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PFAS in Agricultural Operations

Good afternoon. Let's get started. Welcome to today's webinar entitled PFAS in Agricultural Operations. My name is JEN Ryan and I am a natural resources specialist for the conservation services support center and I will be your host. I'm excited about today's webinar brought to you,. [Inaudible]

I want to take a moment to remind us that the use of trade names in any of our webinars is for information purposes only. Mention of a trade name does not constitute, nor does it imply endorsement by the department or, with that we will now begin. I would like to introduce Jeff Porter. Located at the east national technology center in Greensboro, North Carolina. His main responsibilities include reviewing and evaluating innovative technologies in manure management. Working with states to assist in the transfer of these technologies to help carry out the mission. After working for the agricultural research service he transferred to NRCS and worked in various Michigan, Missouri, Iowa before accepting a position with the nutrient management team, formerly manure management team. He received,. [Inaudible] Cultural engineering. Jeff, you may now begin.

Well, thank you very much, Jan. I appreciate that. I want to thank all of you for joining us today as well. It's great to come and to hear about this topic. As was earlier mentioned. Our webinar is being conducted jointly and it's an honor to be working on this endeavor. Here we are. Polyfluoroalkyl substances, if you can say that without messing up 3 times in a row, you're an expert. This is take two. What I mean, this is the second webinar. We're looking at the area of PFAS. A few months ago in the first session, we looked at the history of PFAS, the impact on water, and reviewed a few of the removal or remediation technologies. We saw that these human made chemicals that consist of nearly 5,000 different compounds, PFAS has been manufactured and used around the world since the 1940s. So it's been around for a long time. But it's something that's just now becoming on the forefront for many of us we've not heard a lot about it. But it's something that the people have been looking at for some time. And they call these forever chemicals because they are so persistent in the environment. And they break down very, very slowly. Today what we're going to do is take a little different perspective in addressing PFAS. We'll be rooking at the impacts of PFAS in soils in manures, and in biosolids. And we'll be looking at the impacts it can have in agriculture applications. And we'll be looking a little bit at what are some of the background levels, since this has been around for so long and it's in everything. What are the background levels and what are maybe the levels of concern that we should be looking at as we're dealing with some of these issues and areas from the PFAS from a solids perspective. And I will tell you we're privileged to have two of the experts in this field. I mean, these are the nation's leading experts in the area of PFAS research related to this area of the solids component of PFAS. So I'm excited to have our two speakers today. The first speaker is Mr. Ned Beecher. And from 1998 to 2019, Mr. Beecher served as the executive director of NEBRA. And that is the Northeast Biosolids and Residuals Association. And what he did he tracked research. Worked with legislation, regulation, provided information to members and to the public. And NEBRA is a regional biosolids nonprofit professional organization. And Ned now serves as a Special Projects Manager for NEBRA. He leads projects, authors articles and papers, makes presentations on biosolids management around North America and much of his work since 2017 has been on the area of PFAS. He is leading a nationwide project compiles state by state a nationwide biosolids management data. He has two adult children and lives, works and gardens with his wife in New Hampshire. Our second speaker is Dr. Dr. Linda Lee. She's a professor at Purdue University. My alma mater in the agronomy department. She joined Purdue in 1993 after, Ph.D. in soil chemistry and hydrology at the university of Florida. She has established a vibrant research program focused on understanding the processes that govern these environmental, and the remediation of these contaminants in all types of media. Con contamination mitigation. Industrial and agricultural settings. For the past 15 years, Dr. Lee has focused on PFAS research as related to environmental behavior, and remediation. She's served on national and international advisory groups and addresses Fairland biosolids policies. Chemical risk prediction and management. Sustainable practices and consumer products, regulations involving these chemicals. Again, I'm excited to have these speakers because of their expertise in this area. And I look forward to the information that they'll be presenting today. So with that, I would like to give control to Ned Beecher. .

Welcome, everyone. Thank you, Jeff, for that introduction. And hopefully, this will be useful information for all of you. Here's the out. We're looking at PFAS, widely used chemicals. Why is there a concern about PFAS regulations? Sources of PFAS in soils and on farms with the audience being focused on agricultural concerns. Why biosolids are applied to soils. Data on manures and farm soils will give some general examples. Fate in soils. And a quick mention of those things. And ongoing research. I'll do some general overview. Broad brush, big picture information. And Dr. Lee will provide chemistry and details on the research and the state of the knowledge. We're going to move quickly because there's a great deal of information. PFAS are chemical that is of emerging concern. One of the emerging concern chemicals that are most extreme in their worst case and in the fact that they are very persistent. They don't break down in the environment and are difficult to break down in a laboratory. And they are the only common trace contaminants of drinking water that is regulated in the low parts per trillion. Parts per trillion. Why is it a concern? There's widespread contamination. These are found worldwide in all environmental matrices: They've been distributed across the globe and through various mechanisms. And there are places where there are higher concentrations due to ground water and drinking water and other contamination by industries and firefighters activities. There are concerns to the public and are kind of scary because of the forever chemical concern about that. That they don't disappear. They are in our bodies as well. Community groups and researchers are calling for more action on them. Some states are taking action. There are voluntary phaseouts which are good things. EPA negotiated a phaseout for PFOS And the ski industry, chemicals in ski waxes. Some of them are beginning to phase out. And there are many perspectives and it's a huge topic. Look around the internet to get a sense of the different ways of looking at this concern.

in the news, there are a couple of things that have popped up regarding agriculture in particular. And we'll talk some today about these two situations in, on Maine farms. I'm based here in New Hampshire. And this has been a concern in New England in the last several years in particular. And Maine has investigated and I've got a ways down the road in understanding PFAS especially related to farms. And in a few situations. And then the New Mexico dairy situation hit the press considerably and that's where some fire fighting foam affected ground water and impacted the farm. So we'll talk a little bit about that with this focus on agriculture. implications for that on farms. So PFAS are widely used. This is a fairly recent paper in the royal society of chemistry that gets into some of or really is the most expansive in terms of the different uses of PFAS chemicals from the research perspective. And your iPhone, your cell phone may have multiple uses of PFAS in it. and then the concern gets greater when we see how widely used these are and then we begin to look at regulations that have begun to be developed in some states for drinking water and ground water so far. And those regulations set PFAS limits in the parts per trillion. Low parts per trillion. There are several states that have taken steps in that direction. New England, upper Midwest, and California has notification levels that are very low. This graph is in the sandy soils of Cape Cod. Background levels are coming from septic systems. Trace chemicals show up. And the background the far left here, the brown circles are showing the PFAS chemicals that were measured. And so we can see that there are less than one for a lot of them. But it's 1 to 10 parts per trillion for some of the PFAS chemicals. And with several states having limits in the teens to 20 parts per trillion. Suddenly, those levels coming from home septic systems where the sources are consumer goods are bumping up the regulatory standards. 70 parts per trillion is the health advisory from the EPA. This shows that the conundrum is that we're running up with what's is the background. The important thing to note is that a part per trillion is a small amount. It can be written as 1 national anthem gram per liter. Again, noting the background levels. When we're looking at use of biosolids which means PFAS. All of them contain PFAS. These traces of chemical are coming from our daily environments and our products. So every waste water has some PFAS measurable. The leaching, use of that wastewater or the use of biosolids or food waste composts may not be able to meet standards in terms of leaching ground water and causing impacts to ground water at the 20 parts per trillion or lower levels that. Maine is the only state that has set a screening value for biosolids. Biosolids are treated sludge used on soils, 60% of the sewage sludge is applied to soils. And the only screening value in the country is Maine and these are very low numbers. We at NEBRA challenge them and disagree with how they were developed, but they are what they are. So these are very low numbers as we'll see. Note that when we're talking about slides, we're talking about parts per billion generally in soil and those are the numbers we'll be using today. When we're talking about water we're talking about parts per trillion. Order of magnitude. It's good to understand which units. .

There's great variability in the regulations and this is caused by the uncertainty that exists regarding the potential health impacts and such of the PFAS chemicals. And there are 4 to 5,000 types of these as Jeff mentioned. We're working with unknowns and regulatory structures are taking different paths. So we have these low drinking water and ground water standards in Massachusetts where, must add to 20 parts per trillion. Virginia set a notification drinking levels in 5.1 and 2.2 for the two prominent and best known PFAS, PFOA and PFOF. And in Canada, the standard is 200 and 600 for those. So it's quite, there's other variations in Europe as well. Certainly, the two standards shown at the top are on the low end, the very lowest. So some of our states are setting the precedent or very low standards. So there are two major sources in the environment. And it's important to distinguish. Industrial discharges and a photo here is showing the Dupont plant at parkersburg, West Virginia. Where PFAS were measured. Around those facilities, but there are others using PFAS or manufacturing them. The fire fighting is the other major juice of PFAS. How it's gotten into the environment. The foams are used to suppress fires of liquid fuel. So this is showing the white is PFAS chemical being sprayed on a jetliner at an airliner where it contained fuel to try to suppress. These kinds of situations have tended to cause ground water, maybe surface waters to be in the thousands to millions of parts per trillion. So again, that's important to note the scale of contamination. How high it is in different. When we're looking at agricultural, worst case scenario sites we're not seeing such high levels of contamination. An example is the site in Michigan the highest concentration measured 76,000 parts per trillion. Near a dump site. the other in contrast is the ambient background levels of PFAS. Most waste water not heavily industrially impacted will include PFAS. All of it will include PFAS coming from consumers and home environment. And so will solid waste. Landfill waste. Even compost. If the food containers where PFAS is used have launched. Paper mills may have septic systems and landfills and all contain PFAS that are coming from more background places. Of course, there's industrial contamination into those facilities, then you'll have much higher levels. .

When any of these are recycled. The background PFAS is going with them. That's the challenge when talking about, recycling on soils or compost use. Anything that is coming from our activities and is being recycled back to the soil. Back to the land, water being recycled back to waterways. All of those carry background PFAS. But these tend to be in the tens and hundreds of parts per trillion. And they end up results in tens to hundreds of parts per trillion in waters. On farms there can be potentially, available on our website, at the bottom of this page. It's hard to know completely what all the different sources are. There are chemicals used in various parts of farm and dairy operations and some of them are likely sources of at least minor PFAS contaminatio Some industry are uses PFAS and blowing the air up into the air and that causes aerial deposition. And this is in Meramec, New Hampshire, and in a couple of places in North Carolina which cause contamination of some soils for miles and miles. There's ground water contamination that can happen like the New Mexico dairy I mentioned earlier where fire fighting use ended up causing ground water contamination that was used by the dairy nearby. Contaminated water was fed to the cows and it cycles into the environment. So fire fighting, if you have a fuel fire on a farm you might end up having used a, for the fire fighting foam PFAS in it. There's lubricants, paints, cleaners, other things that may be found and used on farms. Biosolids, when they are recycled, they are a significant source of PFAS on farms. And it depends again on how much was in the wastewater and whether it's going to have significant. Compost again from food waste in particular may contain, do contain some PFAS. .

So this is looking this is Vermont study that looks at the, looked at background levels of PFAS in soils. 60 some random sites throughout the state. None of them with known nearby contamination sources for PFAS. And a bunch of PFAS chemicals were measured at each site. PFOS is one of the prominent two PFAS chemicals. It's found in every sample at every site. So it's being aerially distributed across the landscape or has been. It's been in use for decades, so not surprising. These numbers on the right are in NANO grams. To get to the parts per billions. We're talking about these locations at 5 parts per billion. So state of Maine standard for PFOS is 5.2 parts per billion. Background levels are close to that in Maine.

So let's talk about why biosolids are used on farms to begin with. Many of you know this well. And this is practice has been ongoing for decades, and well researched. A lot of best management practices. Every state in the union has biosolids recycling happening. And there are strong programs that are overseeing this. It's a strictly regulated practice both federally and at the state level. And it's because the biosolids enhance soil health and recycle nutrients coming from our systems and our processing of food and other organic materials. Putting this material into the soil helps, carbon in addressing climate change. Just like recycling manures or composts. It reduces the use of commercially synthesized fertilizer which also helps with energy use and processes. Strengthens farm economies providing a lower cost nutrient source. With productive use. Every community has to manage. So we take it seriously that we have to figure out how to balance this concern about PFAS with the benefits of recycling biosolids soils.

We're going to shift now and look at the analyses and some data. I'll give a couple of examples and then Dr. Lee is going to take over and get into the nuts and bolts. Let me emphasize again that we want to when we're looking at parts per trillion and we're looking at water data we're looking at parts per trillion. And 70 parts per trillion from the EPA, drinking water is a good benchmark to use as you're looking at these numbers. And again, the lower numbers, an example of lower numbers adopted by states is 20 parts per trillion for six PFAS both for drinking water and ground water. When we're looking at solids. The PFAS in biosolids or soils, we can compare to these numbers here which I mentioned previously. The main numbers, the 2.5 for PFOA and for PFOS. We challenged those numbers but they are there nonetheless. And New York has defined in some particular permits they've defined a 72 parts per billion screening. So that's another number to kind of use in the back of your mind. You look at the data. Past research has indicated that the PFAS does leech some in soil. When you add it in soil. There's going to be slow leaching over time. And it's a well known paper from back, last decade, 10 years ago. That found that indicated. There was also around that time some early work done on PFAS plant uptake. And there's a basic thing that was found and has been corroborated by further research is that short chain, the PFAS have shorter carbon chains will tend to be more mobile. They may leach to ground water more readily, and they are more easily taken up to plants through the roots and into other parts of the plant. So again, those are the, things like that. The longer chain ones, C 8, crest C 9 will stick to the soil more strongly. Those are sort of basic background concepts and Dr. Lee is going to take it from here with some more detailed information on PFAS chemistry.

Thanks, Ned. So first I just think we went one slide too far. Getting back to the PFAS family. So the polyfluoroalkyl substances. The latest count is 7,000. And as more and more manufacturers try to create replacement compounds that number will continue to grow. What I want to emphasize is how do we get so many numbers. First you have the chain that can vary in length. That has completely replaced the hydrogens with fluorine and what I'm showing you and I got rid of animation. What I'm showing you to the right is kind of the family. So we have this whole family. I think I can use a cursor here. But even though I was trained how to do it I've forgotten. We have the whole family and you have several sub classes in the middle section. And each of the sub classes is broken up into different molecules on the far right. And so what you see if you look at the first one. The different molecules are different chain lengths. You have have a certain sub class -- thank you -- a certain sub class like that first one. And what's unique is the red circle is around the chain link that can vary and the box I have next to it, you don't want all this chemistry maybe. But PFOA has. And that's a very common sub class. And you can see several others here. You can see where they've attached different functional head groups. They've attached to both ends of the chains. So this is how we quickly get a lot of compounds. You can have a dozen different types of substitutions and when you add all the different chain links, you immediately get a lot of PFAS. And in addition to that some of you may remember learning about isomers. When we talk about PFOS which Ned mentioned several times and was the first one that got phased out. It has several isomers. That compound alone has at least six to eight isomers that are present. What I want to emphasize is that you have classes and sub classes but the problem is these don't disappear. They just degrade to other sub classes. We have one sub class eventually degrade to others and I'm going to show you a couple slides on that. Here is an example. So here we have something we call, and on the right, here we call it for short. These are two different PFAS that represent the two main processes used to make PFAS. And the tell MER process. Between the functional group. And then on the right you see this SO 2 and this addition at the end. That used to be if it was oxygen, it would be PFOS. And what I'm showing you is through microbial degradation you get intermediate PFAS and then the terminal ones. And in this case I'm showing you one that has ended with PFOA on the left and that's maybe the primary product. And so you go from one PFAS to many PFAS through the degradation process. The terminal product, they have a negative charge, they're more soldier you'll and more mobile. Soluble and mobile. There are intermediates that have stability and some of those are on the EPA 24 list that they are targeting. .

and so the hard truth is that our wastewater, research recovery facilities or what you might better know as wastewater treatment plants, they are a conduit for all of the sources Ned mentioned from industry to military to domestic. And it's just a fact of the matter. And the hard truth is PFASs come in and PFASs come out. Typically, more come out than went in because of the degradation process. Depending on who you're talking to, wastewater will, if they only care about the water and what's being discharged they're thinking they are getting rid of things in the process. And the PFASs they don't see, are showing up in the solids. And that sludge is useful for producing the biosolids that Ned talked about. And sometimes I get asked shouldn't we stop applying biosolids to land? That can be really problematic and is not realistic. We need to understand this more. And I just wanted you to see this entire picture of what's happening in the wastewater process, which is all of our waste, not just industry. So I'm going to show you some actual data for biobased. In a couple studies we did. In one we looked at several different commercially available biosolids and at the time back in 2014 also grab a few A through G, other kinds of compost there are not biosolids based. And if ones in the shaded area are the ones you might be the most familiar with that you can buy at Home Depot and Walmart where you buy the biosolids fertilizer. And when you use these fertilizers next to pots that you don't use them, you can see a clear difference. Plants love biosolids. PFAS loads can be high but you will not see that in terms of plant health. Plants love this organic, rich, slow nutrient released material. On the right I'm showing you several different composes that we got. Composts that we got. 0 waste Washington is very proud of their program. We think we might have made a mistake. We didn't know about the PFAS compounds. Can you help us understand them? Can you help us get data so we can know where this is going. And so they helped collect ten different composts from around the country.

Seven of them were at traditional compost facilities where there's a lot of food packaging material along with other types of organic materials, including different wood wastes, yard wastes, municipal wastes from clippings of leaves and trees in cities. And then three that were supposed to be I don't know if you'd call it controlled background or just leaves and grass from municipalities. So that was I said okay. Let's do this. And neither of these projects had any grant funding so that was fun to find a way to do the work without grant funding but we managed. And so I don't want to belabor the analytical because it's intense but what I want to highlight is at the time we were focused on the terminal end products, the ones that are mostly showing up in water and really the ones of greatest concern. And that ended up being in this case, 17 of the ALKYL acids, or the, like PFOS. And we had other types of analysis to let us know about the other compounds we haven't looked for. At the time there was probably only about two dozen standards available for all the many PFASs there are out there. And now close to 60 standard compounds that you can do quantification. But there's other ways to look at them and I won't belabor that. And one is, known as the top assay. And the other is more intense way to look at things. And we evaluated PFAS released to poor water. Here's a synopsis of what we saw compared to those that did not have slides. You can see in the middle where those are commercially available composts that do not contain biosolids. And there's some PFAS there. To clarify. All the colors are for different molecules that you see in the legend. And the PF means, and if it has an S we know it's cul phonic,SULPHONIC. And O is the 8 carbons. And then you can see the non-biosolid based. And the leaves and grass. They still had PFAS just very low compared to the other materials. And the top 1-7 was the composted materials. So no biosolids, just municipal waste compost. Trees, leaves, paper products and for the most part when you're looking at total levels, you see very similar numbers is what you see for the bottom what I have here, I-R on the bottom. And through the commercially based biosolid products. The J is much larger. What you do see that's different if you see the ones for the compostable food service, you see more blues and purple. Those are more of the shorter chain. And you see the golds and reds and oranges which are the longer. They bioaccumulate in the body. And they have been targeted for phase out. PFOS had been phased out but it's not going anywhere quickly. And PFOA was supposed to be complete about 2015. And that was not a complete phaseout. You might ask what happens with why is it showing up in leaves and grease and background com snows Ned told you many of the types of contamination that can happen. The only thing that came to mind in his list that was not there is PFASs can be present in pesticides as a carrier. In pesticides because they leach from the plastic bottles that they are sold in. And that's been shown recently. Or they can be the active ingredient in a pest side. For example, roach trap was literally a pure PFAS molecule. There's lots of things that can lead to that showing up in your background.

and then I talked about other assays. We just said there's several thousand. So there's one easy way to look at it. You can do a total precursor assay. It uses high pH to get precursors, anything that leads to the acids to break down to the acids that we can measure. What you see here is the black bar is the sum of the car book sillic acids. CARBOXILIC. So that's one way to look at things like that. And it's somewhat comparable to what can happen under microbial degradation active systems, somewhat. somewhat. .

and then here we were thinking that was 2014 and a lot of our initial work. Maybe things have changed over time with a lot of the phaseouts and people being more mindful. And when we looked at, and was really interested in trying to reduce loads. And as it turns out for the biosolids for whatever reasons, there could be a lot of explanations, we do see decreases over time. That would be the blue bar showing the total. And most of the decrease happened by the decreases in the long chain which so us made sense because of phaseouts. Most of the reduction was in PFOS and that was phased out in the early 2000s. And we only analyzed 17 compounds, and now we're analyzing 60 and scanning for everything else. So here was another temporal trend. We had another product we got in 2014 and were able to get a 2019 team product. And we did not see a decrease between 2014 and 2019 even in the acids we were focused on in 2014. It went from 35 to 210-micrograms per kilogram. And when we looked at more PFAS we obviously looked at more because we had more standards by then. It increased to 230 plus. And we also saw the ones I listed on the bottom in boxes. But we hadn't quantified them at the time and we are in the midst of that now. And so the question was, what's the norm? What are we going to see? Increase, decrease? It's hard to say. We have different examples and there are so many things that contribute. All the way from did they change anything in the processing? So anaerobic versus aerobic is going to produce different. And if it's lower than what you might see in anaerobic process, once youland apply it, it's going to continue to degrade. And lastly, I wanted to show some data I got from a land re-clay mages study. I got samples from reclamation. And you're allowed to apply more biosolid. You can think of this as worst case. Five times the agricultural rate. And they were collecting water samples 15 centimeters below the surface. And every time you see an arrow, that's where they applied biosolids. And the gray box which is not unusual to see something be elevated in the first wetting event. After I looked at the nutrient data I realized it was a new site. They brought in soils from a site with poor quality soil from a site. Created a new site. And there was a lot of settling. So I take that gray box with a grain of salt. And later you can see that with every rain event, I don't have the hydro graph. And you would get a small pulse of the PFASs. And mostly we saw the, much higher regulatory provisional levels than anything that Ned really talked about. So yes, they leach, but how much leaches at one time and thousand they'll be attenyou ated by the soil. All that will play a role as to whether or not biosolids will contribute to what is showing up in our ground water. .

Ned? .

This was me too, sorry. And I just want to, so Ned and I decided not to do a two part. We're just integrating together. So thanks for your patience with this. One thing that Ned's group had put together was looking at the range of PFASs they were seeing in sludge prior to additional processing and class A and class B biosolids which are mostly different based on pathogen counts, and class A being able to be applied closer to water bodies and things and paper fiber. So I already mentioned that all these aerobic and anaerobic processes change what you see in the biosolid that you get. And it's very common to see the levels in sludge be lower than in class A and class B biosolids. You are getting degradation of precursors that degrade to many PFASs. And most people are not quantifying the precursors, second thing is you have a lot of solids that are carbon lost in the process. If you don't adjust for that you can have elevated concentrations for that. You're losing carbon mass and concentrating in that fact. Basically, there's a lot of different practices, inputs and practices that change what's in a biosolid. So they're not all the same. .

and then again, the actual properties if you were going to measure aluminum and iron content depending on what kind of residuals might end up. You can have ranges in pH. Some add polymers to help with, some might attract PFASs more. And we're starting to probe for initiated out of some work out of templeton by Eric Mackenzie. Can protein content tell us something about PFAS release? We looked at the obvious easy one which is organic carbon. I'm not showing you the data directly, but if we take what was in the poor water and think about it as a partition coefficient. We see that as we increase the fluorinated chain we see the expected linear increase in this partitioning behavior between these PFASs. And so what this told us is that for biosolid based products and for all that municipal waste, composted material, we see a pretty good correlation that can actually be used. If I know how much PFAS you have in your biosolid. Carbon is not a good indicator. It seems like it might be a reasonable predicter for helping to understand PFAS release.

and I -- my last slide is just putting some of this into perspective. I have one more after this. Fertilizers have different amounts of nitrogen content or soil amendments will have a different amount of nitrogen. And oftentimes it's nitrogen. Sometimes phosphorus that controls how much biosolids you might use on a site. What I'm trying to show here is in the black is how many PFAS you have in the biosolids when you, but the red is how much you're adding to the biosolids based on nitrogen requirements. In the red sometimes you can have a lot of PFAS and they're rich in nitrogen so you're not adding PFAS to the soil. In other cases you're adding a ton to the soil and end up with a high PFAS load. I'm working with her reel brothers to MERRILL brothers How can we maybe exploit that process to have optimal nitrogen and low PFAS in that mix? That's why I wanted to show that. And then a lot of people talk about mitigation and there's not, we don't have a lot on it. What we do know is pretty much because of the deeing degradation processes and the fact that it requires a tremendous amount of heat to break these bonds, the only thing we've seen work for some of the commercial facilities is blending. Blending the biosolid with something that does not have a lot of PFAS in it. You might have a lot of woodchips. Whatever types of waste are in the area that might be low. That's really all we've seen so far that's been an easy way to keep down the loads. And we're doing more work on that and that will come up later. I think now it's Ned.

Thank you, Linda. And we know we're running short on time so I'm going to rush through the last few slides here and we'll finish up. Thank you for questions coming in. We will provide, we will summarize those and try to provide answers to them after the webinar so you can look for those at the webinar posting. Looking at some current field data. There have been investigation by states and other entities looking at sites that have been identified with relatively high PFAS levels. The numbers in the soil, some are shown for this particular site. And we're seeing up to in this particular site up to 878 parts per billion in the soil from some kind of past source. Still under investigation. But one of the details that we're thinking about is whether there's PFAS in manure. And yes, it can cycle in manures. These particular numbers tested at one site found up to 20 parts per billion in the manure. And the ultimate source of how it got there is still under investigation. .

Looking at some a nice set of data that developed in the state of Maine, we're seeing that places where biosolids have been used for multiple years, many years of ongoing biosolids applications on farms, yiewpsing biosolids that are typical. Not industrial impacted. These are the levels. These are in parts per billion. Up to 20 for PFOS which tends to stick in the soil more than PFOA. And some of the numbers are above the screening values. But they are in the low parts per billion levels. Similar situation in Vermont at a site where septic was land applied for many years and this is showing ground water data. And we're comparing it to Vermont shown in the upper right. And some of these numbers are up as high as 176 parts per trillion. These are not the screaming high numbers we see in industrial and fire fighting sites but they are of concern. There's a farm or a farm situation in Wisconsin impacted by biosolids that had some industrial impacts. Again, ground water impacts being found. Drinking water wells being impacted in a couple instances. But only one was above the EPA health advisory. Of concern but not at the screaming levels of industrial or fire fighting activities. A couple of sites in Maine being investigated. Here we had milk at a very high level. And this is under investigation and details are not well understood at this point. But this concern on farms in New England has, there's three of four of them total out of hundreds that have used biosolids and other applied manures and materials over years. And in comparison we have they've looked at the soil on a bunch of farms using typical biosolids and the soil tends to be in the low parts per billion. And milk has been examined closely and is found not to be above the screening value that Maine has established. So it is a concern but not having huge impact on the milk supply which is great. Michigan also has some information. I'll encourage you to come look at the slides more closely these last ones. There are many unknowns and research is ongoing. And Dr. Lee has talked about some of her research. She's doing some of the front edge research on that. There are things we know and things we don't know. And we're going to continue learning over the years to come. There's a project here that is under the water research foundation which is looking at soil column and leaching of PFAS and Dr. Lee has a couple of hoars and then we'll a couple of others and then we'll finish up. .

Remember to unmute.

We have here at Purdue we have a EPA project and an EPA national priority and I'm on the worst one that Dr. Beecher was talking about. On the star we're looking at treatment to reduce the PFAS loads. And including looking at, so we're just looking at that. And we're looking at what happens in the anaerobic and the aerobic, and the possibility of, ones with high PFAS loads as a way to reduce leaching without stuffing them in a landfill. And I will just say that let me just skip to this. So for this, we had a biosolid that had several hundred PPB of PFAS and the poor water concentrations were in the 6 to 12 hundred parts per billion. And once we pyro liesed this. Nothing came out. The most we saw was like 5 parts per trillion well below any levels of concern. So we're also looking to see if, can store from regular biosolids. Just as a management practice. And lastly, we have this national priorities where we're going to be focusing on mostly Pennsylvania, Indiana, and Virginia where we have, we'll be using rural well water network of Pennsylvania. We don't have one of those in Indiana. The goal of this project is to try to understand how much land application of biosolids and other agricultural operations really contribute to the total PFAS loads that might be present in ground water. We don't think that the average biosolid that has not been heavily industrially impacted is actually causing major concerns in ground water. But we need data to prove it. And we have some historical data that we're looking at. And now we'll be conducting new work. And there's two other projects that were funded and you can go to that site and look at that. And then when we're thinking about regulations we want to close with this. Like I said I get asked. These are forever chemicals, shouldn't we ban anything from being land applied. It creates a burden on public municipalities which we pay the taxes for and people will be hurt most will be people that can't afford the taxes to begin with. So there's a lot of unintended consequences. And how close levels are getting to even just background soil levels, that means every homeowner can be suspect for when they try to sell their homes. This is why regulatory decisions have to be made with a big, open lenses so to speak. We want to control sources. Michigan is doing really good to identify industry and landfills, larger landfills that might be contributing a lot of PFAS to the treatment plan. Like in the days of metals which solved our metals problem in biosolids. Work hard to get rid of nonessential uses. The data I showed you for composted city waste was used in the stiff Washington to develop bills to remove PFAS containing packaging. They had to prove that they couldn't find anything better or else by January next year, no more PFAS food packaging in the state of Washington which will trickle down to other states. And I've done work with California. We just generally say let's move fast to get rid of nonessential uses of PFAS. That includes a lot of things. And let's work slow to come up with regulations and provisional values that are protective of human health without causing unintended stress. That's Ned and I's take home message. And lots of research needs to happen.

I'd like to always end with stressing the fact that we can address this issue through phasing out and reducing use of nonessential uses as Dr. Lee mentioned. The most significant reduction of risk in PFAS levels that has occurred including the levels in human bodies has been the voluntary faceout the EPA facilitated for PFOS and PFOA. And blood serum levels have been reduced. Let's take that as a road map and control things at the source. Reduce the most concerns PFAS in that way. So that is what we had. We appreciate your time. And we apologize for butting in on the question and answer period but as we said, I think we'll be

able to provide some responses in a document that comes with the recording of the presentation later. Jeff, I'll turn it back to you.
 Great. Thank you so much. You know, just so much information was provided. I appreciate all that you had there. And I just want to take a couple moments. We have a whole slew of questions, and just like what Ned was saying we'll go through a couple quick questions, but the rest of the questions, we'll present that to our two speakers, and they'll provide answers to the questions, and they will be posted with the recording. So if you download the response to it. There's a couple of questions that I just thought I would ask. And you kind of alluded to it towards the end. If this is such an issue with PFAS and all of these products, why do we still have them? And why do we continue to use those products?   .
 Well, you know, the products include all the clothes that you're wearing that are stain resistant. The carpets that are stain and water resistant. The cookware in the kitchen that are -- even if today we said we're not selling any more PFAS containing products. You have long lasting products that you're not ready to get rid of them all. It would be a lot. Your closet. All your flooring, that's just a start. They are just so pervasive. They brought us such convenience in life. And we've taken that for granted and meanwhile, no one realized the problems that they are. And if we didn't have a lot of direct discharges to the environment through fire fighting training, release of, and large volumes and direct industrial input into the air or streams, and improper disposal of industrial waste. We probably wouldn't be where we are from domestic products, right? But this is where we are.
 All right. Very good. Two administer quick questions. With PFOS, are they found in bulk packaging for fruits, vegetables, meats? You talked about it being in the fast food containers. What about in the grocery store packaging and some of those types of things?
 It's probably in most all your packaging. It's how much of it is leaching into the food. And you'll ask why is this being allowed? We have different regulatory entities in the U.S. FDA step in right away and say no more, could they? Absolutely. But they are not yet.
 and then are pesticides a source of PFOS in farming operations?
 They can be for three reasons. They can be as parts of the carrier. We've learned that most likely in most cases it's actually become contaminated through the container that it's sold in because the containers have coatings of PFAS which again it keeps the pest side from leaking out of the plastic bottle. They are amazing chemicals and what's amazing about them is what makes them persist innocent the environment. And persistent in the environment. And a lot of these hopefully are being phased out that were active ingredients. For most agricultural operations, I would say the CDC be in the carrier. They are great car fact tenants. SURFACTANT. It doesn't mean that every source.   .

 One of the challenges is that these are commercial products that are proprietary. And so it's difficult, it's been difficult to get information. So a lot of this is, testing materials by researchers rather than trying to get because it's impossible to get disclosures of exactly where these have been used or are used.
 You would not find it in the labels?
 No. Inactive or inert ingredients.
 Inert, maybe that's a flag for us.
 It will have a percent of inert ingredients. If it lists anything. It will have the ones with a major source. Foams because they make, to meet military specs, the whole formulation is a 3% delusion. And you have very little PFAS compared to all the constituents and they are the constituents that do the work. They are not considered as a major portion on a percent scale.
 Fantastic. Again, I want to thank both of you for the information you've shared today. There's so much information there. A lot more questions and folks, we apologize for not being able to get to all the questions. But we will get answers to the questions and they will be posted with the presentation. Again, thank you Dr. Lee, thank you, Ned, for your presentations today. Great information. With that I'll return control back to Jennifer.   .
 Thank you, Jeff. On behalf of the USDA and the natural resources conservation service I wanted to say thank you to Ned and Linda and Jeff for providing an excellent presentation today about PFAS in agricultural operations and thank you to everyone for attending today's webinar. Participants don't forget to provide your feedback. And if you, please return to the open browser window to continue the process. Also a reminder the recording of the webinar will be available next week. This concludes our webinar presentation. [Eventconcluded]