>> **Dr. Chrissy Henderson:** So, to begin, I would like to welcome our first presenter for today. Grace Weber is one of our new members of Reclamation's Materials and Corrosion Laboratory. She interned with our group for about two years while she finished her bachelor's degree in Metallurgical and Materials Engineering. She also obtained her master's in Engineering and Technology Management from the Colorado School of Mines. Since graduating, she has been working with the Materials and Corrosion Laboratory full-time for the last year-and-a-half as part of our cathodic protection subgroup. Among her other research and design projects, she is the project manager on the Parker Dam Spillway Gate Cathodic Protection project, which she will be presenting on today. And with that I would like to hand this presentation over to our first presenter, Grace Weber.

>> **Grace Weber:** Thank you, Chrissy, and hello everybody. So as Chrissy mentioned, my name is Grace Weber, and I'll be presenting our first case study for today on the Parker Dam spillway gates. So, today, I hope to just cover our group's general, kind of, cathodic protection or CP design process. Going over the steps from the beginning to the end and then also looking at how our case study applies for each of these steps. First, just a little bit of background. What is CP? So, any time there is a metallic piece of a structure in contact with either soil or water, there's the problem of corrosion, which is degradation of that metallic material due its interaction with the environment. And one mitigation method that we use to address this problem is CP. And there's a couple of different methods of CP which are listed up on the slide. And I'm not going to go into too much detail on this today. But if you would like more information on how these different types of CP work or on different types of corrosion and what they might look like on your structures, I would encourage you to go check out some of our previous webinars, which go a little more in-depth on these topics. So back to our case study for today. You can see on the left side of the screen, there's kind of an aerial shot of the facility. So, Parker Dam is located in California, kind of near the border of California and Arizona. And it crosses the Colorado River, forming a reservoir called Lake Havasu house on this side of the dam. It's known as the "deepest dam in the world" and the powerplant has four units, each with a capacity of thirty thousand kilowatts. There's a variety of structures and equipment that are protected from corrosion using protective coatings. So, these are in some of the areas that receive more severe environmental exposure. Structures like gates, turbine runners, trashrack panels, and other equipment like that. And recently the facility has reached out to our group. And they are looking into getting some cathodic protection on some of these structures and equipment, to kind of proactively protect the coatings that are already in pretty good condition. Since CP works best if you apply it kind of in a proactive way, if metal loss is already occurring, the CP can never get back any metal. But it will act to protect metal that's already there. On the penstock gates, which are over here, there's already a galvanic system that's in place. That was done a couple of years ago. And currently, we are working on a final design for the spillway gates, over here. As I mentioned, we are working on the design for the spillway gates right now, and there are five spillway gates at Parker Dam. So, this picture on the right side of the screen is the upstream side of the dam and the gates are located under these kind of larger gaps That you see in the structure. And they are immersed under water pretty much all the time. They really only operate the gates on an annual basis, kind of cycling through testing each of them out and maintaining them. But, the benefits of cathodic

protection on the structure-- As I mentioned, this is going to help extend the service life of the coating. So even though we're kind of putting in this up-front work and time and money to add this cathodic protection system, there's a really short payback period on how much you get for extending the service life of the coating, since recoating is so expensive. And not only that, but as the coating ages over time and starts to degrade or have some deterioration occurring, the CP will also provide extra protection for any underlying steel that begins to be exposed. So, on the Parker Dam spillway gates, we decided to go with the impressed current cathodic protection, whereas on the penstock gates we went with galvanic. And here, these spillway gates are pretty large. Each of them is fifty foot by fifty foot, so the ICCP is beneficial there with that large surface area. And it also lets us protect the structure without having to apply-- if we were to do direct connect anodes, we would have to remove part of the coating and then perform coating repairs over the anodes. But this way, we're able to protect the structure without really disrupting that coating since it's in very good condition still. And the Parker Dam staff is going to be doing the install. And the Reclamation Materials and Corrosion Lab, which is the group that I am part of, is designing the CP system and providing installation support. So, just taking a step back and looking at our design process-- I've broken it down into these five steps. So first, really, is just contacting us. And I have my information up on the screen. You're welcome to write that down. You can shoot me an email or give me a call if you have any questions. And we're really just interested in hearing about your needs-- What are the problems that you're seeing? How would you like to address them? What are some of the solutions that you'd like us to come up with. And once we kind of have that communication going, we can start putting together a project management plan, collecting design data, and then finally putting together the CP design. So I'm going to go into a little more detail on these last three steps, starting with the project management plan. So, as I mentioned-- After communication, we can start putting together, kind of, what are our objectives? What do we want to accomplish? Breaking that down into a scope and then breaking that scope down into different tasks. And once we have the tasks, we can figure out a schedule. And we're pretty flexible here on the schedule. We can work around--if the facility has certain outage periods or down times when it's more ideal for the work to be performed--we can make sure that our schedule lines up with that, so that our design can be completed in time for these ideal times to perform the work. And then using those same tasks and schedule, we can start putting together a budget; determining the roles and responsibilities-- Which tasks is the client going to be responsible for, which tasks are we responsible for? And then finally looking at any risks and how we can mitigate those risks. Next is collection of any design data. So, there's a lot of different types of structures out there, and with each one, we're gonna kind of want different types of design data. But just in general, here's kind of an overall list of some things we might be looking for. First, just basic information on the structure dimensions. And drawings and photos definitely help with this, so that we can figure out how much surface area of metal are we looking at that's going to be in contact with soil, water, or some other type of electrolyte. And we also like to know a little bit about the operation-- How often is the structure used and which parts move? When they do move, how much they move? And this allows us to create a CP design that won't interfere with the operation of the structure in any way. Next, water quality data or soil samples. So this lets us get an idea of the corrosivity of the environment, as well as how well our CP current is going to be able to get to our structure. So, for example, for a gate, we would be looking for some monthly water quality data. Ideally, from the past couple of years. So this lets us look at if there's any seasonal changes in the water quality. And then, for example, a structure like a buried pipeline-- we would want soil samples. So, we're also interested in if there are any dissimilar metals in contact with the structure. So, for example, you could have a mild steel gate with some stainless steel hoist ropes or other stainless steel components. That's something that we definitely need to take into consideration. Electrical isolation-- so, if there is maybe a grounding mat or other large metallic structures around that the structure to be protected might be electrically connected with-- this is important for us to know. Coating condition-- firstly, whether there is a coating or there is no coating. And if there is a coating-- is it a new coating, is it an older coating? Is there any damage that's already happened to the coating? That sort of thing. And finally, the availability of power. So some facilities, there may be no power available. And in that case, we could opt for a galvanic design, which doesn't require an external power source. Or, with the ICCP design, we would need to be able to hook into power somewhere. So, on the right side the screen, I just have included some of the basic design data that we collected at the beginning of the Parker Dam spillway gate project-- The gate size, kind of noting that it has a riveted construction... And then also making sure we know about factors like the water line or the mudline. So even though this gate is fifty foot by fifty foot, the full surface area of what's going to actually be in contact with water is a little bit less than that since the water line is three to five feet from the top. To collect some of this design data, we can also come out and do inspections. So this is what happened at Parker Dam. We did a spillway gate inspection back in December 2014. So, I've just included some of our snippets of our notes from this trip. So on the left you can see-- over here-- we took some electric potential measurements. And this is data that we can use to help us refine our CP system. Kind of getting an idea of the native potential of the gate-- where does it stand without CP on it and how does this potential change with the depth of the water? Looking at the flow of the water so in this case there's higher flow on the west side of the dam. And we noted that there was more rusting of the rivets on gate number five, which is the west-most gate. So, we take down any observations that might be relevant. We take a lot of photographs. So we noticed some corrosion starting to occur at the rivets. But in the case of Parker Dam, the spillway gates, the majority of the gate is underwater almost all the time. So, we also did a dive inspection the next year-- February 2015. And-- I have just a basic schematic of the gate here-- so you can try to visualize it. But we have this fifty foot by fifty foot gate, and we kind of broke it into sections-- upper, mid, lower-- and went and inspected each of these sections on each of the gates. This photograph is from the bottom section of gate number five. And these red circles are highlighting some of the rust nodules. There was also some rusting on other sections of the other gates, but gate five, as we mentioned, kind of had the most of this. So even though the coating is still in really good condition, they were just starting to see some rusting around rivets. So, taking all this data, we can use it to put together our CP system design. As I mentioned, the first step of this is really determining the metallic surface area that'll be in contact. So, with the riveted construction of these Parker Dam spillway gates-- each gate had about sixty-six-hundred rivets. So we try to take into consideration all of these little metallic components or complex geometries since they can add a significant amount of surface area in the end. So at Parker, these rivets ended up adding about five percent surface area on top of just the flat, fifty foot by fifty foot skinplate. And then we do subtract out that portion that won't be under the water. So, once we know the surface area of metal, we can start looking at the current requirement. So, in the case of the ICCP design at Parker, this meant selecting a rectifier that would be able to supply enough current. And then also looking at the current distribution. So, for steel, in order to properly cathodically protect the structure, we want to achieve at least negative 850 millivolts against a copper sulfate--a copper/copper sulfate reference electrode. But no more negative than negative 1100 because if you go beyond that point, you're overprotecting, and there's the potential to damage the coating. So we have to do some calculations, make sure that every part of the structure can achieve a polarization between this range without going under or over in any area. And we can start working on selecting anodes that will allow us to achieve this. So in this little screenshot of one of our design calculation spreadsheets, you can see this column-- anode style-- We have four different anode styles that we were looking at and they each have different dimensions or different exposed areas. And we're really trying to optimize the design-- which anode is going to require the least number of anodes while still getting us the current distribution that we need. So, once we select our anodes, we move into the anode mounting design. So, where on the structure Or near, around the structure can we put our anodes. And this changes a lot from facility to facility, or structure to structure, just depending on what works best at each individual location. So in the case of Parker Dam, we had a feasibility level design that we originally went with-- so this was anodes hanging from a suspended wire system. And, if you look at this picture-- I am pointing at these concrete piers here, and this concrete pier here. So, these are on either side of the gate-- the gate is down under the water right about here. And our original design was to have rods coming out from these concrete piers. And then using a wire system to suspend the anodes out front. But, after further discussion with the client and talking about the operation of the gate and what would happen-- So, for example, if any debris were to come by, it could potentially run into the anodes. Or if there was an event that caused the spillway gate to be raised, the anodes would potentially just get ripped out and pulled downstream. So we decided to go with a little bit more robust of a design. In this case, for our final design-- and mounting PVC directly onto these concrete piers. You can see that a little better in this schematic here. So these are those same concrete piers that I pointed out before. Here is one of our gates. And then we just decided to run some PVC and mount them directly onto the concrete piers. So we had to make sure that this design would still fit in with our calculations-- make sure we can achieve that current distribution as we need to. And then, the next part of the design was deciding where to put the rectifiers. So, at Parker, we housed all five rectifiers in this breezeway between gates three and four. And we decided to go with five rectifiers-- one for each of the gates-- so that we can operate and maintain each of these CP systems independently of each other. The other breezeways are not accessible and this ended up being the best location to house all five. So then we decided to run our conduit on the face of the dam so that it doesn't cross over anywhere above these gates and interfere with any of the operation. And this is just a blown-up view of one of the breezeways just so you can get an idea of what they look like. So, the installation has not happened yet. We have experienced some delays this summer just due to the circumstances. But the design is very close to finalized and we are planning to do two trips for the installation. So trip number one-- providing installation support, assisting Parker Dam staff with the first gate CP system. Showing how to hook up all of the components and then initializing the system and making sure that everything is set up properly. And then a second trip after the system has been running for a little while and everything has stabilized. We can take a look at how the system is performing-- Make sure we're not underprotecting anywhere, overprotecting anywhere. And also training the Parker Dam staff on how to do that monitoring themselves for the future. So, essentially during our CP design process-- we really take each of these case-by-case. No facility or structure is the same as another one, so we want to take a look at the environment at each facility-- how that affects our CP design. And really just work with the client to put together the optimal CP design for protecting their structure, accomplishing whatever needs they would like to accomplish, and fitting any requirements that the client has. And this might include working through some challenges and design changes. So with Parker we had some big changes from the feasibility to the final. But we just made sure to communicate with the client through every step and figure out what would be the most optimal CP system. So, with that I do want to acknowledge John Steffen-- the manager at Parker Dam-- and the rest of the Parker Dam staff. Their input was very valuable in putting together our final design. And also the three TSC groups who assisted with the work. So I have those up on the slide. And with that, that's the end of my presentation. So, as Chrissy mentioned, you can enter any questions into that Q and A function now. We will be addressing them at the end of the presentation. You're also welcome to send any questions to me over email. But with that, I'll hand it back to Chrissy.

>> **Dr. Chrissy Henderson:** Thank you very much, Grace, for your excellent discussion of the Parker Dam case study. With that, I will go ahead and introduce you all to our second presenter for today. Dr. Daryl Little has been with Reclamation for over fourteen years. He earned his Ph.D. in Materials Science and Engineering from the University of Virginia. As a member of the Materials and Corrosion Lab, he has worked on many projects using his knowledge of materials selection, corrosion, cathodic protection, and failure analysis. He has tested cathodic protection systems throughout Reclamation as well as cathodic protection repair and system replacement. We will now go ahead and hand over this live event to Dr. Daryl Little.

>> **Dr. Daryl Little:** Good almost afternoon-- I guess in a few minutes it will be. As Chrissy said, my name is Daryl Little-- I've been with the Bureau for quite a while now. And today I'm going to talk about a cathodic protection case study-- Going out and testing the cathodic protection systems at Mni Wiconi core pipeline. So, the objectives of this webinar are first to review-- reviewing field data collection procedures. Like, what do we need to do the job and to make sure that your structure is protected. And then, also, I'll be talking about the data analysis that comes after. So, evaluation process is: number one, contact between ourselves and the client. Then, we need to know what are your needs? Do you need it tested, inspection... Are we looking at repair services? Or just training on the CP system? Or how to test the CP system? So, what we need from a client is-- first, we need that scope of work or what the problem is. Photos-- we love photos. Just be wary that we will probably use them in a presentation as well! So, the more photos the better. We also need historical data. Especially if you have the original startup data or the design of what went in. Then we also want to look at drawings. What do we have around? The final products that we'll deliver are the report, including the data, photos,... ... observations, recommendations, conclusions. Some of the repairs can actually be performed during the

inspection. Some repairs may be more extensive and have to be done at a future date. And then also at the end would be an SOP for actually testing the CP system. So, if we trained personnel, now they'll have guide to go by. Or if you need the system tested the next year, you have a guide to go by to either give to someone who knows cathodic protection systems or to test yourselves. So, the Mni Wiconi core pipeline. The cathodic protection system-- There is... actually we have two on there. But this pipeline delivers water from the Missouri River, west to Kadoka, South Dakota, and provides water to over thirty nine thousand people. It's about a hundred and twenty three miles of mostly twenty-six diameter, welded steel pipe. And then there's also approximately ninety four miles of PVC pipeline that has metal fittings on it. So the two cathodic protection systems-- on the welded steel there's an impressed current cathodic protection system. There's over three hundred test stations along this because it is, you know, a hundred twenty three miles long. And there are about-- there are ten rectifiers approximately even spaced along that pipeline. It's located-- the Mni Wiconi water treatment plant, which is at the upstream side of this pipeline, is located in Pierre, South Dakota. And it goes from Pierre, cuts down the highway across a lot of agricultural fields, down an access road. And then, there's actually another little system all the way down here. But it's also impressed current system. The PVC pipeline coming out of-- I believe, Valentine-- comes up and actually joins onto this steel line. So, actually, it's going to go this direction. And it has a galvanic anode system. So it's got zinc anodes on those metallic fittings. So, the system testing-- we were approached back in 2014 to evaluate the CP system. And, when we first went out, we were just looking at the rectifiers. Okay, are they operating? What do we think of the system? Looking at some historical data-- test data-- as well as initial startup data. And after talking with them, since the system hadn't been looked at in a couple years, it was decided that the best course of action would be to go out there and test the system. Now we recommend, even if we're not the ones testing the system, that we look at the data approximately every five years. This will give you another look at-- someone else's eyes on that data. To make sure that-- yeah, hey, this is-- we're agreeing with what you're seeing. What recommendations we can make. If we see that, hey, maybe the system's not protecting as well. And we see that maybe, you know-- maybe this area if we-- if that's turned up, put out some more power, try to raise the potentials there. So these are all things that we're going to want to look at. So to go along with this, the annual testing is crucial to ensure that the system is operational-- all the rectifiers are on or all the anodes are connected. But, it also-- whether or not it's providing that adequate protection. So utilizing our resources in this case was very desirable to avoid additional costs that might be incurred by contracting the work out. We're big proponents of can we do this testing in-house. Whether it be through another Reclamation office or helping out a water district to test their own systems. Because the more the client understands about the systems, the more that they can understand what's going on and also maintain them. So, let's get into a little bit of the CP system testing. Now, the first thing we normally do when we walk up to an impressed current system is look at the rectifiers. So, we're going to walk up to them and you need to know things like-- okay, what's the condition of it? Is it-- in one case-- is it falling off a pole? Are there broken wires? How much, you know, overgrowth is there? Or is there insects, like yellow jackets, in them? Then we also want to look at the name plate, which is this thing right here. And we want to know-- okay, what's the rating of it? What size is it? What model, style? Is it an automatic or is it a manual? We also want to know the tap settings. These are the taps, they actually control the output of this rectifier. Then we want to know the voltage output. Now, we'll do this two ways. We want to look at it both using the meters-- to do voltage and amps-- but we also want to use a portable voltmeter. Because sometimes these dials get frozen or broken. So we'll measure both the voltage with that portable, but also the current. And to measure the current with a portable voltmeter, you're going to need to measure it across this shunt, or a calibrated resistor. And on these, there is-- the rating is usually stamped right there and there on this style. Or it'll have a rating on it. But it'll always be written on that or on the panel itself. Next, we'll also want to go up to the test stations and collect data there. Now, the data that we're going to collect at these is actually two types. It's the uncorrected potential, or the "on" potential, and the polarized potential, or the "instant-off" potential. But first, you're going to look at that condition. Again, same thing-- You'll want to know: broken wires; is it standing up, laying down; is the face plate on it; are wires disconnected; is it hard-to-find because the vegetation is grown up around it; or again, the insect infestation? So, after you've determined the condition, then you measure the potentials using a voltmeter and a reference electrode. Then you look at the anode current output for-- if it's a galvanic system. So there will be little shunts in those test stations. And, you'll take your wires across that to measure the current coming off of that. Now, the other critical information that we want is the GPS coordinates. Because there's many years when you have these test stations out there that you may find them one year, but you may not find them the other. Well those GPS coordinates or other identifying features right around the vicinity are key to helping that test station be located every year. So, to perform these surveys-- Number one, in order to get that instant-off value, that polarized potential, you need to install a current interrupter on each rectifier. So if you have multiple rectifiers, you're actually going to have to interrupt them at the same time. The easiest way to do that is to use the more modern interrupters which actually have-- they can be GPS synchronized to get that same interruption cycle. So, what we'll do is... the interrupters are usually programmed to about seven seconds on, three seconds off. Now, the new data loggers-- like the one pictured below, here-- can actually measure faster interruption cycles. It'll actually pick up that interruption cycle and capture those values without an issue. So, you don't actually have to use your eyes to capture that interrupt-- that instant-off. The data logger will do that for you. Now-- reason for this is, when you just get an on potential, it's kind of like-- you know, that reference electrode is sitting on the ground. But that pipe is, say, maybe seven feet down. Well, by interrupting it, it's almost the equivalent of taking that reference electrode and putting it directly on the pipeline. So you get a better idea of what the actual potential is on that structure. And to do that, it's really just disconnecting the anode cable from the structure cable at the shunt for a galvanic system. Or installing that interrupter and letting it... do the work of disconnecting that circuit. Now, there was a previous webinar given in 2014 on how to test these cathodic protection systems. And it is available online. And if you need any help finding that, let one of us now. We'll be glad to get that to you. So, now let's talk about the actual review and analysis of this collected data. So, for impressed current system-- Especially with the data logger, but either way, you're going to want to utilize a program such as Excel, Origin, or something else that's equivalent. Something that is a spreadsheet software, so that we can actually look at the data, pull it up, and manipulate it. So that we pull out just the data we need, so that we can actually look at that directly. Now, for what we've clicked on the other, we see this "V off"-- that's the instant-off potential. "V on" would be your on potential. And here is your GPS coordinates of that test station. And, over here in the comments, that's what we're saying-- like, okay, this data is for test station forty five. This was test station fifty-six. Test station fifty-five. So this is what your data might look like when you upload it from a data logger. Or, you might have to input it by hand. Not as fun when you have a significant amount of data. But, obviously, we do what we have to do. Next, we're going to want to actually pull out that on and instant-off potential data. And then we're going to plot that versus the test station number. So, this is so we can see-- like, okay, over that entire three-hundred-plus test stations, what is the potential on the structure actually doing? We want to see where it starts dipping down. Okay, are there areas where it's not protected? Are there areas where maybe it's overprotected? So, what we'll do is actually take and put this dashed line here. And that's our minus 850 millivolt protection criteria. So, NACE is our corrosion engineering professional society. They put out these international standards, and standard SP0169 dictates that ideal protection of a metallic structure, buried or submerged, is having a potential--a polarized potential-- more negative than minus 850 millivolts versus the copper sulfate reference electrode. So that's the ideal. Now, the other criteria we can use is what's called the 100-millivolt shift or minus 100 millivolts of polarization from the static or native potential. So if we actually have that-- and in the case of the Mni Wiconi core pipeline, we actually do-- we can use that if, say, it is below 850, but then we have to look at it on a location by location basis to make sure that-- at that location, are we truly seeing that 100-millivolt shift. So, in this case, the data indicates that, yes-- okay, there's this difference between the on potential and the instant-off, or polarized potential. We want to make sure that we see that. If we actually see that the instant-off potential is more negative than the on potential, then we're looking at a possible location of interference. Whether it be from another structure or another CP system. So, those are things that we're looking at... And in this case, we can see that yes, most of this pipeline does exceed that minus 850 millivolt criteria. So we know that this protect-- this pipeline is protected. However, there are some locations where it looks like it might be overprotected. It's past that minus 1100 millivolt criteria that Grace talked about in the first presentation. We want to make sure that the coating is not going to be damaged by the system. So, one of the easiest ways to just look at it is-- actually, let's get rid of the on potential and just focus on that instant-off, or the polarized potentials. So we'll pull out that data. And whereas looking at one year is great-- is good-- Looking at multiple years of data is even better. Because that'll tell us exactly how that system has changed over time. And we know that not all test stations can be measured-- like, we can't measure the potentials at them every year. We can't find them or they're inaccessible to due to flooding, like this. Or one of them gets damaged. And it's not an issue when you're looking at the overall system, but it is good to locate as many as possible and test them each year. But, if you-- say it's inaccessible due to flooding, maybe next year we can actually get out to that one and test that one and then put it back in the dataset, so that we can see how that location is also changing. So, here's our data that we collected over a period of three years. And you can see that, you know, it's not laying on top of each other every year. So, there are things that happen. In some cases, we may have actually turned the rectifier down or turned it up. It was a little high here, so we turned it down and that's very visible that-- okay, it dropped even more. Now, something else is going on here that I'll get to in a second. But we can see that even in 2019-- that instant-off potential is a lot more negative than it was the previous two years. And that could be the effect of what the environment was like. And in this case, it was a really wet year. Now the gaps are actually indicating where there's missing data-- broken test stations or missing test stations-- we couldn't locate them. So we're going to just-- so that we don't get a lot of these dips-- we're going to just ignore that, at that time. But a significance spike like this may actually indicate that something happened there. Maybe it's a bad measurement. One year we did notice that we did have some bad measurements. Now, some of these locations are still a little high-- over that minus 1.100-- so we want to keep an eye on that. And the polarized potential at test station two-thirty-eight is really close to the native potential. And there's really no change observed in the values during the interruption cycle. So that's a concerning thing that we want to make sure to keep in mind and take a look at. So, the conclusions from that-- from the impressed current system-- is there were low polarized potentials observed at the beginning of the pipeline. The first year, they were good, then they drop the next two years. And that was actually due to a broken bond cable that was discovered in the vault. So that's why those potentials went down. We've reattached them and hopefully this next year we should see those potentials come back... up, or go... in the negative direction. The rectifier output should be increased at some of the locations, but when we do, we have to monitor or investigate those locations when it does get more positive than the minus 800 millivolts-- we don't want it to go too positive, even if we're looking at that 100-millivolt shift. So, there's areas that you may not do anything now, but we want those multiple years so you can see when you want to change it. The rectifier output should be reduced where the potentials are more negative than minus 1100 millivolts. And that test station at two thirty-eight should be investigated for-- maybe it's a possible short to steel in concrete or some other issues. So we're going to have to look at the historic data for that location. Now for the galvanic system, the data collected on the non-metallic pipe-- on those few test stations where there's fittings-- we also plotted it over multiple years. And this data indicates that most locations were adequately protected except for two. And that would be this test station here and this test station location right there-- three thirty-eight and three forty. So, those are of concern to us. Now, we wouldn't see that sometimes unless we do it over the multiple years. So, conclusions there is: we're recommending that at those two locations, the anodes be replaced as soon as possible. But because-- two locations out of that-- they were all installed at the same time. You want to make sure to closely monitor the entire system yearly to see if any of the other anodes are going to be dropping as well. So, that's the end of my presentation. I'd like to thank the office in Pierre, South Dakota for bringing us out there and letting us evaluate their system. And I would like to thank you all for attending... And I'll turn it back over to Chrissy.

>> **Dr. Chrissy Henderson:** Yeah, thank you, Daryl, for that presentation. We will now go ahead and open this Teams Live Event up for questions. So I see that questions have started coming in in the Q and A chat box. So you can continue to do that. What I'm going to do is go through the questions and ask them. And then our presenters will go ahead and answer them. The first question is-- what is the estimated maintenance cost-- labor hours-- to maintain the system. And I'm assuming this is for the Parker Dam. But this could also be applicable to Mni Wiconi as well. So, Grace and Daryl-- you are both free to answer as you see fit.

>> **Grace Weber:** Daryl, do you want to take a stab at this one?

>> **Dr. Chrissy Henderson:** Daryl, I believe you are on mute.

>> **Grace Weber:** Alright, I'll give it a go... So, the Parker system is not installed yet. So I'm honestly not sure what the maintenance cost and labor hours are going to be for that one. But I did go out last year and help Daryl do that survey on the Mni Wiconi pipeline. And I think we were both out there for maybe five to seven days, not including our travel time. And we were working, maybe... between eight to ten hours a day.

>> **Dr. Daryl Little:** Yeah, I just got off mute. Yeah, Grace, you're correct on that. And it was five days. I was there an extra day, but that was because we ran into an issue with Construction on the road, which actually stopped us from being able to get to some of the test stations.

>> **Grace Weber:** Yeah, so, we're looking at maybe... Two staff for five days, ten-hour days. On a pipeline like Mni Wiconi.

>> **Dr. Daryl Little:** Some systems will cost... differently. Mni Wiconi, the cost actually has gone down over the years. Even with our rates actually going up. But that is because we now know where everything is and we've actually tested that system over a couple years, so we understand it. I've located all the-- it took almost two weeks the first time we did it because we didn't know where any of those test stations were. But, now that we do, we're down to five days. It also is travel time to and from the site-- can be a factor. In general, I haven't had too many jobs that have gone more than a week.

>> **Dr. Chrissy Henderson:** Alright... I will go ahead and move to the next question. Let's see.. it's-- would you mind talking about the benefits of combining a coating system and a CP system, and how the two should be linked for maximum benefit, where applicable?

>> **Grace Weber:** Yeah, so... The benefit of combining the protective coatings and the CP... so the protective coating kind of acts as that primary defense against corrosion. It separates the metallic surfaces of the structure from interacting with the environment. But over time-- and even right away, you know, no coating is perfect-- so there's gonna be some holes or defects in the coating. And then over time, as the coating ages, the number of defects might increase or the defects might become larger. So, these points in the protective coating-- the structure would be vulnerable to corrosion there. So if you also include a CP system, not only is it going to extend the life of your protective coating system, but, it's also going to protect those defected areas where the metal is becoming exposed. So those aren't susceptible to corrosion anymore. Versus, on the other hand, if you have a CP system and no protective coating, there's really going to be a very large current draw on the system. It's going to require a lot of current to polarize the entire structure. So, the two mitigation methods really work well in conjunction with each other.

>> **Dr. Chrissy Henderson:** Alright, the next question that we have is a-- for you, Grace. Do you know what the approximate amperage requirement is by the rectifiers at Parker Dam?

>> **Grace Weber:** Yes, I do... let me think. I don't know if I remember exactly off the top of my head... Daryl, did we use two-amp rectifiers for each spillway gate?

>> **Dr. Daryl Little:** I believe so, yes. Kind of a rule of thumb is... Depending on the velocity of the water or the turb-- and the quality of water or soil... It's usually anywhere from one to three milliamps per square foot of bare area. It's a rough rule of thumb.

>> **Grace Weber:** And we do calculate based on the end of our lifetimes. So we design our CP systems for a twenty-year service life, typically. We can go shorter or longer, just depending on what we're looking for. So we are looking at the end of the service life, after-- maybe the coating has deteriorated a little further-- and the system might be requiring a greater amount of current. So we're designing for that case.

>> **Dr. Chrissy Henderson:** Okay. This is another question regarding Parker Dam. Do you have any recommendations for methods to protect the left and right edges of the gate skin, outboard of the side seals, that may be sprayed due to leaks in the seals? We might need-- this looks like it's from Kevin Tibbs. We might need you elaborate a little more on your question, regarding that.

>> **Grace Weber:** Yeah, um... We do have protection methods for small areas, what we call "hot-spot" cathodic protection. It really depends on what environment that metal is seeing-- if it's immersed all the time or if, like you said, it's just getting sprayed. It would really depend on how often that electrolyte is sitting there. Whether or not those pieces of metal are already coated. So, without knowing too many more details-- maybe we can just have a separate conversation about that. You're welcome to e-mail us, Kevin.

>> **Dr. Chrissy Henderson:** Are there any safety precaution needed when working in the water around a cathodic protection system?

>> **Dr. Daryl Little:** This is Daryl. I would actually say of course, always. But I have-- There's a unique structure down in New Mexico called El Vado Dam. It's got a steel face plate. And it is under cathodic protection. I have never-- I've walked on that plate, I've been down at the water. Fish have swam right up to the plate, tooled around, and swam away. So I haven't seen any true issues there. But if you're-- obviously, if you're in a confined space, like say the inside of a tank-- an impressed current system-- definitely want to be careful. Galvanic systems, you're not going to have any issues other than the wires and anodes themselves-- don't get tangled in them. But actual electrocution, I honestly have not seen any problems. I think, just looking at the cathodic protection ahead of time, you'll know. Like at the rectifier, seeing what it's doing. You should know whether or not there's any issues with the cables and if you could have a frayed cable or something like that. But, if you're worried about it, the best bet is always turn it off.

>> **Dr. Chrissy Henderson:** Alright. The next question is: What is the role of a dam safety inspector in verifying the operation of a cathodic protection system during routine inspections?

>> **Dr. Daryl Little:** Unfortunately, we don't actually get involved as much in the dam safety. But, I would love to help people out with that. One thing that they could look at when looking-- when doing these-- performing these inspections is the condition of the structure. Seeing if the rectifier is actually turned on and operating. So, that it's actually putting out voltage or current-- and current. And, looking at-- are there historical test records? Once we have a-- once that information's been gathered, than it can be relayed to our group. And we can help make further determinations as to-- is this something that should be looked into further. Hopefully that answer your question.

>> **Dr. Chrissy Henderson:** Alright. It does look like that is the end of the questions that we have. And I will give you guys a few more minutes to ask any other questions that you would like. And, if there aren't any, we will go ahead and close out this webinar.

>> **Dr. Chrissy Henderson:** I do want to give you guys the option too-- as you're listening in to the webinar-- that you can always ask questions of us by email. Just contact any one of us and we will get back to you with any question that you may have. We also-- a number of questions have been asked regarding the-- getting a copy of this webinar. And we will be putting it together. It has been recorded. So once we have all of that finalized and put together, we will send it out to the Corrosion Webinar list. And you'll get a copy of it as well. And so, far it, looks like I do not see any more questions. So I believe we will go ahead and conclude today's webinar. I want to thank you all for joining us. I think it's very important to get the word out about cathodic protection and how it can help mitigate the issues of corrosion for all of our structures. So, once again, thank you very much for attending! And we will be sending out another invite for a webinar that will be in about a month-- on the twenty-first. It will be from our hazardous materials specialist. And it will be going out to the same list. If for some reason you are on this webinar and you did not receive an invitation, but you got word-of-mouth from someone, and you still would like to be on our distribution list-- Please email me at chenderson@usbr.gov. The "c" stands for Chrissy-- chenderson@usbr.gov. And I will make sure to add you to our distribution list. All right, well-- and with that we want to say thank you once again for joining us today!

>> **Grace Weber:** Thank you, Chrissy, for hosting!

>> **Dr. Daryl Little:** Thank you very much.