeholder-centric project on the cape that is working to address nutrient problems by finding watershed scale solutions. and so, as a part of that, we're piloting a range of alternative technologies including I/A septic systems, cranberry bog restoration, PRBs, shellfish aquaculture, et cetera. And for those of you who don't know what I/A septic systems are, they're essentially systems that are designed, they're septic systems that are designed to remove nitrogen through an extra denitrifying component, whereas your traditional system treats for pathogens but doesn't necessarily treat for nitrogen. so, a lot of research has gone into understanding how much these pilot these alternative technologies cost. also, how they work. but we know that there's a lot more to the use and adoption of some of these alternative technologies than their cost and their technical efficiency.

So, if I/A systems are to be a part of the toolkit that we use in southern new England to address nitrogen loading, we need to understand the people side of adoption. so, the we need to learn from the users of these systems, and I want to start you with a quote from an engineer who's been working on these systems for a while. she recently wrote "no matter how technologically promising a system might be, it

cannot achieve either sanitation or sustainability goals unless people are willing to use it" and so she's essentially highlighting those social and cognitive factors can influence whether a technology like I/A septic systems can be adopted or not adopted. so why do this research? we've done this research around the adoption of I/A septic systems because this was a need that was identified in the region by researchers by decision makers by people piloting these technologies and also because some of my co-authors on this work had previously conducted interviews with decision makers and implementers, and found that there was a lot of interest around using I/A septic systems to address nitrogen loading, but they also found that there was a lot of uncertainty. so, there are still a lot of unknowns about these septic systems, from the perspectives of those implementing these systems as well as from those using these systems. and so, since homeowners are the end users, we need to learn from the experiences of the early adopters to identify sources of uncertainty and to address them. it's also important because adoption is currently voluntary, so currently a lot of these systems are either implemented because homeowners are seeking variances because they're required to buy occasional local mandate or because they're participating in a pilot. so, if these are really to be used, we need them to be socially desirable or make them sexy as Alissa said.

So, our goals with this research were to identify some of the factors that drive or inhibit homeowners to adopt these systems and to learn from some of their experiences about uncertainties and their lessons learned. and in doing so, we hope to improve how these systems are communicated, we hope to provide guidance on issues to target to reduce some of the barriers to adoption, and we also hope to better communicate these systems to the public. so, we conducted a series of focus groups, now two years ago, and to inform these focus groups so we started with a literature analysis. so, we looked at the literature on decision making and behavior change models which essentially explain how and why people make decisions, we also looked at literature on technologies that are similar to I/A septic systems, so these are technologies like household solar panels, agricultural best management practices or BMPs, electric vehicles. these are technologies that like I/A systems have high up front initial costs, they're perceived to be environmentally friendly, and they're adopted at the unit of the individual or the household. and the benefit is that these technologies have much longer research histories than I/A systems, so we can learn from these technologies. so, we conducted a series of virtual focus groups in summer and fall of 2020. we conducted five focus groups and we spoke to people who had adopted these systems. as well as prospective adopters from Massachusetts pilots. we did try to speak to homeowners who chose not to install these systems, but it was significantly harder to recruit from this group. we relied pretty heavily on our partners for recruitment and we ended up speaking with homeowners from 25 different households. the focus groups consisted of a card sorting activity called the Q-Sort, a brief one-on-one interview with the homeowners, and then a larger semi-structured group discussion. because we were going about this research shortly after the pandemic began and it had to be adopted to a virtual format, we were not able to statistically analyze the Q-sort due to software glitches and issues using zoom, but it is important to mention because we feel it could have influenced some of the discussion that came after. we recorded the focus groups, we transcribed them, and then we coded them for themes in a software that social scientists used for qualitative data called NVivo. we also conducted an intercoder reliability, so this is when multiple researchers code the same interviewer focus group and compare codes to kind of remove some of that extra subjectivity. and we then created a mental model to illustrate decision making around the adoption of an I/A system.

And when I say created, we essentially modified a model by Reimer et al., who modeled farmer's decision making around the adoption of agricultural BMPs. so, this is a simplified model in that it's linear. we start with the catalysts, which are the initial reasons why people consider adopting these systems. then we have background factors, so these are factors that are external to the adoption process but still influence adoption. then we have our perceived practice characteristics, so this is how homeowners view the process of adopting one of these septic systems and how they view I/A septic systems themselves, and then we have their resulting attitudes beliefs norms and intentions around these systems. and finally, we have the adoption of a system.

In terms of catalysts, there were several that really stood out. these included the perceived need to replace the system because it was old or failing, the need to comply with a local regulatory requirement, and the desire to protect the environment. but we really found that there was a synergy between some of these catalysts and this is illustrated in the following quote “My septic system was failing. if I was going to replace it, I was going to upgrade and accomplish the goal of improving the water quality. there was no question in my mind that I wanted to do something that would contribute.”

Now we have our background factors, and they were really four that were highlighted in the focus groups. and these included whether I/A systems met technical and regulatory requirements, whether homeowners had access to sufficient funding for one of these systems, whether they had the right property for a system, and whether they possessed environmental values. and again, we started seeing a synergy between multiple of these factors. so, one homeowner shared “I’ve seen the degradation of the cove and harbor market markedly over that period of time; it's effectively dead. I did it out of a moral concern that I enjoy the water that I live and play on, and felt I had the resources economically and that it was the right thing to do.”

So next we have our perceived practice characteristics and they were really three here. the first was whether homeowners felt that they could access digestible, trustworthy information on these systems. it was also whether they felt these systems were affordable, and whether they had anticipated any complications or issues with appearance noise and smell from these systems. so, in terms of information, most homeowners felt that the information that was out there was jargony and largely inaccessible. so even after having adopted some of these systems, homeowners still had questions about ongoing costs, maintenance and monitoring, system longevity, and effectiveness. one homeowner mentioned “no one could give me an idea of what it was going to cost to run the system month to month.” in terms of affordability everyone overwhelmingly agreed that these systems were expensive, they talked a lot about not only the initial costs of purchasing a system and installation, but they also talked about long-term costs like monitoring and maintenance. they talked about the cost disparity between an I/A septic system and a traditional septic system, which is also known as a title five here in Massachusetts. they also talked about the importance of a subsidy and offsetting some of these expenses. one homeowner that was required to install one of these systems outside of a pilot mentioned “I don't make that much money so adding another $1,200 a year just to maintain my system which already costs a fortune is a lot.” Finally, anticipated appearance noise and smell was really not that significant of an issue. we had maybe three or four homeowners mentioned some minor they had anticipated issues with like appearance and noise and smell but it wasn't like really a major issue.

So, despite this kind of lack of accessible information that a lot of the homeowners described in the focus groups, we found that they were pretty confident overall about the I/A technology. and this is something that we attribute largely to trust in some of the non-profit organizations that were overseeing some of these pilots. so, one homeowner that participated in a pilot being conducted by a nonprofit mentioned “I have no reason to believe that the pilot organization would tell us something that wasn't true. and the system they have seems very simple.” homeowners also had to be willing to spend their own money, and they had to be reassured that their landscaping and aesthetic concerns could be mitigated and, in many cases, homeowners found really simple easy fixes.

So, this is where our model differs a little bit from the Reimer model that I mentioned earlier. we added this large box with uncertainty, because we found that uncertainty really wove through every aspect of I/A system adoption and through every aspect of the focus group. one homeowner we felt put it pretty perfectly, he mentioned “I think there's confusion on the different systems that are out there. I think for the layman walking into it, trying to navigate the different systems is a lot for ninety percent of the consumer homeowners out there to take on.”

So, this is what a completed picture of homeowner's decision making around I/A system adoption looks like. again, I want to reiterate that it's a simplification. decision making and reality is really complex and it's not linear, and we're currently working on publishing a manuscript on this now. we have one in review. so

now we focus our attention on how to use results from these focus groups, and couple them with behavior change strategies that have worked for similar technologies to potentially diffuse I/A septic systems.

When I talk about diffusion, I also just want to mention that I mean wider scale or wider community adoption. some of the strategies that we've looked at include harnessing pure effects, using normative messaging, information campaigns, financial incentives, and making behavior change convenient. and I'm just going to walk through some of these pretty quickly.

So harnessing peer effects is one of the more powerful behaviors change strategies. peer effects are essentially the influence that our peers have over our attitudes and ultimately our behavior. so, in order to harness a peer effect, you have to model a desired pro-environmental behavior to set a new standard of behavior. this might sound a little counter-intuitive when it comes to I/A systems because they're located underground, but there are ways to make them more visible. so, for example you could use local and social media to publish testimony from adopters such as videos and short articles. and this is something that our partner the Barnstable clean water coalition did with their Shubael Pond pilot. pictured on the right is one of the homeowners that's participating in their pilot, she's sharing her experiences so far with her I/A system. and I also just want to point out that she was important and that she's a community champion. she was one of the first homeowners to buy into this pilot, and she was really helpful in garnering interest and support from other neighbors to participate, so working with community champions is also really important for visibility. you can also have a demonstration site like mastic has, and you can even consider partially exposing or exposing a system to better explain what it is and how it works. signage can also be used by willing homeowners. so, while signage wouldn't necessarily encourage others to adopt, it would shed light on what these systems are. in the focus groups we found that most homeowners were not aware of what these systems were until they either participated in a pilot or until they were required to install one. so, signage would be useful to getting people to start looking into what these systems are and talking about them and would be useful for generating that kind of curiosity. you could also foster learning from trusted sources. this is important because people learn more from the experiences of their peers or others like themselves, than they do from scientific experts. so, creating situations where early adopters can share their experiences with prospective adopters, it's really useful as a vehicle for providing trustworthy, localized, experience-based information that people trust. this is something that was used in the diffusion of solar panels. so solar community organizations are organizations that are comprised of previous adopters, also community organizations, and local nonprofits, and they essentially existed as a resource for curious homeowners to come to where they could learn about experiential information, pros and cons. and they were effective in that they don't have a commercial stake in whether people adopt these systems but they're just a really good use of resource for people's information.

We have information campaigns and this is crucially important I feel when it comes to I/A septic systems because again many homeowners didn't know what these systems were prior to participating in a pilot. and even someone who might know what they are might not know how to go about actually adopting one. and we also have identified a lot of uncertainty and information gaps in our focus groups. so again, people were uncertain about their monitoring and maintenance responsibilities, about the longevity of these systems, they had questions about siding considerations. so, in order to address these knowledge gaps, there are several things that we can do. we could create homeowner informational binders. so, this is something that the Barnstable clean water coalition has done in the Shubael Pond pilot, they've provided homeowners with binders, with a Q&A session and all the information they would need on the system they're adopting, as well as the process of adoption. and they've done it in non-technical terms. we could also encourage realtors and developers to present and introduce homeowners to I/A systems when they're buying a property with an old or failed system. so again, just another way to get the word out about what these systems are. when it comes to an information campaign, it'll be really important to pay attention to how these systems are presented or framed as well as the messaging or the contents of a campaign. so, information campaigns should include localized examples of impacts and benefits, they should include local values and local needs, they should use vivid imagery and visual tools instead of

complex graphs or lots of complicated text. so, a good example is this infographic do your part be septic smart on the right. information campaigns should also appeal to environmental values. this is important because when we spoke to homeowners in the focus groups, every single person had exhibited some kind of environmental value, even homeowners that were required to adopt these systems outside of a pilot. so even people who did not receive a financial incentive still felt strongly about the environment. we'll also have to promote the benefits of installing these systems and this is where it gets a tiny bit tricky because unlike solar panels or unlinked electric vehicles, there really is no mechanism with an I/A system that would save a homeowner money or that would even help them generate money off of the system. but we could still promote some of the societal benefits, this was successful with the adoption of electric vehicles. we could also promote the opportunity to take advantage of temporary incentives or to build an additional bedroom etc.

Another important behavior change strategy is making behavior change convenient. some behaviors such as the adoption of an I/A system can be perceived as costly because they require cognitive effort and time. and we need to remember that the decision to adopt currently takes place within people's already busy lives, where they already have competing priorities. so, examples of the cognitive burden that adopting an I/A system is associated with includes; finding contractors and engineers, system approvals, permit applications, actually receiving a financial incentive if you're going to get one. so, some ways to address this would be to establish responsible management entities or RMEs. I won't go into this too much because I know Brian's going to talk about this next, but in addition to collecting good third-party data they're useful in that they remove some of that responsibility or that burden from the homeowner for like maintenance, monitoring, paperwork, etc. We could also make decision support tools. so, mastic and the buzzards bay coalition had actually teamed up several years ago to create an excel based tool and this tool helped homeowners… they really care about.

So finally, we have financial incentives. and I just want to stress that the biggest barrier to adoption that we came across in the focus groups was cost. some things that we can do to relieve this barrier is to introduce monetary subsidies. so, we could use performance-based incentives or PBIs for nitrogen removal for example. we could use tax credits, rebates, and exemptions. these have all been useful in the adoption of solar panels. where monetary subsidies are not possible, we could also use long term low to no interest loans.

I just want to leave you with a couple of takeaways. through the focus groups we identified that there was a slew of conditions and considerations that will either drive or inhibit adoption based on whether or not they're addressed. we also found that uncertainty is pretty pervasive, and we identified different sources of lacks of information. and currently because there's no requirement to install these systems, if these are to be used as a tool to improve water quality to achieve wider spread adoption we're going to have to work with local organizations or nonprofits that already have the trust of community members and have ideas of what communities need and want. and we'll also have to use financial incentives. so again, we have our manuscript on the focus groups currently in review and we're working on a second manuscript about the behavior change strategies currently. so, if you're interested stay tuned, and if you have any questions, please feel free to reach out. thanks so much.

Sarah: thank you so much. I'm sure that many in this community will be eagerly awaiting that publication, so wonderful. and with that I will ask Brian baumgaertel, if you could go ahead and bring your slides up, please. Excellent. Brian is the director of the Massachusetts alternative septic system test center and is a senior environmental specialist at the Barnstable County department of health and environment. he is a registered sanitarian, environmental health specialist, title v soil evaluator, and wastewater treatment plant operator. Originally from upstate New York, Brian has lived on cape cod for 15 years and currently resides in Mashpee, where he serves as chair of the local board of health. Brian, we look forward to your presentation responsible management entities for decentralized wastewater treatment infrastructure. take it away.

Brian: Thank you so much. Can everybody hear me, okay?

Sarah: We can, yes.

Brian: Okay, very good. So, thank you for joining us today. again, my name is Brian baumgaertel, I'm the director of the Massachusetts alternative septic system test center out here on sunny, it is sunny today, joint base cape cod where we test different technologies and verify their performance, and participate in a whole bunch of different activities surrounding the concept of I/A systems and their use, more broadly. you know we do a lot of testing here, but we also explore areas of financial resources and you know actually just getting these systems out and deploying them into the real world.

You know one of the things that I like to start out with when it comes to RMEs is it's not the most exciting topic. you know, Alissa said a few minutes ago we want to make septic system sexy. my presentation won't do that for you unfortunately. however, it is a very important subject because you know when we talk about I/A technologies and broader use, there are two questions that usually pop up. the first is always well do we have technologies that can compete and that can get us nitrogen removal in the realm that we're looking for? and the answer to that, generally speaking at this time, is yes, it's looking like we're going to have those technologies within the next you know three years or so. possibly three to five years. and then the second question is well how do we how do we manage them? how do we make sure that they're performing? how do we make sure that homeowners aren't burdened by the long-term maintenance and monitoring costs? and some of the things that Alexie pointed out a few minutes ago, you know, that are concerns of homeowners. So that's where RMEs can kind of come in to help address some of those concerns in a more structured way. and what we're talking about here really is something that Alissa had mentioned earlier which is really looking at on-site systems as infrastructure. and that's the reality of the situation is that you know they're infrastructure in every way shape or form particularly when we're going to use them in a larger scale.

So hopefully you've all had your coffee and you're all excited to talk about RMEs.

But first I'm going to give a brief overview of what can I/A septic system is for those who might not be familiar. though I think this is a pretty well-informed audience.

So regardless, there are different types of on-site wastewater treatment systems, you know. cesspools were very common on cape cod up through the 70s. you know it's basically a hole in the ground where all of our waste would go. cesspools were like I said widely used and unfortunately there are still quite a few of them in existence today because they're not necessarily banned by the title v regulations that we use in Massachusetts. individual towns will ban them, but you know there still are quite a few of them. septic systems or the conventional title v technologies, septic tank, distribution box, leech field; pretty simple. the idea here is keep the wastewater away from people, so we're going to keep it underground and we're going to try to get rid of it as fast as possible and that's what title v is designed to do. it's a public health primarily concern with making wastewater go away as quickly as possible without it coming in contact with people. I/A systems are an advancement of the title v technology, you know. you might add some additional components; pumps, levers, switches, wood chips, rocks, membranes. there's all kinds of things that you can add to put together an I/A septic system and you can modify the leech field. some of The work that's been done here at the test center over the years particularly by George hoyfelder who is my predecessor as director here did a lot of work on modifications to leech fields that can actually denitrify pretty significantly. and that work has been done in a lot of locations around the country, including stony brook university. we partner with them on quite a few projects in this particular area and the advantage of those technologies is that they're non-proprietary so anybody could pick them up and use them.

So really historically I/A systems have been looked at as individual systems for individual needs. so maybe it's somebody who wants to add another bedroom onto their house and they live in, what's called in Massachusetts, a zone two. which is an area of nitrogen sensitive area of concern and a zone is a wellhead protection zone that limits the number of bedrooms per acre. and maybe they want to have an additional bedroom so they put on an I/A system so they can get an additional bedroom. or maybe they

have a depth to groundwater issue, or you know there are a number of other different issues. but the key here is that typically I/A systems have really only been looked at as individual systems for individual needs.

But really what we need to think about in the future is how can we utilize I/A systems in a broader deployment and really target some watersheds and be able to use these systems in a broader context. and we're trying to remove nitrogen of course in this case but what we really need to talk about is the aggregate of all those systems to remove nitrogen. we're all familiar with what tmdls are and cwmps and twmps and all the other acronyms. the meps that go along with nitrogen removal in our watersheds. but the key here really, I think is that we need to think of I/A systems more as infrastructure because now we're talking about broad deployments of them and utilizing them in a way that solves a problem that is at a much larger scope. it applies to everybody who might try to use that particular watershed or water body, it definitely has an impact you know for people who are even further away.

So one of the things I like to say is you know 19 milligrams per liter has been talked about in the context of I/A systems for years and years and years and I've given presentations about 19 milligrams per liter well I want you to just basically throw that number out right now because it's not we're talking about newer technologies that get us much better removal than 19 milligrams per liter this number has just hanged hung around and it's you know it's not really helping the issue a lot so if there's one thing you could do today after this presentation is just remove 19 milligrams per liter from your lexicon when you're talking about I/A systems because this is not what we're concerned with anymore we need to do much better and I think that the technologies and the management principles that I'm going to talk about offer the possibility of doing much better than that.

So, this is you know a basic block diagram of what centralized wastewater treatment looks like. you know we're familiar with this, we're moving wastewater from individual homes putting it in a central location and then disposing of it somewhere. you know you have all your staff centralized in one location, you have some folks that are going out to do maintenance on pipes and those types of things, but the idea here is that we're moving wastewater into a central location so that we can treat it and dispose of it.

I/A systems if we're setting this up right and we're thinking about these as infrastructure rather than moving water and waste around we're actually doing the treatment in situ on the site, and then the thing that we're moving around is data and the people that go out and do the maintenance on those systems. so, there is some centralization to the effect of we're putting data in a central location to be able to take a look at it. maybe we're going to use the nitrogen sensor data that but Dunbar talked about earlier in the day or a number of other sensors that are possible, we could use feedback from individual homeowners on how their technology or how their system seems to be performing, and then we can make decisions based on that data and be able to effect change at individual locations. and it's pretty clear where the final disposal is, it's on the lot. the advantage there of course being that we're also recharging our aquifer in the process of treating our wastewater rather than just putting it somewhere else and I would contend sometimes making it someone else's problem but anyway.

So, we need to bring together all these different groups the technology, the users, the regulators, and the managers and try to figure out where that little sweet spot is in the middle where we can try to better manage the systems.

So, what is an RME?

Well, here are some things that I'm not talking about okay

I'm not talking about MREs

I'm also not talking about REM or REO Speedwagon

What i'm talking about are responsible management entities. so there are an organization or collection of organizations that are really tasked with overseeing the cradle the grave life cycle of on-site wastewater treatment infrastructure. if you're using centralized treatment you don't just say we're going to put it in the ground and forget about it and maybe in you know 10 years we'll come back and look at it. you know we're concerned with the cradle to grave concept and i think that is a key part of the application of RMEs is because we're looking at everything from education at the start, and helping to address some of the issues that Alexie brought up with you know just basic public knowledge of wastewater and wastewater treatment systems. but also looking at things like planning and financing and construction and design and operation and maintenance, and what do we do with the residuals? what do we do with the sludge? anybody who knows me knows I talk about sludge probably more than anybody should but it's certainly a concern I think that faces not only on-site systems but it also spaces central sewerage. so, the idea here is to try to put together some sort of a management entity that's responsible for overseeing most of the aspects that are involved in the cradle-to-grave life cycle of on-site systems.

Before there were RMEs there was chaos and some of you might not know this and you're probably looking at my little picture right now but this was me back before the concept of RMEs was introduced to me.

And this is after I found it much younger, I shaved the beard off you know and I just decided I would throw all my reports in the air.

But the basic concept here is how it works now in Barnstable County, the owner works with the designer to get the board a health permit, the owner pays for the system to be installed, then the owner contracts with an O&M operator, then the owner petitions for sampling and O&M reductions, the operators are submitting reports, the owner is arranging for pumping, the owner is paying for repairs, and you're seeing a whole lot of the owner the owner the owner. and I think that's where some of the perception comes out there where people are concerned that you know there are going to be a lot of long-term costs that they're going to have to bear directly and that doesn't necessarily seem fair when somebody across town might be getting sewer and they're paying one sewer bill and that's the end of it for them.

You know that's an area where I think RMEs can come in because we have the opportunity to create a utility for on-site systems and make it like that central sewerage concept. so, there are five levels of RME that EPA has put together I actually don't have my copy handy it's probably in my bag but many times when I've done presentations about RMEs I pop out EPA's little phone dial thing. Where is it? looks like that; the management guidelines. if you'd like to learn about RMEs go and look at this document, I'm sure it could be shared after this or you could email me and ask me for a copy of the link to it. it's a great document put together by a lot of really smart people at EPA to help outline what an RME should be, so get yourself a copy. it's not that long and you'll learn about what I'm going to talk about in a little bit more detail. so, the five different levels; homeowner awareness is the lowest level, maintenance contracts are a step up from that, operating permits is a little step up from that, and then the two that I'm really going to focus on are level four and five. which are RME operation and maintenance and then level five is RME ownership. I'll talk a little bit more about what those actually mean in a moment.

And I'm just going to kind of breeze through these quickly because I'm short on time but

Model one, homeowner awareness. basically, the idea is you're not doing a whole heck of a lot, you're putting systems in the ground and you're hoping that the homeowner's taking care of it. Anybody who's worked in this particular industry knows that that doesn't really work very well. you only need to talk to some of the folks down in Lowndes County Alabama. There's some colleagues down there that work on these systems and unfortunately, they deploy these systems and they don't have anybody to take care of them except for the homeowners themselves and they're doing the maintenance on their own systems so that doesn't work very well. So, model one to me is really a non-starter when we're talking about I/A technologies.

Maybe it's applicable to some place like Windsor Massachusetts where you know you have almost no density maybe you have low areas of concern when it comes to potential treatment from septic systems but really you know you don't need a whole lot of a management entity to run something like that. Model two is maintenance contracts which is getting into the area where we're at in Massachusetts right now.

Maintenance contracts basically the owner owns the system they have to contract with an operator to come in and the operator takes care of the system in terms of operation and maintenance if there's sampling involved maybe they're doing that hopefully you have some sort of a tracking system in place so that you can make sure that the systems are working but that's the basic concept of maintenance contracts. You know it's a little bit better than homeowner awareness but it's not a whole heck of a lot better.

You know maybe it's for some place like Sharon Massachusetts where you know you have some water bodies that you might be concerned about, you're pretty far away from the coast at this point so nitrogen isn't really what you're concerned with but you have you know more density you want a little bit better of an organized method of making sure the systems are working so maybe this is applicable for a level two.

Operating permits again I'm gonna breeze through this one it's just a step up from the last one I talked about but the difference is that there's an operating permit involved and some sort of compliance monitoring so that the owner is a little bit more beholden to the performance of the system because they have to report on it to some sort of regulatory agency in Massachusetts typically that's the board of health local board of health who by the way tends to be very understaffed anybody who's worked with the board of health over the years knows that most towns don't get a whole lot of resources for maintaining their health departments .

Level four army operation and maintenance so this is the first level of management model where we're actually talking about establishing some sort of an entity that's able to do the oversight for these systems in a more integrated way and all these bullet points are really pulled from that document that I gave you a little while ago so I would suggest you know kind of popping into there you know a little light reading for over the weekend perhaps or if you need to fall asleep at night and you can't pull that out from underneath your pillow because that's where I keep my copy and do a little do a little bit of reading on that but you know one of the major pieces of this is that the RME is doing a lot of that operation and maintenance they're taking on the pumping they're taking on some of the repair aspects hopefully there's some sort of a funding mechanism put in place the idea here is to take some of the burden off of the homeowner to make sure that the systems are performing much better than they might otherwise be and that's really the critical piece of this because when we're talking about trying to protect our watersheds we can't just be thinking about individual systems again this is infrastructure it needs to be treated like infrastructure and this first level RME is sort of like that sewering authority except instead of the town owning the whole sewer system this would be like individual homeowners are owning all the pipes and it's kind of a weird analog but that's the closest I could think of

maybe that's appropriate for somewhere like Wellfleet… thank you. maybe that's appropriate this level force appropriate for somewhere like Wellfleet. you know Wellfleet harbor is a major impact at bay embayment and Wellfleet doesn't have really a whole lot of density to be able to do sewering systems more broadly so they might consider using I/A systems and you'd want to be able to make sure that they're all functioning well so you might engage a level RME in the town of Wellfleet just to help make sure those systems are working

and then last but not least model which is RME ownership the critical difference between level and level five is who owns that piece of technology that system that's in the ground at the end of the day. in this particular model the RME the responsible management entity actually pays for all of that cost. so, they're actually purchasing the system contracting with the contractor to put it in and then at the end of the day the RME owns it. the homeowner has very little to do with any of the process that goes into that. it definitely takes away the sufficient or the lion's share of the responsibility for the system performance

from the homeowner. which I think has some advantages some disadvantages, and it's something we're trying to figure out down here on the cape; what is the most appropriate tack to take when it comes to who owns what and when and so on and so forth.

so, some of the benefits obviously you get the highest level of oversight, you know. it's closest to the concept of central sewage because instead of a homeowner contracting with a contractor and then contracting with a pumper and then making sure that the board of health is getting all the data that they want and all their reports have been submitted and if they want to have a reduction in sampling they're going to have to go and get that information all together. in this case the RME is handling all of that and at the end of the day the critical piece is that the homeowner is going to get one bill at the end of the year much like their sewer bill that's going to pay for all of the operation and maintenance and those long-term costs and that all might sit alongside maybe a betterment or something like that which you would have for a sewer. the key piece here is that it spreads the risk out amongst a broader group of people much like insurance does it's not a new concept so that we're making sure all the systems are working making sure that the whole concept is economical and that we're not necessarily hitting homeowners with all of the expenses for trying to clean up everybody's water and maybe that works well for Wellfleet again might be a good place for a level five in Wellfleet.

So, thank you if you want to email us masstc barnstablecounty.org. I have a couple of colleagues on the phone who will help me answer questions that being Bruce Walton who's the chair of the I/A task group at nuia, they've got a great website put together with a lot of information on it so check that out. we also have Scott Horsley on who can help answer questions. Scott's working with the town of Wellfleet and a number of other towns on projects and trying to help them figure out how to use I/A systems and also Allison Bowden is on the line with us to help answer questions. she's with the nature conservancy and is assisting us with the financial aspects of trying to get an RME put together and running in a regional respect here on cape cod. so, with that I will finish up and turn it back over

Sarah: Thank you so much Brian. Could you all please join me in thanking Alissa, Alexie, and Brian for three exceptional presentations. Seems like some of you have already found that reactions button where you can do some little applause. Those are a ton of work and information shared very wonderfully.

SNEP Symposium – Science Bringing Solutions Delivering Environmental Improvement to Southeastern Coastal New England

Room 1, Afternoon Session

May 18, 2022

Kate: In the meantime, we're going to go ahead and get started, the first speaker today. I'm, oh sorry, I'm Kate Mulvaney, I am a social scientist, I'm based in the EPA's research lab Narragansett Rhode Island. We are really excited for the three presentations today, kicking it off for us today, is Dr. Jennifer Karberg. Jen is a coastal and wetland ecologist, she's a research program supervisor for the Nantucket Conservation Foundation and that means she manages research related to all aspects of ecological conservation on more than 9,000 acres of permanent conservation land, her focus is increasingly on nature-based solutions to climate change and sea level rise. She represents the foundation on Nantucket's coastal resilient advisory committee and volunteers as an advisor for the envision resilience Nantucket project. Her recent research includes dune stabilization, salt marsh restoration and intertidal oyster reef restoration. Take it away Jen

Jen: Thank you so much, Kate, I'm going to get my presentation up, here we go, it just takes a minute because I'm doing it through my ipad, but thank you all for being here today and I'm going to talk today about an oyster reef project that the foundation has worked on and it's actually tied to a salt marsh that we've done a lot of restoration on and now we're moving into doing some kind of shoreline stabilization and piloting this oyster castle reef that we put into place just this year. I'm not on Nantucket, which I don't have to tell everyone where that is, I'm actually currently in the Midwest, at the Society Wealth and Scientist Conference and I had to actually put up a map of where we are out here, but the Nantucket Conservation Foundation is a non-profit, on Nantucket we own about a half of the island in conservation land and we do a lot of management and research around the management on our properties and I am a wetland ecologist and doing a lot of coastal resilience stuff.

So I'm talking today because we're starting to explore more and more living shorelines and on an island like Nantucket, thinking about coastal resilience and thinking about what we're going to look like as an island in the next 10, 20, 30 years, is a conversation that's happening quite a bit and I'm falling on the side of the conversation that's really exploring how do we do this, while using or enhancing some of the natural areas that we already have, because we have extensive salt marsh already on the island, we have extensive fairly stable dune systems, how can we enhance those and maybe even add to them, to provide resilience for the island and the foundation out of the 1600 acres of salt marsh that we have on the island, the foundation that I work for owns about 1200 acres, so we're really starting to focus our research on understanding the health of our salt marshes and how we can help them, provide some of these living shoreline of benefits that, you know, improve water quality and habitat and biodiversity while also potentially helping provide resilience to our shoreline.

So this is the project area, it's the Medouie Creek Wetland Complex, which you can see in green here, is a large salt marsh area that we've done some tidal restoration on that's been fairly successful, but in recent years in this front part of the marsh, the kind of smaller part here, just south of the dike road, we've started to experience quite a bit of salt marsh dieback, which has led to some destabilization of the salt marsh sediment, so one of the things that we began to explore in recent years was how to use a potential oyster reef within the harbor to help, really just protect the shoreline from erosion and then think about some additional benefits, so the project site I'm talking about, we have a site, is proposed here, but we just installed it, so I'll talk about that process and then we have some reference monitoring associated with it.

So this is the site, this is where we have been experiencing salt marsh dieback and this is dieback that is driven by herbivory from the purple marsh crab, I know there's a couple different kinds of dieback that we see in New England, but this is a big one that's happening along creek beds and along shorelines and it's a process that we started seeing on Cape Cod and parts of the mainland about 15 to 20 years before we started seeing it on Nantucket, we've really only seen it on Nantucket in sites in this particular harbor, actually, within the last eight years or so and we've been documenting crab populations so that we could tie that to the dieback that we're seeing and what's happening is that the purple marsh crab, it's a nocturnal crab, it's a native crab and it naturally eats spartan alternate flora and it eats the whole plant from the roots, you know, to the shoots, the entire thing, when the population is stable with a stable predator population, it doesn't decimate the marsh, but in areas where something has happened to offset the balance of the crab population, you end up getting these large dieback areas of exposed marsh sediment and so that's what we began seeing in this salt marsh and as we saw this, as you can imagine, even when just daily tidal events, we got calving of the sides of the salt marsh and we're losing significant sediment because there's nothing to stabilize it, so we first started to decide what could we do about this process and we decided to actually act as predators for the crab and in 2019, we began what we call our crab removal research, which essentially meant we set out traps for the crabs throughout the season from May into November, we checked them three times a week and we pull the crabs out and we euthanize them, so within this particular creek, in this particular salt marsh, we're attempting to stabilize the crab population to see if we can get the grass to recruit and give space to stabilize the soil. So we did it in 2019, we actually had a lot of spartinal regrowth, which I'll show you in a moment and we continued in 2020 and 2021 and we'll keep doing the crab removal for quite a bit of time here, we also did out planting of spartina alternoflora in 2020, we had mixed success partly because we just had issues with getting the plants here with shipping slowdowns due to the pandemic.

But we've seen, some decent reestablishment of the spartina by doing both crab control and out planting, we've had pretty high success, this is a photo from last year, so two years of the trapping and one year of the out planting, but as you can see, even though we've had a lot of regrowth in this same dieback area, we still have some bare areas and we're still seeing significant erosion and loss of the sediment, we think this process will get us to where we want to be eventually, but it's about a five-year process so we started thinking about what else we could do to stabilize the shoreline at the same time and that's where the crab project or where the oyster project came into play.

we wanted to install an intertidal reef, so similar to this photo on the left-hand side of your screen where the oyster reef is in the intertidal zone to slow down wave, reduction and force, hitting against the shoreline, to reduce erosion, hopefully to trap sediment also behind that reef potentially to elevate it and allow migration of salt marsh seaward towards the reef, that's one of the outcomes that I'm really hoping to see, I'm definitely hoping to see, you know, loss of erosion, a reduction of erosion, reduction of loss of elevation in the marsh and re-establishment of that marsh stability, but I also think it'd be really great to use this as a method and prove we can use it as a method to help salt marsh actually advance and gain a little bit of salt marsh area with sea level rise.

This is the product that we used, it's called an oyster castle, we got them from a group called Allied Concrete out in New Jersey and I call them legos, legos for adults, legos for wetland practitioners, they're hollow in the middle and then the edges are sculpted so that they actually interlock to create a fairly stable reef structure and they're made of a substrate that oysters like to attach to.

We did a lot of environmental monitoring beforehand, just to go through the permitting process, we started with transects and pink both in the restoration area where we wanted to put the reef and in a reference area and then through the permitting process we actually added additional transects on either side of where the reef is going to go, to look at if there's any edge effects to where the reef itself is in the water, on those transects we are measuring vegetation, composition, amount of bare ground that we're seeing, we're using RTK GPS along those transects to look at elevation, to document elevation there's no set stations out in this marsh previously, but we wanted to start with elevation now, so we're using the

RTK and we actually also use drone imaging to get detailed elevation models in the early part of the season before the vegetation comes out and we'll do that each year. We also have lagers to look at water level, dissolved oxygen, temperatures, fat collectors out to look if there is an oyster population and then we use this fabulous logger from Lowell Instruments in Lowell, Mass and it's called a tilt meter and it rotates on its axis and actually records the degree of rotation and the force of water movement so we can actually document where water is coming from, how fast it's moving and how tides are changing, so we can get an idea of the dynamics of the water within that site and then how that changes when the oyster reef is in place and actually have data to show how the oyster reef impacts water flow in the area.

So with all that data that we collected, we designed what the oyster reef was going to look like, this is the site prior to restoration, we got mean water depth so we could design the height of the oyster reef, so the oyster wouldn't be exposed for too long, we looked at salinity, as you can see, it's a fairly degraded as far as habitat goes, there was no submerged aquatic vegetation in our shellfish surveys, we found one quahog out here, our spat collectors saw no oyster spat whatsoever in 2020, we had two in 2021 come in, so there's not a huge larval population out here.

So from that data, we designed a reef structure that is three oyster castles high, which puts it about two feet, we'll get some settling in that substrate, which you can see looks fairly soft, so the reef will provide a place for oysters to actually attach to and then we took about a third of the oyster castles and sent them to our town of Nantucket shellfish hatchery and we set spat oyster spat on those castles so we could start with a base oyster population.

And then we went through permitting and this is the first kind of intertidal oyster reef of this structure using the oyster castle structure in Massachusetts, our permitting was pretty extensive and much longer than we anticipated, both because it had a really intensive review process and then of course the pandemic kind of slowed the process down, but it took about 18 to 20 months, between local and state and Army Corps review of the process, it was actually the chapter 91 license that took us the longest amount of time and consisted of us calling the governor's office saying we had baby oysters that were going to die if we didn't get this reef in place, and we got funding for this, that's a significant funding for the process, we got some initial funding from our local shellfish association and then we enrolled in the Massachusetts In-Lieu Fee Program, which is really the reason that we were able to do this project and offered significant support in moving through the permitting process as well, which was really great for us. There's a required five years of monitoring attached to the In-Lieu Fee Program and set aside money in that budget for mitigation in case we have to rebuild the oyster reef over time and then we just have to provide yearly reports back to the program in the Army Corps.

We got our permitting finally, in November of last year, I got it right at the end of October and I looked at the tide charts and the weather and I said, well, it's going to be sunny in 50 degrees with low tides the first week of November, which is not usually when you want to be in the water in Nantucket, but we decided we were going to make it work, so that we wouldn't lose our oysters, we pulled in a whole series of volunteers, we're a non-profit, so this wasn't a project that we used, you know, barge and crane work for, we used people and we used small boats and we built an oyster reef out on the site, it took us three days, working about four hours each day, around the low tides, we definitely found that sedimentation in the area as we were moving through it made it harder to build the reef, we practiced building it on dry land first so that we could then go out and place it.

And after three days, here's an aerial photo of the reef we put in, so there's three linear reef structures and you can see the creek mouth here, that's coming out of the salt marsh area with the dieback associated to it, we staggered the three reefs over the mouth so that we could still have drainage out of the mouth, but have water flow through where that reef structure is, this reef over here on the left-hand side actually ended up extending just past that white boat, so to kind of cover that whole area. In this, we're going to continue, as I said, taking data associated with this over, you know, the next five years and look at how it impacts salt marsh health care, but also hopefully, documenting how it helps that salt marsh, maybe adapt and move outwards and provide fairly localized resiliency, as a pilot project, that

could potentially be implemented other places in Massachusetts and be replicable, hopefully and perhaps with a shorter permitting period, once we go through the proof of how this project works.

And my data is here, if you would like to reach out, unfortunately I won't be able to stay through to the end of the question period for this presentation today, if there's time for a question or two now, I could do it, but if you want to screenshot my information and reach out to me, I'd be happy to answer any questions about what we've done with this project and I'll transfer back over now to teams and stop my presenting. But Kate, I don't know if you want me to, if we have a little bit of time, to take questions or not, I could do that now or drop off.

Kate: So, you finished four minutes early, so she still, so she's got, I didn't have to cut her off, so if somebody has a quick question. MaryJo has a question here in the chat now, what factors did you consider when selecting your reef material that led to choosing the legos and now that you've been through the permitting process for the material, do you think permitting would be possibly quicker in the future or do you have tips for others interested in doing so? One question before you scoot out.

Jen: Sounds great and that's a really great question, thank you, so there had been our shellfish hatchery had done a kind of a reef installation where they used the shell bags on an island and it wasn't so much a protective reef, but a reef within a small embayment, but we felt what they found was that those bags just sank so much and got silted over, that it wasn't an effective substrate so we wanted to build the reef knowing that we would get sinkage at the bottom but at least the top layer and a half, two layers would be able to provide, hopefully good substrate, for those oysters to survive and that's one of the things that will hopefully document over time and when I went looking for possibilities for a reef you can do, you know, like the reef balls are a similar substrate but didn't necessarily give that protective factor that we wanted to see for this reef, so we found the oyster castles and the company that's doing it, they've done a lot of restoration work in Chesapeake Bay and some other areas for their oyster reefs down there and he was really excited to help us get something going up here in Massachusetts and maybe even going other place. From the permitting perspective, I hope that things go faster, smoother and easier particularly once we get documentation of what we're doing here. I mean, I really think the best advice is to reach out to the organizations that you're getting your permitting through, before you even start the process, so that you can make sure you're checking all the boxes at the right time and get a lot of it, you can get a lot of advice on what that permitting looks like, but and I've had a lot of these conversations lately with both different state organizations and people that are looking to do projects, permitting is one of those big hurdles we have to jump through for post-resilience projects and I think it's something that we have to think about, you know, do we provide guides for how to do something like this, that's one thing that I think would be really great, resource guides or potentially ways to facilitate maybe a faster, smoother permitting process for projects that are proven to help with post-resiliency, but I think that's something we'll probably all be discussing in the in the next couple years.

Kate: Thank you, Jen, and so a round of applause for Jen before she scoots off.

Jen: Thank you.

Kate: And then, we still have two really great speakers for everyone else and we will have a question and answer session at the end. So our next speaker that we're lucky enough to have today is Dr. Micheline Labrie. I'm going to read her bio so I get it right. She is a research assistant professor in the Department of Estuarine and Ocean Sciences at the school for Marine Science and Technology at Umass Dartmouth. She's primarily a biogeochemist, whose research includes nitrogen cycling and quantification and evaluation of innovative nutrient remediation approaches in estuaries. So, Micheline, take it away.

Micheline: Thank you. Okay. Hi everyone, thank you for joining a session for my talk on floating oyster aquaculture in southeastern Massachusetts.

To start, I'm going to talk about nitrogen enrichment and how it applies specifically to this region and the application of oyster aquaculture and I'll go into my primary research questions, the first being what is the spatial distribution of oyster biodeposits across receiving sediments and second, do oysters enhance sediment denitrification.

As we know, anthropogenic eutrophication is a worldwide problem in southeastern Massachusetts, the contaminant of most concern is nitrogen and so towns and managers must develop management plans to address nitrogen enrichment. This image illustrates the various roots of nitrogen input, you have atmospheric deposition, urban runoff, agricultural surface runoff and as we've seen today, there are also multiple approaches to nitrogen reduction and one being nitrogen can be reduced at the source, so say wastewater treatment plant, two, nitrogen that enters the groundwater can be reduced in transit and then three, the nitrogen that reaches the estuary can be removed through burial or denitrification.

And we know that, sewering is the traditional approach, but it's expensive and invasive and we've seen today, again, there are multiple viable non-traditional approaches, technologies which can be less expensive and less invasive, however, we need to quantify the amount of nitrogen that can be removed before these approaches can be incorporated into TMDLs and water quality management plans

So here are five approaches to nitrogen reduction, they're all less expensive, they all have their own advantages and disadvantages, we have composting toilets, denitrifying septic systems, permeable reactive barriers, pond and wetland restoration and floating treatment wetlands, and the composting toilet and denitrifying septic system are approaches that remove nitrogen at the source, PRB and pond and wetland restoration reduce nitrogen as it travels through the watershed, and the top figure shows a PRB with organic carbon is injected into the groundwater, ground to intercept nitrate as it flows through the watershed and then similarly, we have waterside nitrogen can be reduced through natural processes and freshwater ponds along the transport pathway to the downgradient estuary.

But the sixth non-traditional approach is, oyster aquaculture and this is an image of a floating oyster aquaculture, deployed through the town of Orleans, is part of an oyster, started as part of an oyster demonstration project that has been turned into a full-scale commercial aquaculture site, so this approach has been used by town of Orleans, Falmouth, Mashpee, Barnstable, Wellfleet, Westport, Harwich and Dennis Massachusetts and so our research attempted to quantify the nitrogen removed through oyster aquaculture.

Oysters increased water clarity through filtration of water through their gill and trapping of particulate matters to phytoplankton detritus bacteria, oysters are unique in that they don't stop filtering when they're full, however they are selective feeders and they reject excess particles or less nutritious particles as pseudo-feces, so these fecal pellets and pseudo-feces are collectively called biodeposits and these biodeposits are more compact than the ambient particles and tend to settle faster through the water column. Number one, nitrogen enters the estuary and stimulates primary productivity or the production of phytoplankton, two, oysters filter this phytoplankton of particulates from the water column, three, they can assimilate the ingested nutrients, some of which is excreted and these excreted nutrients remain in the water column where they're available again for uptake by phytoplankton, and then five, the un-ingested or undigested portion is voided as biodeposits, which are released from the floating bag to the water column. And the carbon and nitrogen in these biodeposits settle to the sediment where they're available for microbial processing or they may be permanently buried in the anoxic sediment layer, six here represents just the background settling and all this nitrogen reaching the sediment can be mineralized to ammonium, which can be released back to the water column or remain in the sediments and be transformed to nitrate through another process called nitrification and then if that nitrate is proximal to an anoxic sediment zone then it may be converted to N2 through denitrification and then this N2 is released to the atmosphere and is permanently removed from the system.

Floating oyster aquaculture is thought to remove nitrogen through assimilation of nitrogen into the oyster soft tissue and shell denitrification in the sediments and then burial in the sediments, so in order to

quantify these permanent removal pathways, I had to quantify the individual arrows and I'll show that at the end, and last to look at the effect of that biodeposits have on the sediments, I had to quantify biodeposition rates and the distribution of biodeposits on the receiving sediments.

Also, in addition to permanent nitrile nitrogen removal we found that oysters improve water quality by reducing the particulate organic nitrogen and chlorophyll and increasing water quality, sorry water column clarity as the water flow through the oyster bags. In this plot, we have the x-axis is the distance from the center of the oyster deployment area expanding extending outward away from them, and then the y-axis is the excess articulate organic nitrogen compared to the oyster site at each water quality site, so the main takeaway from this is that, once the oysters were put in place there was a gradient established in the water column PON.

So to quantify nitrogen removal, the first question becomes, what is the spatial distribution of biodeposits on the sediments and to answer this question I developed a numerical model to predict the biodeposition area or the area of sediments over which the biodeposits are settling, so this model incorporates the biodeposit settling rate, the wind and tidally driven currents, the tidal range and the depth of the oyster deployment area, so as the biodeposits settle through the water column they are dispersed by horizontal currents and the model is described by this analytical equation the displacement depends on the stage height as a function of time, velocity as a function of depth and time, and biodeposit settling rate which is a constant term. In this figure here, the stage and velocity vary through time, at high tide the distance over which the biodeposits can be displaced is greatest, but the velocities are minimal, so these interacting elements control the displacement and they're going to be site-specific.

So here are the model results for Lonnie's Pond, which is estuarine basin of the greater pleasant bay estuary, it's located in Orleans, the polar plot shows the predominant direction and displacement distance of biodeposits from the source location, so the source location being that oyster bag here, the maximum distance was 10 meters, but most are displaced within four meters of the source bags, so then on the right we did a 2D grid was created, detailing the position of the individual floating bags, which within each deployment site, so these little dots are each floating bag and the model, biodeposition displacement were recorded as these heat maps of biodeposit intensity overlaid with the floating bags as the point sources, so in the absence of horizontal currents biodeposits settle directly below the bags and in low velocity systems, most biodeposits settle directly below the bags, but not all, so you still have this gradient beyond the floating bag area and like the polar plot, the biodeposit area extends to the northwest, so the biodeposits in Lonnie's pond at the site, on average, are towards the northwest and this is driven by the non-tidal currents, so sorry going back, we have this simple model that shows the predicted intensity based on this these analytical equations and we verified the model using flux rates determined by sediment cores collected within and outside of this biodeposit area, so you can see the cores are labeled C1 through 16.

And the next question, question two, builds off of question one, the sediment cores that is showed, we used to validate the model were also incubated to determine sediment nitrogen fluxes between the sediment and the water column, from these incubations we measured total dissolved nitrogen, nitrate plus nitrate, ammonium and N2, we determine denitrification rates using isotope ratio mass spec, so that measures the N2 excess with its ratio of inert gas argon.

So straight into some results, these are three years in Lonnie's pond starting 2016 to 2019, we conducted fluxes in summer, fall and then the following spring, these are the mean denitrification rates for treated and controlled cores and the cores were identified as treated or controlled based on their location relative to the biodeposit areas, so were they receiving oyster biodeposits, then we conducted t-tests to determine whether denitrification was significantly enhanced above the background and you can see that eight out of the ten flux dates had significantly enhanced denitrification and these two that were not, the august and september 2017, they had sulphatic surface sediments so they were anoxic to the surface which likely inhibited denitrification or coupled denitrification from occurring, and so now we know if there are too

many biodeposits settling in one area then the oxygen demand can be elevated and the sediments can go anoxic.

Through this research, I was able to quantify the nitrogen transformations, starting with the nitrogen removed from the water column, by the floating oyster aquaculture deployment, the numbers contained within the red arrows are grams of nitrogen per meter square and this is standardized to a 225 kilogram dry tissue weight deployment, this represents the three years of data collected from Lonnie's pond and the red arrows represent the flow of nitrogen in an estuary when the oyster aquaculture is present and the beige arrows are represent the nitrogen cycle in the absence of oysters, so what's going on in the background, so we have number two here, that's the nitrogen assimilation into the oyster tissue and shell, that's one of our removal terms, number three is excretion, as I said, that's nitrogen available, once again, for uptake by phytoplankton, four is the nitrogen voided as biodeposits, you'll see that's nearly equivalent to this simulation term and as part of question one, I quantified biodeposition rates and where those biodeposits end up, so after, and then after biodeposition number five is the background sedimentation of nitrogen and this deposited nitrogen, whether from background or the biodeposits, can be removed from the system through long-term burial, but this burial term is going to be small relative to assimilation into the oyster tissue and shell or sediment denitrification, and you can see in number seven the regeneration of nitrogen is large and the denitrification is small in comparison, most of the nitrogen is regenerated in the water column, but about 21% of that deposit of nitrogen is denitrified and then you see most importantly, the majority of nitrogen was removed through assimilation and then the harvest of the oysters from the estuary.

Considering the 2020 Lonnie's pond oyster deployment, you see that 109 kilograms of nitrogen was removed through both assimilation and harvest and denitrification, and that 15.5 kilograms of nitrogen was removed through sediment denitrification and that's just this southern plot in the map here, the target annual removal for Lonnie's pond was 75 kilograms nitrogen, so that goal was exceeded with 93.1 kilograms nitrogen removed and that was just for oyster harvest, and this plot here shows the day number on the x-axis, so that's the number of days from the start of the oyster growing season, and then the y-axis is nitrogen removal in kilograms, and you'll see that there are negative values to start and that's just the addition of the oysters, the deployment at the beginning of the season. So for all of this, currently the cost to the town for this remediation method is 270 dollars per kilogram nitrogen per year, because it is a novel method and it requires the full compliance monitoring such as the bi-weekly water quality monitoring, the sediment nutrient fluxes, all that analysis and you know, tracking the input and output of oysters and looking at the nitrogen carbon content of those oysters, but if this remediation method came into more general use, that cost could come down to 107 dollars per kilogram nitrogen per year because the monitoring could be much reduced from its current amount and then unlike other, a lot of other remediation methods, oyster aquaculture, it generates a valuable product, so this commercial oyster grower that's there currently, can sell these oysters and from a figure I got from the DMF annual report, the economic value is about seven dollars per kilogram oyster.

So in conclusion, to quantify nitrogen removal, we developed the simple model to predict the bottom area over which biodeposits settle and then using the model, we found that oyster aquaculture can enhance coupled nitrification denitrification and sediments that remain anoxic, we found that nitrogen assimilation removes the most nitrogen followed by denitrification and then sediment burial and the nitrogen assimilation denitrification in Lonnie's pond can remove 109 kilograms annually and with reduced monitoring, the cost of the town could be 107 per kilogram nitrogen per year.

So with that, I'd just like thank you and that's it.

Kate: Thank you Micheline. We're going to save questions for the end if you want to put them in the chat that's okay if you want to gather your thoughts and then we'll have Micheline after this next talk. Our next speaker is Sharl Heller, I'm going to read her bio to get it right. Sharl Heller is the co-founder and president of the Southeastern Massachusetts Pine Barrens Alliance, the SEMPBA, an all-volunteer organization that operates a climate and nature center at the beautiful Center Hill Preserve on Cape Cod

Bay, that's in Plymouth, Massachusetts. She is a co-founder and coordinator of the Massachusetts Coastal Pine Barrens Partnership, which in 2015, joined the Regional Conservation Partnership Network, a multi-state network of partnerships collaborating to advance the pace of conservation throughout the Northeast. Sharl, did you find, did the share come up for you?

Sharl: yes I think ready to go

Kate: Alright, that's wonderful, alright, so you can go ahead.

Sharl: Okay, let me share my screen. How's that? Hello?

Kate: it looks great.

Sharl: Okay, thank you, because as one of our other speakers said, I'm a zoom girl, so this is a little tricky for me. Hello, everyone and thank you for letting me share this, I'm really standing in for Carl Honkanan, who is the forest watershed specialist for the Forest Service in the eastern region, Carl originally proposed this presentation and unfortunately or fortunately, was called away on forest service business and he asked me if I would stand in for him and of course, I was happy to do so. Carl wanted to share this, the Massachusetts Coastal Pine Barren Partnerships USDA landscape scale restoration grant that I was involved in, me and my partner, Frank, from the Southeastern Massachusetts Pine Barrens Alliance applied for this grant and we received this three-year partnership grant.

And let me just talk a little bit about our coastal pine barrens partnership. We formed in 2015, as was said and we're one of 52 partnerships in the regional conservation partnership network, the Massachusetts coastal pine barrens partnership is the community united in protecting, restoring, managing, linking, celebrating and recreating within the unique environmental resources of the Massachusetts coastal pine barrens. You might be saying, well where is this Massachusetts coastal pine barrens.

And I will get to that in a minute, but first let me introduce the pine barrens partnership steering committee, as the president of SEMPBA, we formed the partnership with the help of Heidi Ricci, who I saw was on this talk earlier, and Mary Griffin, who many of you may know. This partnership that formed in 2015 brought together others into the partnership, Heather McElroy, who I also saw was on the meeting today, from Cape Cod Commission, Eric Walberg, who was formerly with Manomet Inc, he was a leader in climate services there, Tim Simmons, who many of you probably know from NHESP is on the partnership, he is now the owner of Simmons Stewardship and Conservation Ecology, Paul Gregory, management forester for DCR, he was actually the one who brought this LSR grant to us in the first place, suggesting that we apply for it, and James Rassman, another DCR staff person, he is, was at the time stewardship coordinator for walkway bay national estuarine research reserve and Mary Griffin, who at the time of this grant application, was the regional director southeast for Cape and the Islands for the Massachusetts Audubon Society. And SEMPBA, as I've mentioned, it is an all-volunteer organization we formed in 2013 and formed this partnership in 2015. I think Carl wanted to highlight us because of this partnership and because of how much volunteer effort went into it.

So here's a rather fanciful picture of our ecoregion, this was an artwork created as part of this LSR grant. I'm showing this because, we weren't just involved in restoration, a large part of our effort is to really involve the public, non-scientists, in restoration and conservation of this area, so it involved a lot of different aspects, including this kind of a fanciful vision of the eco region. Now, the Massachusetts coastal pine barrens includes 34 towns, it covers about 615,000 acres, 492,000 of that is estimated to be former or pine barren's habitat, I say former because under the rate of development we're losing forested land and habitat at an alarming rate, which is why we formed the conservation partnership and this area is the second largest of the three remaining coastal pine barren eco regions in the world, the other two being the New Jersey pine barrens and the Long Island coastal pine barrens. Its globally rare habitat, it contains about 40 natural communities and about 200 state listed species.

This was the end result of the LSR grant project, the entire project, all the data and information from it, is on this website and is available for anyone to download the project, so the Forest Service really does a wonderful job of providing support and ways to show off or allow other people to access the projects that they partner with. Anyway.

Our grant was called Rebuilding the Massachusetts Coastal Pine Barrens, of course we can't rebuild them all at once with one grant, but it was an effort and I've broken it into our, some of our projects, into four different categories, habitat restoration, regional conservation planning, education and branding, in our way to make coastal pine barrens a household term and it and that was important to us because many people living in this region have never heard of coastal pine barrens, they know that we look a little different from the rest of the state with our stunted forests and rather sandy habitat landscaping, but they don't really understand that we live in a globally rare eco region that's very distinct and so branding is a big part of our effort for this grant.

But the habitat restoration we did was, kind of exciting, our first project that I'll talk about here is Tidmarsh Farms, I have Tidmarsh Farms labeled here because, I knew it first as Tidmarsh farms, but it's now a Mass Audbon property called the Tidmarsh wildlife sanctuary, it's a 400 acres of former cranberry bog and it's the largest freshwater ecological restoration in the northeast, if you haven't seen it, it's amazing, after re-channeling the bog, they recreated at three and a half miles of stream that runs through this property and it went from pretty much being a denuded cranberry bog to this, in just a few years, a flourishing wonderful area with the white cedar swamp and ribbing herring returned, it's full of birds, it's just amazing, I really encourage you to visit there, it's here in Plymouth and what, you know, with this 481 acres, there was still quite a bit of area outside of the river channel that needed to be restored and this project helped Mass Audubon restore two former sand pits to a sand plain natural community and remove invasive plants on a 10-acre site, which were replanted with pine barrens, shrubs and seeded, and the Mass Audubon then created a volunteer program for mapping invasive species and created a geo-database to track treatment and the success of the treatment and removal, so Tidmarsh was a very active partner in restoration, as was the town of Plymouth.

This grant involved David Gould, who's the director of marine environmental affairs for Plymouth and you'll see him on the right side of the screen, talking with Carl Honkanan, and that's Carl on the left side, standing in front of a very large patch of diseased red pine, David Gould felt that this was an important part of the project to remove those dead trees and allow pitch pine scrub oak to grow again, this forest is right in the middle of a very dense part of Plymouth and very close to a school and David considered it a a fire hazard and of course, we're trying to get more early successional pitch pine to grow in this area, so that was meant to be a 12 acre removal, unfortunately by the time we actually got around to hiring the company to remove the white, the red pine, the price had increased, so we were only able to do about half of the original restoration project, but it was finished and it's on their way to a lovely forest.

Another big part of this project was mostly under the direction of Manomet Inc., some of you may recall this was the Manomet, the Manomet Observatory, sorry I can't remember now the name of it and also with Cape Cod Commissioner Heather McElroy was a big part of that, so the project goals for the regional conservation vision map planning, was to be the creation of a conservation vision map that could serve as a regional standard, to outline the linkage of biodiversity support and climate change resiliency, develop a green infrastructure map for the ecoregion, publish a booklet of results derived from the green infrastructure mapping process, incorporate habitat protection and management into the Cape Cod Commission's regional planning activities, including their regional policy plan and to create a coastal pine barrens conservation vision online story map, which I will share with you later.

So, to begin the regional conservation vision map planning, the partnership began with the definition of a vision map, with a comparative review of 30 different towns' open space and recreation plans, their hazard mitigation plans, local comprehensive plans and municipal vulnerability preparedness reports and this was mainly done by a young woman, Alyssa Young, who was our terracore member for the year for the southeastern Massachusetts pine barrens alliance and for the partnership, and Alyssa, not only did

she review all of these plans, she created an easy way of comparing what the priorities for each of these towns were, hoping to find a way to bring in a conversation that included an understanding of what these different towns felt, what's their highest priorities and where they could coordinate and cooperate in different areas of priorities. Alyssa also went in person, doing surveys of conservation commission members and different natural resource department heads, as a preliminary to inviting them to a series of workshops that the partnership hosted.

And here is some photos from those workshops, we hosted four stakeholder workshops at different locations throughout the eco region, we engaged conservation staff from 15 towns,19 conservation organizations and several state and federal agencies, all together 90 stakeholders participated in these workshops and we gathered local information and suggestions for the data layers to include in the final green infrastructure map, it was felt at the time, this is Eric Walberg there at the map, at one of our stakeholder workshops and on the bottom you can see that, first we gave a presentation and then we laid out maps and gathered local knowledge of what was actually conserved land or any of these questions that might have come up with the mapping process that you just can't get from looking at maps, you need that local information and that local input, but as I said, we had started engaging people, stakeholders, from the different towns so that they would know that we weren't just creating a map overlaying the community in the entire ecoregion without input from them and without understanding what their priorities were, so I thought that these workshops were highly successful in engaging people.

So here's some of the components that Eric Walberg and Heather and her team from Cape Cod Commission worked on, the green infrastructure components were areas of above average resilience, they were drawn from the BioMap2 core and critical natural landscape mapping and they included surfaces, water surfaces within, I'm sorry areas within 100 feet of water surfaces and those created our green infrastructure map and then from the green infrastructure map, I created a map of the undeveloped and unprotected green infrastructure.

And as you can see from this slide, 53 percent of the green infrastructure network is currently undeveloped and unprotected in our ecoregion and this represents 39 percent of the study area or about 243,000 acres, so these are the areas that we want to focus on for conservation and regional planning.

And from that grant, we were able to create what we think is a very helpful topographical map of the ecoregion with those, the undeveloped and unprotected areas in dark green and the lighter green are areas that are in conservation now or in some way part of that green infrastructure, this topo map, by the way, we have a very flat ecoregion and so this is blown up seven times in resolution to get this lift for the topography.

Now the story map, created by Cape Cod Commission, is was a very important, we all agreed that having a record of the project and a record of the planning and our products from this grant was very important this is a just a screenshot basically of that story map and to the to the left there is how you can access that story map and I think it came out really nicely.

And includes interactive maps as well as the a link to the where do you love site where we've asked people to share what they love about this community, so I hope you will visit that story map. Education.

Kate: You're about running out of time, so just start to head towards wrapping up a little bit,

Sharl: I'm sorry, I'm almost done. Anyway, education was a very big part of this, part of the grant was to develop a climate and nature center and as you see, we were able to lease the town property and this building is at the Center Hill Preserve and it is open for, it's where Southeastern Mass Pine Barrens has their headquarters and it is also, we share this with an indigenous resource collaborative, a native group that runs programs and stuff out of that, so please come and visit us at some point.

Here's another aerial view of it.

And just briefly, this is part of our branding process that we went through, we developed these interpretive panels to be placed at several department of Massachusetts and conservation parks in the southeast region.

And this is the last thing I'll share with you, this is another attempt to brand and have people become aware that we live in a unique globally rare ecosystem, these different roadway signs are placed around Plymouth and Carver and are slated to go in different parts of the Cape as well.

And this is all I have, Thank you.