STATE OF MICHIGAN

STATE OFFICE OF ADMINISTRATIVE HEARINGS AND RULES

In the matter of: The Petitions of the Keweenaw Bay Indian Community, Huron Mountain Club, National Wildlife Federation, and Yellow Dog Watershed Environmental Preserve, Inc., on permits issued to Kennecott Eagle Minerals Company. _______________________________/	File Nos.: GW1810162 and MP 01 2007 Part: 31, Groundwater Discharge 632, Nonferrous Metallic Mineral Mining Agency: Department of Environmental Quality Case Type: Water Bureau and Office of Geological Survey

HEARING - VOLUME NO. XXXIX (39)

BEFORE RICHARD A. PATTERSON, ADMINISTRATIVE LAW JUDGE

Constitution Hall, 525 West Allegan, Lansing, Michigan

Tuesday, July 15, 2008, 8:30 a.m.

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Lansing, Michigan

Tuesday, July 15, 2008 - 8:33 a.m.

JUDGE PATTERSON: Are we ready?

MR. HAYNES: Yes, we are, your Honor. Petitioners call Dr. Kenzi Karasaki on rebuttal.

REPORTER: Do you solemnly swear or affirm the testimony you're about to give will be the whole truth?

DR. KARASAKI: Yes, I do.

KENZI KARASAKI, Ph.D.

having been called as a rebuttal witness by the Petitioners and sworn:

DIRECT EXAMINATION

BY MR. HAYNES:

Q Dr. Karasaki, would you say your name and spell it for the record, please?

A Kenzi Karasaki, K-a-r-a-s-a-k-I, last name; first name K-e-n-z-I.

Q Dr. Karasaki, could you give us a brief description of your educational history?

A Well, I went to Tokyo University, School of Engineering, and got a bachelor's degree in petroleum engineering. And I went to UC Berkeley to do my master's degree under Paul Witherspoon. I did groundwater hydrology. The department was in School of Engineering, material science and mineral engineering department. And I went on to do a Ph.D. in

hydrology again at UC Berkeley, same -- stayed at the same school. And my Ph.D. thesis was on well test analysis in fractured media.
Q And just for the record, your educational background and work experience, awards, journal publications and conference proceedings are contained in your resume, are they not?
A Yes, they are.
MR. HAYNES: And for the record, that resume has been marked as Petitioner's Exhibit 187. That's a different number than I gave counsel yesterday, but it's because of the two exhibits that were admitted yesterday. And by stipulation, your Honor, that resume has been admitted.
Q Dr. Karasaki, what was your thesis for your Ph.D.?
A It was -- the title was "Well Test Analysis in Fractured Media." What it is is --
Q And what are fractured media generally?
A Generally it's fractured bedrock, fractured, faulted bedrock hydrology. And especially when you want to characterize a fractured rock, you drill a borehole and you do well testing, namely pump tests or sometimes you can do injection. And my thesis was about how to analyze the fractured rock and mainly on analytical solutions and theory. But I did a numerical analysis as well and did some field example calculation and characterization.
Q Dr. Karasaki, we have -- you have prepared a series of

slides to assist you in your testimony today.

JUDGE PATTERSON: I don't have a copy of that.

MR. HAYNES: Oh, all right. May I approach?

JUDGE PATTERSON: You may.

Q Dr. Karasaki, you've prepared a series of slides to assist you in your testimony today, did you not?

A Yes, I did.

Q And we have up on the screen right now slide 2, which contains the outline of your education and employment history. And I want to get back to your Ph.D. thesis. You obtained your Ph.D. in 1986; is that right?

A That's correct.

Q Okay. And after you obtained your Ph.D., did you engage in a postdoctoral fellowship?

A Yes, I did.

Q And where was that at?

A Lawrence Berkeley National Laboratory.

Q And what was your work generally as part of your postdoc work?

A Again fractured rock hydrology.

Q And since your postdoctoral work, Dr. Karasaki, where have you been employed?

A Lawrence Berkeley National Laboratory.

Q And what is your title at the Lawrence Berkeley National Laboratory?

A Staff scientist.

Q Can you describe for Judge Patterson what the Lawrence Berkeley National Laboratory is?

A I want to make it clear that I don't represent the lab. But it was founded as a -- one of Manhattan Project labs -- nuclear lab. And now it has diversified into medicine, other engineering areas, but physics, biochemistry and earth sciences. And I'm in earth sciences division. But Lawrence Berkeley National Lab gets most of its funding, about 80 percent, I think, from Department of Energy, its energy lab.

Q Now, can you, Dr. Karasaki, describe for us in general your work experience as it relates to your testimony today?

A Yes. I worked and am working on projects that relates to fractured rock characterization and fractured rock hydrology in the application mainly for groundwater contamination, groundwater resources and geothermal energy. And the biggest funding sources now are from agencies that look into geologic disposal of nuclear wastes. And that will be -- in many countries that would be in fractured bedrock.

Q I see. We have up on the screen slide 3 for your presentation, --

A Yes.

Q -- which contains, I believe, some relevant work experience. On the first bullet, you describe your experience in fracture hydrology for underground tunnels and mines. Could

you explain what those are, please? Start with the Yucca Mountain.
A Yucca Mountain is our nation's proposed nuclear waste repository where about 500 meters underground tunnels will be -- right now there is a eight mile long exploratory tunnel drilled or bored using a tunnel boring machine. And it's in an unsaturated zone, which is kind of unique compared to other countries' approaches. But you drill a lot of boreholes to look at, again, flow in fractures. It's highly fractured tufaceous rock. And LBL has been involved in characterizing how much and where and how long the water and contaminants take to flow through the mountain.
Q I see. And LBL, Dr. Karasaki, is the Lawrence Berkeley Laboratory; is that right?
A Yes.
Q And then you also list on the first bullet of slide 3 the Stripa Mine. What is that?
A Back in early 80's and maybe a little bit early 90's there was a multinational collaboration research program at Stripa Mine, which is an abandoned iron mine. And we used that to again study and characterize how water flows in fractured rock for the application of --
Q And the next item --
A -- I'm sorry -- for the application of nuclear waste storage.

Q Okay. And then the next item is labeled Grimsel in Switzerland. What is that?
A Again this is another effort to do research of fractured rock hydrology in an underground tunnel. In this case, there was an underground power plant beneath the Swiss Alps or right at -- to the Swiss Alps downgradient from a dam. And we used -- or Swiss used the tunnels to get access to the fractures, to look at fractures and characterize fracture flow. And we were -- LBL, Lawrence Berkeley National Lab, was involved -- worked with Swiss to jointly learn how water flows in fractures.
Q Fine. And the next item that you list is the AECL in Canada. Would you describe for Judge Patterson what that is?
A AECL means, I think, Atomic Energy of Canada Limited. And that's a group that looked into again the possibility of storing high level radioactive wastes underground in bedrock of Canadian Shield. And there was an underground rock laboratory in Burnett or some town near Winnipeg to look at -- again study fractured bedrock hydrology and transport.
Q And then lastly in bullet number one -- the first bullet, you list the projects at Kamaishi, Tono and Horonobe in Japan. What are those about?
A Okay. They are all run by Japanese Atomic Energy Research Institute. Kamaishi is an abandoned iron mine. And we used

their drifts and tunnels that are already there to access to the bedrock -- fractured bedrock and faults and do testing and learn how water flow in fractured bedrock. And Tono and Horonobe, underground rock labs solely built from -- into pristine rock to again study water flow in bedrock. And we've been involved working with the Japanese on these issues.

Q   I see. You also indicate that you've developed a fracture network flow and transport simulator. Would you explain what that is, please?

A   Yes. This was part of my Ph.D. thesis, too. And it's a numerical model to simulate fracture flow in underground -- water flow -- groundwater flow in fracture -- connected and disconnected fracture network represented by line elements and finite element -- 3-D finite element. And I also looked at transport, which means matter or contaminant movement in connected fractures. And this code -- I used that code for my thesis. And right now there's a version, I think, that sort of branched off by a person who used to work with me. Now he's Itasca person in France and in Finland and also other -- in South American countries this code is being used.

Q   I see. And you have published -- have you published articles on fractured rock characterization technology?

A   Yes. Most of my publications are on fractured rock characterization.

Q And then have your -- your slides also talk about a dedicated fracture hydrology research site in Raymond, California. Can you describe for us what that is?

A Yes. We have a cooperative project with Canada, AECL. And initially it was being done underground rock lab in Canada, but that was not really what we really wanted. And we wanted to have our own site developed in the United States. So I was the principal investigator on this. We decided to go to the Sierra foothills at the town called Raymond near Fresno. And we developed a fractured rock characterization site that we worked about four years. We drilled about nine boreholes and conducted geologic mapping, all sorts of geophysics, radar, seismics, and we did pump tests, slug tests, we did tracer tests, tried to learn how water flows in fractured bedrock.

Q Have you contributed to a book published by the National Research Council called Rock Fractures and Fluid Flow?

A Yes. I was asked by the editor, Jane Long (phonetic), to contribute to the book. And, yes, there was a section about well testing in fractured rock, and I had a section in there.

Q And is the National Research Council a part of the National Academy of Sciences?

A I believe so, yes.

Q All right. And during your career, you have participated in numerous conferences and workshops, technical review panels on -- and technical review panels on fracture hydrology; is that right?
A Yes.
Q And you have a -- do you have a titled called Research Area Leader of Characterization and Monitoring at LBNL?
A Yes, I do.
Q And what does that title signify?
A Well, I am the leader of the -- it's a very loosely type group where -- by discipline, yes, I am supposed to be the leader in looking at and characterizing again rocks and monitoring what happens in rocks but mainly in hydrology. I'm in the hydrology department so characterizing hydrology and monitoring hydrology of -- it doesn't have to be fractured but rocks.
Q And you been the principal investigator on a fault zone hydrology project at LBNL?
A Yes. I got a sizeable project starting last year. I've been looking at -- learning -- we are still learning how to characterize fault zones. And Japanese authority thought it is an important subject. The United States already has sort of decided that Yucca Mountain would be the nuclear waste repository location -- would be located. But in Japan, they don't have the site yet. But they recognize there would be

a lot of faults. And faults will dominate hydrology in that -- in the vicinity of faults. So they decided -- we have by letter agreement with Japanese to work on nuclear repository siting and characterization issue. So they decided to fund us to further look into fault zone characterization. And we spent one year, last year so far, looking at what's published about fault zone hydrology. And I think in the next slide I can talk about it. But it will go on. We will be doing surface characterization and trenching, geologic mapping, geophysics, drilling at a site actually in -- it will be our property. We identified a sizeable fault, not the Hayward fault, which is huge and it's going -- it's supposed to be -- I'm going off the topic. So anyway -- but there's a site that we will be developing under this funding to look at fault zone hydrology.

Q Dr. Karasaki, for your testimony today, have you reviewed the testimony of various witnesses that have testified at this hearing?

A Yes, I did.

Q And did you review the testimony of Mr. Ware?

A Yes, I did.

Q And did you review the testimony of Mr. Beauchamp?

A Yes, I did.

Q Did you review the testimony of Dr. Carter?

A Yes.
Q Did you review the testimony of Mr. Wozniewicz?
A Yes, I did.
Q Did you review the testimony of Mr. Zawadzki?
A Yes, I did.
Q Did you review the testimony of Mr. Wiitala?
A Yes.
Q Did you review the testimony of Mr. Thomas?
A Yes.
Q And did you review the testimony of Dr. Council?
A Yes, I did.
Q And have you reviewed certain reports that were prepared by Kennecott as part of its permit application?
A Yes, I did.
Q And were those -- among those reports, did they include Appendix B2 --
A Yes.
Q -- of the environmental impact statement? And did you review Appendix B3?
A Yes, I did.
Q And did you review Appendix B4, which is the Golder bedrock hydrogeology modeling?
A Yes, I did.
MR. HAYNES: And for the record, those exhibits respectively are DEQ Exhibit 32 starting at page 206, DEQ

Exhibit 32 starting at page 632 and DEQ Exhibit 33.

Q And for purposes of your testimony, Dr. Karasaki, have you prepared what we might refer to as fracture hydrology 101?

A Yes, I did.

Q And can you describe for Judge Patterson the general characteristics of fracture in fault zone hydrology?

A Yes. Fracture bedrock hydrology or fracture hydrology is a very difficult subject. And as I mentioned, there have been many, many projects solely dedicated to look at fracture flow, fracture transport, "transport" meaning contaminant or radionucleids, mass moving through the system. And it's not a solved problem. We have been -- I've been working on this subject for the last close to 30 years -- 29 years. And it's challenging. And there's -- there's not much you can do other than drill boreholes and test them. You can do geophysics. Of course, if you get underground like the abandoned mines we used or the shafts and drifts that are dedicated for underground rock laboratory to look at fracture flow, the common understanding among us fractured rock hydrologists is that it's full of surprises once you go down underground. So you want to avoid that. You want to look at and predict hopefully in the right way how and how much and where water is flowing and going. So we've been working on it hard, but it's not solved. And what we have learned so far by outline, there's a large -- this tradition

of permeability, I can elaborate on that on the next slide. But it can be spread about 7 orders of magnitude.
Q Dr. Karasaki, when you say "permeability," can you describe what that means?
A Yes. It's basically a measurement of easiness of water to flow in rocks.
Q And when you say "an order of magnitude," can you tell us what that means?
A Okay. We typically use meter squared or meter per second if it's hydraulic conductivity, which is synonymous to permeability even though the units are different and hydraulic conductivity only refers to pretty much water. But orders of magnitude mean like it can be -- if I use the non-dimensional unit, if I say 1, it can be 1, it can be 10, it can be 100, it can be a million or it can be 10 million. So 10 million is 7 orders of magnitude spread. So the contrast of permeability can easily be 1 to several million.
Q I see. And do faults generally have dual properties?
A Yes. What we have been finding so far, as I said, we have started to -- on this sizeable project with the Japanese looking at fault zone issues. And the first year we spent all the time looking at published literature that talks about fault zone and related hydrology. And I have a slide regarding that. But we find that faults are most often or the ones we could find have drill properties that means --

fault is consisted of basically mother -- host rock is not really fault, but that's both sides of the fault. And in the middle, there's the section called core, which is very fine, gouged up when two sides of the rock slide each other and they create rock powder basically. And then that forms a core. And that is usually very low permeability.

But at the same time, on both sides of the fault, there is a region called damaged zone. And that is highly fractured. And that is very permeable and permeable alongside the fault plane. And the core is very low permeability. When water tries to cross the fault, it can't. It's very hard to cross the fault. But it's very easy for water to flow alongside the fault on both sides. And that's what we have found.

Q I see. And when you say in your fourth bullet that, "One feature on each scale often dominants hydrology," what do you mean by that?

A Well, that's pretty much common understanding among hydrologists now. Rocks are heterogenous, heterogenous meaning again you look at one spot and you'll find one characteristic or, let's say, a number of 10. You look at next. You might find 10,000. And right next to it could be million or .1. So that's very heterogenous. It's not like uniform sand where you can look at everywhere. You sample one core and you know all the formation. That's like homogenous system. But fractured rock is very heterogenous.

And you -- what happens is you have different scales which you -- sort of artificial, because the rocks are rocks, and it's there and have been sitting there. But us humans, we have to have some measure. So usually for us a small scale is like drilling and taking a core. That's a very small scale. And then next scale is -- well, you can have various scales. But you can have next scale to be a thickness of a formation. And the next scale can be a basin, a groundwater basin, where within that area groundwater collects into one river or type. And then you can go even bigger. So it depends on who you talk to. There's a local scale, regional scale, core scale type. But each scale, when you look at it, fractured rock because of the heterogeneity by nature -- you know, if you have -- let's say you take samples and you got a sample that says 1 and another says 10, another says million. If you average, it doesn't matter. It's million. Million takes over. The larger number takes over. So at each scale you -- there's a fracture -- fractured rock that pretty much dominates, dictates the property of that scale. So if you have a core that has a fracture and you measure the permeability of a core, that fracture in the core dominates the number for the permeability or easiness of water to flow.

And another scale, if you do a well test, again there will be undoubtedly in the fractured rock. There are fractures. And bigger size -- there's a fracture or two that is -- we used to call and still do killer fracture. Killer fracture dominates the hydrology of that scale. And if you go deeper, there's a fault. As you go -- look at larger and larger scale, there is a feature that pretty much dominates the hydrology of that scale. That's what I mean.

Q Thank you. Your next bullet talks about a small response and that the small response does not always mean that there's a low K. "K" means permeability, doesn't it?

A Yes, it does.

Q Could you explain that bullet for us, please?

A Yes. Again I have slides later to expand on all of these pretty much. But what we have learned -- again I said it hasn't -- it's still ongoing work. But it's a misnomer or a misunderstanding or myth for hydrologist sometimes say that, "Oh, I did do a test here. And I listened at a different well. And at this well, I heard it loud and clear. And this other well here located at the opposite side, I hardly heard anything." That means the permeability between this -- where I did the pumping and where I monitored the pressure, it must be low permeability. That's a myth. It can be totally the other way around. You can have a high permeability and have low response. I can expand on that later. But it's a common myth.

Q I see. And your next slide -- or your next bullet talks about slug tests. Would you explain for Judge Patterson what a slug test is?
A Yes. I think he has heard in previous testimonies, too. But slug test, I call it "quick and dirty." And what is it is -- easiest way is, after you drill a well, you pour a bucket of water, and all of a sudden the well level rises higher than the groundwater level. And because it's higher, it wants to get out. So the water level slowly goes back to where it used to be. So if you monitor the transient or prime dependent water level in the well, you can analyze that and hopefully you try to get the parameter like a permeability or storage coefficient or a S sub s, we call it. What that is is like a capacitance of the rock.
And another way is you can evacuate. You can sink in a bucket and then pull it up, and then the level goes down. Or you can throw in a cylinder -- heavy cylinder and put it in simulating putting in water, but sometimes you're not allowed to put in water. Then you can put in a mass, a cylinder, to displace water. It's the same effect as pouring water in, because the water level rises. Another way you can do is, if you can get fancy, you can put packers in to isolate the section. But the same thing, you can -- you pour in water basically or you evacuate water. So you make a sudden change in the well bore and look at the

dissipation of the change as a function of time. You observe how the level goes. And you hope to get a property of the rock you are testing. That's a slug test.
Q And one of the purposes of the slug test is to determine -- or to help you determine the permeability of the rock?
A That's correct.
Q And I think we'll go into another slide about that later. Lastly on your hydrology -- fracture hydrology 101, as we're calling it, you talk about long-term tests and long-term tests are a must. What do you mean by that?
A Well, it relates back to the slug test, too. But slug tests, because it's quick and dirty, it only tests a very small radius. And it is prone to give you a wrong reading because there are a lot of well bore -- near well bore heterogeneities. We call them skin. When you drill, you basically damage anulus zone of well bore. And that can affect the readings for a slug test.
The last bullet, when I say "long-term" is -- I didn't say pump test, but pump test or you can evacuate -- inject. But that's unpractical. So you -- this pretty much means pump test. You pump out. In order to characterize a large volume of rock, the only way is to pump long term and hopefully, if you can afford, many locations. So the longer you pump, the larger volume you test.
Q All right. Dr. Karasaki, slide number 6 you prepared is

a -- contains a bar graph. And what does your -- what does the slide -- how does this slide assist you in describing the characteristics of fractured rock?
A   Well, this is data from -- data taken from Tono that I mentioned previously. It's an underground rock lab being built in Japan. And they have been drilling boreholes, probably 30, 40 boreholes, deeper holes. And they do testing -- pump tests and some slug tests, too. And this is just to show -- and this is the -- I had raw data, so it's easy to plot. So I used this. But this is very typical. You ask any fracture hydrologist. This is a distribution of permeabilities from bedrock. And you -- in this case, Y axis means number of tests. So there were 30 -- near 30 tests that yielded permeability of 10 to the minus 9. By the way, X axis is the log scale. Again minus 9 means 10 to the minus 9 meters per second.
Q   And would you explain for the record what a log scale is for those of us that don't ordinarily work in these areas?
A   Oh, log scale is again -- in this case, you just write on the X axis the power of 10 numbers such that -- okay -- if you have 100, log -- base 10 of 100 is 2, 1,000 is 3, 10,000 is 4 and 1 is 0.
Q   And then for negative log scales, what does that mean? Do you have like --
A   Again so if you have minus 1, it's 1 over 10. Minus 2 is 1

over 100. So minus 9 is 1 over 10 to the 9th power.

Q I see. And the 10 to the minus power is a way that hydrologists typically describe permeabilities?

A These days in metric system. There was a -- way back when there's a unit that's called Egyptian bucket per lunar month. And it's very difficult. And right now it's standardized pretty much to meter per second.

Q I see. And so if we look at this chart, Dr. Karasaki, going from right to left, we have decreasing levels of -- decreasing amounts of permeability; correct? From right to left?

A From right to left, yes; correct.

Q And explain the distribution here again --

A Yes.

Q -- now that we've gone through the X and Y axes.

A Okay. It's called sort of bell shape. And what it is, it looks like a mountain. And you have foothills on both sides. And again this is plotted on log scale. And this is from one bedrock. If you do a lot of tests, you pretty much get this kind of distribution. There's a darker purple or brownish color that's a little skewed. That's another -- so I was just talking about the purple one. But there is a brownish one that's another bedrock different distribution. But what I wanted to -- the point I wanted to make on this slide is that this is pretty much common understanding among

us fracture hydrologists that fracture permeabilities or properties basically are widely distributed. You cannot just test one and you think you got one number for that rock. You have a big distribution. And what happens is put it all together. The largest permeability -- in this case, you found 10 to the minus 5. And probably that's the only one. And that pretty much dominates the whole system. But if you didn't test it -- let's say, "Oh, you know, I'm done. I've done already 20, so I'm packing up and not doing it," then you may not catch that minus 5. Or in this case, maybe you may not have caught minus 4 that may be sitting out there.
Q I see. Dr. Karasaki, on slide number 7, the title of this says "Larger scale, larger permeability." This slide shows a chart with a lot of what appear to be data points. Can you explain what this chart purports to show?
A Yes. Again this is from Professor Illman's paper in 2006. But this is again pretty much common understanding among fracture hydrologists or hydrologists in general. If you test larger and larger scale -- see, in like layer cake, very homogenous rock like oil reservoir -- but nowadays oil reservoirs are finding, if you look hard enough, it's very heterogenous. But first assumption you could almost get away by testing a core and trying to tell what the property is for the formation. That's a layer cake, nice formation.

But fractured rock, because the rock matrix don't -- doesn't let water flow very much, fractures dominate. And those features and fractures, the larger a scale you look at, the larger feature you find and larger feature meaning larger permeability. So Professor Illman plotted -- he gathered data from different people's publication, and he plotted it. But this effort was done by other like Professor Neumann and many other people who looked at the scale dependency of the parameter.
Q And on this chart, Dr. Karasaki, --
A Yes.
Q -- the X scale says it's log 10 scale in meters. And can you explain for us what the numbers mean?
A Yes. This is like -- again log 10 scale of 0 means that it's 1 meter size, 10 to the power of 1 -- 0 is 1. And so 0 is 1 meter size sample. 1 is 10 meter size sample. 2 is 100 meter sample. 3 is kilometer sample. So -- and minus 1 is 10 centimeter. This is about the size of a core.
Q The 10 centimeters?
A Yes.
Q I see.
A Or even less. Probably 10 centimeter size is pretty big core. So smaller than that would be the core size.
Q And then the Y axis, what does that axis show?
A Is the permeability. This is different from the meter per

second. This is actually permeability. This is meter to the squared. And the hydraulic conductivity was the previous slide. But this is -- for people who are not really hydrologists, you can just think of this as easiness -- like permeability, easiness of water to flow.
Q And then the chart shows -- seems to -- it has two lines that trend from the lower left to the upper right, and it would seem to bound some of the data.
A Yes.
Q What does those lines mean?
A This is what I think Professor Illman drew to bound these data to indicate there's a trend. If you look at smaller scale to larger scale, there's a trend that permeability goes up. The larger scale you look at you find there's larger permeability.
Q I see. Let's go the next slide. Dr. Karasaki, we now turn to some -- we have a slide that depicts a borehole schematic for hole 04EA084 from this project. And you have annotated this figure, have you not?
A Yes, I did.
Q And can you explain for Judge Patterson what this figure shows and what your annotations mean?
A Yes. I --

MR. LEWIS: If I may first, Mr. Haynes. Sorry to interrupt. Renew our objection, your Honor, based on the scope of the rebuttal. As Dr. Karasaki testified, he has reviewed the various Golder reports that Mr. Wozniewicz and Mr. Zawadzki talked about. These slides are all addressed to the modeling and characterization of the groundwater flow in the bedrock. The underlying reports were submitted with the mine permit application materials a long time ago long before the petitions were filed in this case. Mr. Wozniewicz and Mr. Zawadzki in their testimony reviewed what they did, the methodology, the analysis that was already reflected in those reports. So there's nothing new in their testimony. And, in fact, there's been no identification at this point as to what specific new information was presented by Kennecott witnesses to which Mr. Karasaki is providing fair rebuttal.

Furthermore, the Petitioners already had Dr. Prucha testify at some length about the work done by Golder, by Mr. Wozniewicz and Mr. Zawadzki criticizing that work at some length. So I think it's clear that this is not responding to anything new presented by the Intervenor which the Petitioners did not already know about and which they could not have presented in their case in chief, that it is duplicative and they're attempting to bolster the evidence they already put in and ought not be allowed on that basis, your Honor.

MR. HAYNES: Your Honor, this is merely

foundational. Dr. Karasaki is going to testify specifically in rebuttal to the testimony of Mr. Wozniewicz and Mr. Zawadzki. And as we get into the testimony, we'll see that. But in order to understand Dr. Karasaki's testimony, we have to have some sort of a foundation. And if it's mildly duplicative, I don't think that goes beyond the bounds of proper rebuttal. What we are doing is either explaining Mr. Wozniewicz's and Mr. Zawadzki's testimony or we are directly addressing it, which is the test for rebuttal testimony. So if -- this an area that Mr. -- Dr. Prucha did not specifically go into. And again it's foundational. And I think I'm going to take about three minutes on this slide and then move on to other general matters that relate to specific rebuttal testimony relating to Mr. Wozniewicz and Mr. Zawadzki.

MR. LEWIS: Again, just to be clear, my objection is as to the content of the entire set of slides, not only to what's already been testified about. And the entire content of these slides is what I'm talking about in terms of this is information that was already presented in the Golder reports and the mine permit application materials. This was made an issue by the Petitioners in their petitions. It was part of their case in chief. They've already presented testimony on this issue. And this is cumulative, and it's improper rebuttal testimony. And there's not going to be any new information identified that already -- was not already presented in those Golder reports and analysis.

MR. HAYNES: Your Honor, if I may, rebuttal testimony is not required to address new information. Rebuttal testimony is supposed to address testimony brought forward by the Respondent here. And we have -- we had presented to us for Mr. Wozniewicz 41 slides in his presentation in which he attempted to explain the groundwater investigation at the site. We got these slides the morning of or the day before his testimony. Dr. Karasaki is going to be addressing and has in his presentation several of these slides that we will be directly addressing. That's proper rebuttal. And the same is true for Mr. Zawadzki. We had 21 slides from Mr. Zawadzki, who attempted to explain some of the modeling outputs -- the groundwater outputs from the work that was done. And Dr. Karasaki will be either explaining that from a proper hydrological perspective or directly addressing it, which is the scope of -- which is the proper scope of rebuttal. So this is entirely proper. This is not something that we needed to -- that we could have addressed on direct, because we didn't have Mr. Wozniewicz and Mr. Zawadzki's testimony at that point.

MR. EGGAN: I would add, Judge, that the case that we cited in our response to their bench memorandum, the Figgures Case, addresses the point that counsel continues to raise, and that is their contention is that we can't raise information that we could have somehow raised in our case in chief. We are not doing that. But what I would simply state that, in <u>People versus Figgure</u>, the Supreme Court said the test of whether rebuttal evidence was properly admitted is not whether the evidence could have been offered in a case in chief but rather whether the evidence is responsive to evidence introduced or a theory developed by one's opponent. And that is precisely what Dr. Karasaki is doing. He is responding directly to Wozniewicz and Zawadzki's testimony. If you recall, they brought in animations of packer tests being inserted into boreholes and talked about just how their testing was effective. And I think we should be allowed to respond to that.

JUDGE PATTERSON: What about the argument that it's duplicative? How is it different from what Dr. Prucha testified to?

MR. HAYNES: Well, it's not duplicative in the sense that Dr. Karasaki is going to be talking specifically about Wozniewicz's and Zawadzki's justification of their work. And they took some of the Golder reports and said, "Here's how we did it" and explained -- or attempted to explain to this tribunal how it worked. And Dr. Karasaki is not going to be dealing with the modeling aspect. He's going to be dealing specifically with the testing that was done. And so it is -- of course, there's some overlap. But that's not the test, as Mr. Eggan explained. The overlap is not the test. It's whether the testimony is responsive to evidence introduced by the opponent.

MR. LEWIS: Well, you have the legal memoranda, your Honor. I think the Petitioners' view of the law here is that there are no boundaries, that they're entitled to engage in endless repetition and calling new witnesses repeatedly to cover the same subject matters. And I don't believe that's the proper reading of the law that's been submitted to the court.

Secondly, I believe that it's clear that Dr. Prucha did address all of these areas. All they're doing now is bringing in another witness to attempt to bolster his testimony.

MR. HAYNES: Again, your Honor, and I hate to belabor this point, but we have called Dr. Karasaki specifically to rebut evidence introduced by Wozniewicz and Zawadzki. That's his purpose here. It's not necessarily --

MR. HAYNES: Based on that, I think it's proper rebuttal. I'll overrule the objection.

MR. HAYNES: Thank you.

Q Dr. Karasaki, --

A Yes.
Q -- on slide number 8, we have a schematic of borehole 04EA084. And can you -- and as you testified, you've annotated this slide. And can you explain for Judge Patterson -- to Judge Patterson what your annotations mean here on this slide?
A Yes. First that purple circle is where the pressure is monitored. I'm not really bringing this as pointing out a problem with the system that Golder used. It's just to show what it's like when we are doing tests in fractured rock. It is still a cartoon, but it depicts that -- the system and the workings in underground.

So when you do a pump test, you evacuate water -- pump out water in the well. And you monitor -- you have a pressure sensor, in this case pressure sensor is in this pipe right here (indicating). So water is evacuated from this inner pipe to the surface. So the water level in this inner pipe goes down. And that means lower pressure. And the pressure is monitored here. It is a vibrating wire transmitter or transducer. And then there's a little lead line that comes out to through here. And this is where pressure is monitored. But what we really want to monitor is the pressure in here or better yet right here at the -- the oil industry calls it sand phase. But it's not sand. Rock phase right here. That's where we want to monitor the pressure. But typically it depends. This schematic shows it's monitored here (indicating). There's a plumbing here that can constrict water flow that you can actually be monitoring the pressure in this -- in the pipe out here, which is where we -- use our -- base our analysis on. And other things, it's similar. There can well bore -- near well bore heterogeneity like this constriction in the fracture or something gets stuck like a drilling line or cuttings. That gets stuck in your well bore. When you do well tests and slug tests, you measure these parameters. You really don't measure something out here because of the near bore -- near well bore heterogene skin and we call it "skin." Or constriction; same thing. Constriction in the plumbing where we don't have our analysis method account for.

MR. HAYNES: Next slide, please.

Q Dr. Karasaki, in slide 9 -- slide 9 has a great deal of -- as many equations which I'm not going to ask you to explain because we may be here for a week.

JUDGE PATTERSON: Thank you for that.

MR. HAYNES: You're welcome.

JUDGE PATTERSON: We all went to law school to avoid this.

MR. HAYNES: I think we all did, your Honor.

Q But these equations are -- appear to be taken from some work

that you did in the past; is that right?
A Yes.
Q And the equations -- what do the equations explain in regard to slug tests?
A Well, this is an analytical solution that developed when you do a slug test. And there's a well in the middle and it's a schematic and right around it is a heterogeneity due to the -- again, we -- borehole damage drilling, or just naturally you can have heterogeneous or non-natural -- oh, it can be natural. But basically there's some different parameter property region around near the well bore other than the actual system parameter. Did the mathematics to develop the solution for the slug test analysis. And what I found is basically when you do slug tests -- and the solution is basically -- it's actually in the oil industry it's called "drill stem test." And you -- what you do is you prematurely terminate slug test and it's like a pressure build-up analysis, but I don't get into detail.
So this is the solution basically I use to calculate but what I want you to focus on is the slug test and actual. This is the synthetic actual case. So case A is where it's a homogenous; slug test gives you actual permeability of ten to the minus seven. But case B and C are the cases where you have near well bore heterogeneities. This was to show how my method worked good, but in -- the

reason I brought out is that for slug test you actually end up measuring or getting the effects from near well bore region that you underestimate the permeability of the real system. So this slide is just to show analytically using equations that you indeed end up underestimating the permeability when you use slug tests when there is near well bore heterogeneity.

Q Dr. Karasaki, we now have slide 10 which talks -- which has a series of -- which appears to have a series of drawings and relationships between those drawings in permeable structures and fault zones. Can you explain briefly what this slide -- how this slide helps us understand permeability?

A Yes; yes. This is the still ongoing subject matter. Just like fracture hydrology, this is fault zone hydrology. I brought it up. But this figure is a famous figure by Caine who looked at -- he's more geologist who looked at the fault development. And he looks at -- you know, faults starting, cracking -- the rock cracking in the middle. And then if I said "core," that the crush part in the middle that produced -- that's produced by sliding rocks against each other, and that's core. As you have more core developed you have low permeability region that's call core.

And then another way of developing a fault is to have a damage zone. When it slides you have -- on both sides you develop a fracture damage zone. As you develop more and more, develop damage zone and develop core you end up with this combined conduit barrier fault. And Caine published and saying maybe he has observed these faults somewhere and he lists places where he observed these. But these are surface-based and core-based investigations and we did under this project that I mentioned that started last year for five years on fault zone hydrology project, first here we spent basically doing -- writing white paper and looking at literature and those literature that we could find that talked about fault and fault zone hydrology at the same time -- because we were not really interested in just geologic description of fault; we wanted to find publication that talks about hydrology with relation to faults.

And we couldn't find literature that talks about this conduit barrier fault. Okay. Back. All the literature that we could find was talking about this combined conduit and barrier fault; meaning, at least in our mind right now -- and we will find out; we'll be going to the field next year -- starting this year to do further calculation. Initially we hoped that geology -- geologic information alone will let you know what fault hydrology is. You know, it's nice. If you can just look at the rock type or ask geologist, you know, to look at the fault and ask him and if he could tell you what the permeability of fault is, that would be the greatest thing, because drilling boreholes and doing testing costs a lot of money.

So we had hoped that we could actually classify faults using geologic information. At least in the literature we couldn't find it; we could not correlate it. And what we found was that all the faults that are published in relation to hydrology, they have dual properties. One core in the middle is highly nonconductive to water, so when water tries to flow across it, it has hard time; it can't -- it does cross, unless it's solidly impermeable. But another property that fault has is the permeability high damage zone alongside the fault plane that lets water flow freely almost alongside the fault.

MR. HAYNES: All right. Could we go to slide 11, please?

Q Dr. Karasaki, slide 11 has another chart that talks about -- well, the slide seems to have cut off a portion here. But this slide -- does this slide talk about steady state responses for permeability?

A That's correct.

Q And what -- and can you describe briefly what the point of this slide is for Judge Patterson?

A Yes. This is the bullet -- this concerns to the bullet that I talked about, that low response does not necessarily mean lower permeability. This is -- I lifted out a figure from

Anderson's paper in water resources research -- no, "Advances in Water Resources" in 2006, relatively new. He developed analytical solution for steady state when there's a -- this is a cross section of, let's say, to make it simple, water level. Let's say water level. When you have a well bore and you do pump test in here and you cut the rock and take a cross section, here's the water level that develops. But if you -- he developed a solution for the case when he has a fault, when there's a fault here.

And if you look at the cross section of water level, what happens -- what he found is that -- across the fault. So the other side of the pump test well of the fault, if you observe the water level the fault can be highly conductive or very low conductivity, or dual property fault like it's called -- he calls it general fault -- all of them have very low response as opposed to -- if you didn't have a fault -- I could have had the broken line drawn, the response of water level would be here (indicating). But low permeability fault, high permeability fault, or dual property fault all produces very small response across the fault.

MR. HAYNES: The next slide.

Q Dr. Karasaki, slide number 12 now has a chart that deals with transient responses. Can you briefly describe the significance of this slide?

A Yes. This is basically same -- it says the same thing as the previous slide, but this is a transient case and there's no analytical solution for transient case, so I used a numerical model to basically simulate what Anderson's paper did in transient state. So "transient" meaning the pressure change as a function of time. So again, here's the pumping well and pressure change when you're pumping -- actually, this is a drawdown, so if you pump the water level goes down but you don't want to usually plot negative numbers, so it's flipped to a positive number. But this is like water level going down, going down, going down and then you stop pumping and then it recovers back. And this is a numerical but this is the water level behavior at the pumping well for different cases of permeability of fault that I described previously. The same situation.
Q And the pumping wells here are shown in the solid lines; correct?
A That's correct.
Q And then what are the dashed lines?
A Dashed lines are the observations at well -- observation well across the fault, just like the previous slide.
Q And what do the -- what do the intersection of those lines at, you know, between 10 and 15 days show? When the lines tend to come together.
A Oh, that's -- oh, right here. Oh, well, right here you

stop pumping and it goes back to the previous phase. But what I wanted to point out in this figure is that -- the observation while you are pumping, this is the pressure behavior of observation, or water level behavior. And again, this is the axis is flipped, so this is like water level going down. But this is when there's no fault, you have drawdown or water level going down as high as 25 meters. But for the cases where you have faults you have water level going down very little, like less than ten meters. So again -- and no matter what kind of fault type you have, you have high permeability fault, low permeability fault, sandwich fault it's much lower than you would expect without the fault. So seeing -- again, observing very little response does not necessarily mean there's a low permeability in between pumping well and observation well.
Q Thank you. Dr. Karasaki, we have put up slide 13, which is Figure 8.1 from Appendix B-3. For the record, DEQ Exhibit 32, page 476. And this is one of the figures that you studied in preparation for your testimony?
A Yes.
Q And explain for Judge Patterson what this figure generally shows.
A This is -- was used by one of the Golder's testimony too, I believe, but this shows that here's a solid dark line here. This is where there was -- a pump test was done; the only

one pump test they conducted. It was done in here. And they describe on the plane view -- plan view what observations or drawdowns or responses they observed in different wells that they used to observe.
Q And what was your understanding of the response at well 20?
A They described it's very low response.
Q And in your view is that description -- excuse me. Did they ascribe what the cause of that low response was?
A Yes, they said there's low permeability rock, or it's low permeability; very little connection between these two points.
Q And then, Dr. Karasaki, you have modified this figure a bit. Can you explain what the modification shows?
A Well, yes. You can -- my previous two slides I explained you can have very small response even when there is a highly conductive feature in between the two, because it takes up all the drawdown. Basically what it is, is water -- by pump -- doing pump tests you drill -- draw water from the rock. And the water comes through the easiest path, and if there's a easiest path like fault -- permeable fault along the plane fault, water happily comes through the fault and exits at the pump here. So it doesn't bother the rock upward. So again, it can be lower permeability here too, but it can be higher permeability and you can get exact same result.

Q Dr. Karasaki, slide 14 is a copy of slide 21 from Mr. Wozniewicz's testimony and how is this -- how are the conclusions from Mr. Wozniewicz related to your testimony?
A I looked at his testimony and their report and one of the things -- the results that he lists is that there's one localized conductivity in lower bedrock. And if you look at the report there was only one test done. You do one test in one -- find one localized zone -- conductivity zone, that's surprising. I was just surprised that they didn't do two, three, ten pump tests to investigate if there are more than one localized zone.
Q In your view, Dr. Karasaki, what is the minimum number of tests that should have been done -- do you have an opinion as to the minimum number of tests that should have been done to arrive at a conclusion that there's one localized moderate conductivity interval here?
A Well, you know, as a researcher we like to have as many as we can, and in some places we had like 50, a hundred tests and we still scratch our head. And actually at Raymond site we had over 4,000 responses, pairs taken. And in my mind I would install -- I'm struggling. I have identified a couple of big features, but if I was asked to really tell you how much -- if I construct a mine there and how much water is coming in, I still am not clear. So the more the better. But one -- if you ask any hydrologist any -- particularly

fracture hydrologist; if you say, "Are you happy with one?" I'm sure everybody says no. And how many? Again, it's hard to say. But again, you be economical as well. So if I -- if you really ask me a number, it's just I have to give you like ten, yes.
Q And the second point in Mr. Wozniewicz's slide here talks about the lack of correlation between the 18 structures identified in core and zones with modern hydraulic conductivity, do you explain that in a later slide?
A Yes.
Q Okay. All right. Well, let's go to, then, slide 15. Slide 15 talks about hole 54 and you have annotated this slide -- first of all, tell us what is depicted on this slide.
A Yes. Actually, I added the right-hand figure here just to illustrate what is missing, but I had -- and I looked at the -- in their report this similar looking figures, like four or five of -- I think it was four. But this hole had interesting feature here. They annotated there was flow even at non-pumping condition. And this is -- okay. So this is a geologic column and I think this is the calliper. That means the radius or diameter -- I don't know which -- of well bore. You do that to look at how borehole's surface is shaped. So this is the calliper. And this I believe is the temperature along the borehole, and this is the fluid conductivity and resistivity in the borehole. And this is

where I think he -- they did fluid -- I mean heat pulse flow meter survey where --

Q What is a heat pulse flow meter survey?

A You typically have this little heater in -- lowered in the well bore and you run electricity through it. It'll generate heat and raise the temperature in the water packet and you look at the loss -- by measuring the temperature, observing the temperature right above and below you can infer how much water flow in the well bore.

Q And what does this column dealing with the heater show us?

A It's annotated here. It says I think -- it's kind of hard to see it. But when I read it without my contact there was flow observed here (indicating). And they actually annotated with these arrows -- they indicated they found water inflows --

Q I see. And then you've added --

A -- based on pumping condition doing heat pulse flow meter survey.

Q And you just mentioned that you've added a figure to this slide on the right-hand. What is that figure?

A Yeah, I just wondered why -- in the next figure you will see some boreholes they did this slug test along the borehole, but in this hole they didn't do it and I just wondered why. You have a borehole, you see some signatures like high fluid conductivity; meaning, formation waters coming in and heat

pulse flow meter says there are a few signatures with these lines indicating. I just wondered why they did not do. So if you click once more I said this part is missing; they didn't do the flow slug test in here.
Q And you found that unusual?
A If I was -- you know, I've learned that there are like a hundred boreholes. It's like a heaven. If you wanted to really characterize it you would try to find the -- again, you want to find the killer guy, killer fracture or killer fault and you go after that. But you -- somehow this was selected out of 109. And there were I guess eight hydrology boreholes, but then they ended up really testing one and also some boreholes that they didn't even bother to do slug tests. And this -- the last column of figure is missing for hole 54. And the next one too.
Q All right. We've now gone to slide 16, which talks about hole 77 and hole 84?
A Uh-huh (affirmative).
Q And for hole 77 you apparently have added a figure here that shows the slug test was missing; is that right?
A Yes. Again, same thing. You know, this is hole 84 that they did slug tests. And a pump test right here -- sorry -- pump tests here and some slug tests, and --
Q And did you find it unusual that there was no slug test done for hole 77?

A For the same reason as the hole 54. And actually, there was another one, hole 74 or -3 that wasn't even listed like this geologic column and all this thing, and apparently they didn't do anything. So this is just to illustrate, again, they saw some signature of inflow, of flow doing heat pulse flow meter, but curiously they didn't do -- but not just this one; there were, again, like hole 54 and another one, that didn't even have these columns that wasn't tested. So if you -- I know there's a limitation in budget, but if you have selected eight or nine you would test them all, and somehow, you know, these things are missing and it just puzzles me.

Q I see. And in hole -- we now go to slide 17, which has a -- it's Table 3.2 and you've annotated this table to illustrate what?

A Yes; yes. Again, this sort of summarizes the -- a couple of figures that I showed previously. Hole 54 -- and I failed to actually bracket hole 74. This is the one that's missing the whole column that I showed you and the tests, I showed that they didn't do tests. It says, "Not used." And so these are the nine -- I understand the boreholes they used for hydrology testing, I understand. But somehow the ones, 54, 74, 77, 17, 20; these were not -- they are annotated like saying, "Not used. Not used. Not used." And then some says, "Flow logging." But flow logging is the test that you do along the borehole. It's again, a quick and dirty method to find the inflow points. You can look at the temperature anomaly. You can look at the fluid conductivity anomaly. Or maybe heat pulse flow meter survey is somewhat borehole logging.

So it's quick and dirty because, again, you don't see out pour in the rock. You only see the perturbation or the heterogeneity or properties at the borehole. Flow logging is basically that. So it's quick and dirty but it really doesn't see into the rock. So I do have problems -- you know, if I was told, "Okay. There is actually 109 but you can only have nine," but then you don't end up using all of them and you only -- I guess one pump test that was done in 84 and the rest were flow logging or slug tests.

Q Dr. Karasaki, slide 18 is a reproduction of slide 23 from Mr. Wozniewicz's testimony. And this slide is Table 7.1 from DEQ Exhibit 33, Appendix B-4 at page 33. Can you describe your views about this particular table and what it represents?

A I'm puzzled, because everybody knows in our field that not all fractures conduct water. I had mentioned about Raymond site where I had nine boreholes logged more than hundred fractures in each of them and only two or three fractures conducted water. So it's a common knowledge that structures or geologic signatures, fractures, not all of those conduct water. But water-conducting fractures are -- water-conducting locations in bedrocks are always fractures. So this table is sort of showing the common understanding we know, but it looks like -- what's curious is it almost looks like this is listing all the features that are there and it almost sounds like all the features that are observed don't conduct water or very little water.

And that's very curious because, again -- I have to explain it slowly. Yes, we all understand if you list all the fractures, all the features and try to look at fractures -- I mean flow, permeability, not all of them conduct water. As I said, only one or two in hundred conducts water, but those conducting ones are features. And I understand at least there was one feature in 84 that was tested and in the previous testimony that there was two bullets about results that said one feature of moderate feature was observed. And I'm wondering why it's not listed in here if this was listing all the features.

So if I were to do this, I would list the features that conducts water. Yeah, there may be thousand features that don't conduct water, but we want to focus on the features that conduct water. And those water-conducting features in fractured bedrock where a matrix is so tight and you observe water inflow, that's a feature; that's a fracture or fault. No doubt. Now, if there is -- if you say -- if they say they can't find it, then they missed -- be an error in the measurement. And sometimes we do this still. We use different runs or you go into borehole and do a geologic survey and you have depth measurement in one system and you go in and you lower a packer string and you hope to know where you seat the packer.

But that measurement system is different. You can have -- if in a deep borehole system you can have packer string stretch and you -- again, you measure by pack -- drill pipe or pipe sections. "Oh, okay. I added two or five pipes, so it must be 50 meters." But it can be off by a little but it can add up. So what I'm saying is in fractured bedrock if you see water inflow, that's a feature, not the other way around. So this table is kind of odd in the sense that it's listing features, but almost depicting like all the features don't conduct water.

Q Dr. Karasaki, you have analyzed Golder's bedrock hydrogeologic model; is that right?

A Yes. I looked at their report.

Q And also the testimony of Mr. Wozniewicz and Mr. Zawadzki concerning the model; correct?

A Yes.

Q And do you have some -- do you have some opinions about adequacy of that model based upon their testimony and your review of the model?

A Yes. It's mainly based on the input data. I'm not really a modeler. I have done a lot of modeling but I don't consider myself a modeler, because model is only as good as your input data.
Q And what are your opinions about the input data used for the Golder model?
A That's the part that I have been talking about where -- you know, fracture hydrology's such a difficult subject. Doing one test, one pump test and several slug tests and determine the property of 87-square-kilometer model is a little bit stretching, if I put it mildly.
Q I see. And what about the inflow rates used for the Golder modeling effort?
A Excuse me?
Q What about the inflow rates and their sensitivity to permeability on slide 19?
A Inflow rates? Oh, what -- see this is a more general statement. Maybe we should move on to -- regarding this bullet move on to the next slide in talking about the sensitivity and the resulting inflow of -- into a mine using the model.
Q All right. Let's go to slide 20. And, Dr. Karasaki, slide 20 is --
A We can go back to -- that's right.
Q I'm sorry?

A We can go back to the previous slide later; right? Yeah.
Q Well, we'll walk through the slides.
A Okay.
Q Slide 20, Dr. Karasaki, represents what?
A This is a cartoon but pretty much what depicts the controlling parameters of the model that was constructed by Golder and to predict water inflow into mine. And if I could go on. These wiggles -- or I call them "resisters" -- basically the nobs one could tweak in the model, and --
Q What do you mean by "tweaking nobs"?
A Changing levels, like resistor is one over permeability but I thought resistor is easier terminology and easier to understand. Like water -- when you make an opening water wants to come in. And in the model -- I guess this is very simplistic but this is pretty much they essence of the model that was constructed. And when lower bedrock has a permeability or resistor. When water comes -- tries to come into the mine, there's a resistor or permeability -- one over permeability, the inverse of permeability and the upper bedrock has the same thing.
And if there's a fault, the fault has a resistor; same thing. And fault, if it's connected to the surface, or not, sort of is depicted by this resistor too. If fault goes to the quaternary here, then there's -- actually where it meets the river that's basically very little resistance.

And if the fault is somehow ending up here within the lower bedrock, down here in the lower bedrock the resistor is very large. Same thing. The boundary condition for the Golder model had top boundary condition with the modified one that was testified had resistor basically in between the quaternary and the bedrock. So by tweaking these; I mean, changing numbers to low resistivity to high resistivity you can control the amount of water that gets -- ends up into the mine. So these five parameters are sensitive in deciding what -- how much water going into the mine.
Q All right. Let's go to the next slide. Dr. Karasaki, slide 21 is a reproduction of slide 17 of Mr. Zawadzki's slide show, which deals with mine flow predictions and you have annotated this slide dealing with the sensitivity analysis, and can you explain your annotations for us, please?
A Yes. I annotated putting the title here and I said not so sensitive analyses, because one of the reasons that they find in their sensitivity analyses that -- it didn't even go to their worst case or upper balance scenario by changing the upper bedrock permeability by a factor of five. And all these sensitivities are run by changing the parameter by a factor of five. But as I showed you in the slides where there was a bell-shaped distribution of permeabilities for spanning seven orders of magnitude, doing sensitivity study by doing this factor of five or minus five is way too small.

Q And what factor would you have recommended to be used for the sensitivity analysis here?
A Well, in --
MR. LEWIS: Let me place an objection, your Honor, on foundation and qualifications. We've gone quite a bit down this road with Dr. Karasaki's opinions as to the modeling now, and before we started down that road the foundation question, he elicited the response from Dr. Karasaki that he's not a modeler; that his opinions are limited to the input to the model. And we're now per se talking about the modeling, so --
MR. HAYNES: Well, on the other hand, doing the sensitivity model -- sensitivity analysis in a model, as I understand it, your Honor, involves inputs and certainly Dr. Karasaki can testify about the appropriateness of inputs used to adjust the sensitivity of the model based upon his extensive experience in studying fracture flaws.
JUDGE PATTERSON: And I believe he testified he has that extensive experience with modeling, even though he doesn't consider himself a modeler. I think there's a proper foundation. It may go to the weight of his testimony.
Q Dr. Karasaki?
A Yes.
Q What would you recommend for this kind of a system for

looking at the factors and how the using -- what factors would you use for adjusting the sensitivity of this model?

A Well, yes. If you ask a number minimum two plus, minus two as a magnitude, but what's best is to sample from the distribution you would have collected by doing many tests. If you --

Q And did you see that in Mr. Zawadzki or Mr. Wozniewicz's testimony? Did you see that that was done here?

A It looks like only one pump test was done; and slug tests, as I said, there -- has problem of the near well bore skin effects. And also the influence radius is very small. So to decide the property you go out miles and miles out without data and when you have a model --

By the way, I want to make one comment about being a modeler thing. Modeler is -- as your Honor has mentioned, I have done a lot of modeling and I do -- right now I'm doing all these modeling. But modeler has a little bit different connotation in my mind that when you say "modeler," modeler -- in a big organization a modeler's work is to just use input data you were given and you run the model. And that sort of gives the connotation I kind of don't subscribe to. I don't -- I want to look at and I want to collect in the field my data, or at least supervise the data collection and make sure that there's enough data collected. And then I use that data and do the modeling.

So modeler in general -- maybe I'm just biased, but when I say "modeler," like modelers just go out and just use whatever parameter they were given and happily run the models. That to me is a modeler, so that's why I say I'm not a modeler. But I have done a lot of modeling and still do a lot of modeling.

Q I see. And for the sensitivity analysis here -- getting back to the question, Dr. Karasaki -- what factor would you have used before the sensitivity analysis besides the plus or minus five that was used by Mr. Wozniewicz and Mr. Zawadzki?

A So basically I would use a hundred times bigger or minimum hundred times bigger, or minus hundred. But again, ideally you'd collect a distribution of parameters or the numbers, permeabilities from the field and then you sample from those. And undoubtedly if you do enough samples and data collection, this is not -- this bar would go up here (indicating) and this bar would go down undoubtedly because there's a spread.

And another problem I have with this sensitivity analysis is that when you -- it's okay. This sensitivity is okay to -- actually in my mind sensitivity analysis is to find where data most counts. You know, if you have a big sensitivity -- if you tweak a nob a little bit and the model results change drastically, that means that parameter is very important to your model; at least to your model. Maybe not to the real world, but to your model result. If you tweak a little bit, model results change quite a lot, then that parameter is important. Then believing that your model is correct, then you have to go out and measure and collect more parameters that are sensitive to a model. That's one; that's the one use of sensitivity analysis.

And then another thing you have to do after sensitivity analysis -- and sometimes people just use it synonymously -- is you look at the range of outcome of the model by combining different parameter variations. So you would -- you know, these cases here, one case upper bedrock hydrology conductivity was changed. Next case number of connected permeability feature -- actually, I can get to that later. But third one hydraulic conductivity of permeable feature changed, but they were changed independently one by one; just tweak a nob, put it back. Let's go to another; tweak your nob and tweak it and put it back.

Q And in your view, Dr. Karasaki, is that the proper way to do a sensitivity analysis?

A Again, doing sensitivity analysis one by one is fine, but looking at the model uncertainty and the spread of the uncertainty you have to test the combination of parameter variations.

MR. HAYNES: All right. Your Honor, --

A So these -- excuse me. If I can explain a little bit. So upper bedrock, lower bedrock, hydraulic conductivity of these permeable features; they're not mutually exclusive issues. They can concur, co-happen, coexist. So higher permeability of these three things happen. So again, if you have bell-shaped distribution of observations and then you sample from those and run the model, then you have this spread of outcome of inflow. But if you're just one shot or one -- tweak one nob, that's not really a complete modeling in my mind.

MR. HAYNES: Your Honor, we're going to move into a slightly different area. Perhaps this is a good time to take a break.

JUDGE PATTERSON: Okay. I agree.

(Off the record)

Q Dr. Karasaki, before we left for the break we were going to go to slide 22, which is a reproduction of slide 18 of Mr. Zawadzki's testimony and this slide talks about the sensitivity of certain features that were testified by Golder; is that right?

A Yes.

Q And what is your evaluation of Mr. Zawadzki's opinions here?

A Well, this slide and next slides too, they gave a couple of -- three different cases where sensitivity was tested.

And this slide says there's a -- assuming used big fracture sitting a hundred meters away from the mine didn't change the result much. I could have done that without -- said that without doing the modeling, because if you go back to slide 20 the resistor or the nob is set very low or high resistivity between the mine and the supposed fault that they put in. Without doing it you can say, "Yeah, there's no change." Because again, the lower bedrock permeability or resistor is set too high, or permeability is set too low, very low.
Q And are you aware of other features in the area such as the intrusive that -- in which the mine is going to be located?
A Yes.
Q And is that a feature that you would have recommended to be connected for the purpose of doing the inflow analysis?
A Intrusive rock itself probably is not that permeable, but when it intrudes into the mother rock or host rock it usually, you know, damages and crack -- develops cracks and rubble zones around it. So yes, that's probably the first place I would go an test it.
Q And did you see any testing for the intrusive zone?
A No.
Q For slide 23 -- I think we've already been over some of this, but in terms of the combination of parameters this slide 23 in your presentation is a reproduction of slide 19

of Mr. Zawadzki's presentation. And do you -- did you see in Mr. Zawadzki's testimony or in his slides any indication that the combination of parameters was tested?
A No.
Q And in your view they should have been?
A Yes.
Q Now, for slide 24, slide 24 is a series of -- is several figures taken from Appendix B-4 and what do these figures show in your mind?
A This is a slide from Mr. Zawadzki's presentation or Wozniewicz's -- Mr. Wozniewicz's presentation. And I just lifted that as is. But they argue that their model matches very good, but if you click once, if you'll look at here -- and it's hard to see but this is the data. The above one is the data. And this is their prediction of base case. And to me this is not a good match.
Q And what is the -- what is the relevance of having a good match?
A Well, it's very important to match toward the later time. That tells you the bigger volume of rock. And in this case they do say, "Well, you know, if you start pumping it drew down so fast. And they lowered the pumping rate and further and further down it went down so fast it must be low permeability." But the thing is when you match it at the end, this recovery, they couldn't keep up. Their model

couldn't keep up with the recovery of real data.
Q And what is the significance of that?
A I think they are under predicting the permeability and, therefore, inflow.
Q I see. And the right-hand slide here from Mr. Zawadzki's -- excuse me -- the right-hand figure from Mr. Zawadzki's slide 11, which is your slide 24, what does that show?
A This is their match of the recovery plot and there's a data -- if you go to one click here, their match to -- data is this dark dots. I think originally it's blue dots, dark blue, but now it's like black. And what I'm circling here is their model is not matching this hump, early time at all. As they "improve" their model they go farther and farther away. This (indicating) hump goes farther and farther away. I think this is the derivative plot. I don't get into detail, but basically this is a low plot of -- this is the permeability.
Q On the "Y" axis?
A On my axis and this is the time. And yes, what's important is matching this part.
Q When you say "this part," what do you mean?
A There's a later time.
Q All right. And just for the record, the figure that you're pointing to is Appendix B-4, Figure 8.4; correct? That's the right-hand --

A It's from my report.
Q Yes.
A And again, I lifted the whole -- this whole slide from Mr. Wozniewicz's presentation.
Q I think it's page 11 from Mr. Zawadzki's presentation.
MR. EGGAN: It is. It is.
Q All right. And if we can go to slide 25, which is an enlargement of the figure you were just talking about; is that right?
A Yes.
Q And what -- you have an annotation here that talks about the downward curvature. Could you explain what you mean by that?
A Yes. This is a relatively new approach in analyzing well tests. And this is, again, derivative and this indicates permeability. But one assumption this does is it's a radial flow, but the --
Q And when you say "radial flow" what do you mean?
A It's like in -- from oil industry initially it's a layer cake, nice. When you drill a well the pressure propagates radially in a circular -- in circle; concentric circles. And the flow is all happily coming evenly from all radial directions. But they analyzed this plot to determine the property of the conductive feature and they end up assigning that number to a flat feature, which is 1-D. So anyway,

this plot is -- if it's ideally radial, this gives you toured in the larger rock property. I would say property of larger volume of rock. So as you go further and further out, but unfortunately the build-up is shut off here (indicating), so it ends here.

But the curvature, what this means is that this feature or the permeability or water supply is increasing, but it's stopped after test was done before the full recovery was done, so it stopped here. But if I look at this purplish blue-ish curvature going downward, I would read it that there is more water supply, more connection to the system than their determination of limited length of feature and low permeability.

Q Thank you.

MR. HAYNES: Next slide, please.

Q Dr. Karasaki, your slide 26 is, for the record, figure 8.14 C from Appendix B-3 at page 491. And what -- can you explain this -- the figure for us or your understanding of this -- of your -- of this figure?

A Well, again this is used to show the -- their conceptualization of the pressure behavior, or this, again, is a recovery behavior. But you can think of it as depicting "permeability," quote, unquote. And they say --

Q Excuse me. I want to back up for just a second. This figure 8.14 C deals with the conceptual model for the

pumping test response from 084; is that right?
A That's correct.
Q All right. Please continue.
A So bottom line, they used this figure to show that there is very little, small permeability, low connection to here (indicating) but --
Q What do you mean by "here"?
A "By here"? Probably through well 20, right here.
Q All right.
A And these are too other observation wells. But if you look at this curvature, again, even the observation well, which they didn't show the match -- the time line match, shows the downward curvature. Downward curvature on this type of plot means increased connection to a larger feature, larger permeability. And it's not -- like they say, it's limited. Here too, if you believe in this plot in the sense that this is really used for radial system -- but it can indicate connectivity. If you believe this plot, if you go here, you have much higher permeability. This permeability goes up downward, by the way. Why access -- the lower you go, you have higher permeability.
Q And when you say "here," you're pointing with the laser pointer to a series of X's that are lavender -- I guess lavender.
A Yes. These are the, I believe, other observations here, --

Q From hole 20?
A -- including 20, yes.
Q I see. And again, explain for us what the plots of the lavender X's means to you.
A See, one, they didn't carry the test slowly enough to see this response develop. So if you -- ideally you would -- in the observation wells too at this far out, you want to see it develop doing like this (indicating). But here the test was only seven days, so the pressure didn't get far enough one -- or long enough. It wasn't tested long enough. But even if you take this data as is and push it back to the transmisivity of permeability plot, you get higher permeability.
Q The next slide, Dr. Karasaki, your slide 27, is a table 4.5 from Appendix B-2 that deals with slug tests; is that right?
A Yes.
Q And on this table you have analyzed a subset of these slug tests, and what does your analysis show?
A It's very interesting and curious. Can I draw?
Q Of course.
A Okay.
Q Flip the chart up, and keep your microphone on.
(Witness draws diagram)
A This is test borehole 084, so in their mind their borehole -- and there's some feature here. And then first

they did slug tests for the entire region and got one number, which is this. Let's say transmisivity of 2.8. And then they moved down and assumed lower and upper bedrock boundary. They tested this length and got this number.
Q Which is what?
A 1.9. And so they tested this. They got 2.8. They got -- tested this. They got 1.9 -- no; no -- 1.9. So subtracting it you get 0.9, which is their permeability that they, quote, unquote, "inferred". So upper bedrock, which was most sensitive parameter in their sensitivity study, this parameter was inferred by subtracting this number -- by subtracting this number permeability from this number, and they got this number. And it's all inferred -- all -- pretty much all the slug tests -- they actually didn't conduct slug tests in upper bedrock. They inferred from subtracting large sections permeability -- no -- lower sections of permeability from large section and inferred this permeability for upper bedrock.
Q And what is the significance of having inferred permeability for the upper bedrock?
A You wouldn't do it. You have to measure it. But another thing -- interesting thing that points -- this points out is that they further went down and did tests, and then they tested from 213 to 302. They tested -- I may be off, but let's say they tested this much.

(Witness marks on diagram)

So they further went down in sections -- subset from 100 to 213, so it's lower. So they did this much. And actually, lo and behold, they got fooled. So when they tested this, they got 1.9, which is 2, with the other 10 to the minus 9, but I'm ignoring that. So they got 4 -- no -- 2 here. They tested the subset. They got 4. You can't even imagine -- you can't subtract -- if you subtract it, you get negative number. So, this -- again, this is unphysical. You cannot have a subset and higher permeability. That means the slug test analysis or slug test inherently is error prone. And what happened is they backed off a further subset of this section, and they got a little bit smaller number than this subset.

Q And the number you're talking about here is 3.14?

A Yes.

Q And that's for the test number 4, which is the interval from 257 to 260; correct?

A Correct. So further subsets --

THE WITNESS: Let's go to the next click and -- once more.

A And then actually, again, this subtraction is -- this one you can't even subtract, but here you can subtract. So for the benefit of doubt that the slug tests is working and slug tests give you the right number -- okay -- so let's assign this transmisivity to this section, and the rest -- so 4 minus 3 is 1. 1 time is 10 to the minus 6 permeability or transmisivity has to be assigned to the lower bedrock.

THE WITNESS: So if you go to the next slide -- oh, can you go to another one? Could you click that?

A Okay. It's part here. Actually --

Q Dr. Karasaki, --

A Yes.

Q -- let me back up here. We're now on slide 29, which is page 22 from the Wozniewicz slides, and you have added two red lines to what I think is the lower bedrock area; is that right?

A Correct.

Q And tell us what the significance of those red lines is based upon your analysis.

A Okay. So assuming their slug test analysis valid, for those two slug tests that was conducted that you can subtract at least -- and you subtract out this portion, which plots pretty high here, and they admit that's a moderately high feature. But the rest, 4 minus 3 1, 1 times 10 to the 6 and to plot permeability you divide that by section length. So going -- without going through all the math, the rest remaining of that conductance of permeability, if plotted in permeability and bedrock, it'll stay here. So it's much higher. It's one order of magnitude higher than they have

plotted for the lower bedrock.
Q I see.
MR. HAYNES: And then could we go back one slide to 28?
Q Dr. Karasaki, on slide 28 you have taken table 7.1 from Appendix B-3 at page 389 and analyzed that table for purposes of -- have you taken that table and analyzed it for purposes of determining permeabilities in the lower bedrock?
A Yes. I -- when you look at this table, again, it -- their distinction between Upper and Lower Bound changes, I guess, or -- anyway, based on their base case, Upper Bound is 90 -- no; no. Upper bedrock is at 90, so this goes in sort of lower bedrock. And by the way, this hole 107 is the only hole that they carried out slug tests in upper bedrock, so this part is upper bedrock. But lower bedrock here, I pick this number and, if you look at this number, it says 1.8 times -- no; no -- 8.9 times 10 to the minus 8. So it's almost 10 to the 7th -- minus 7th. So if you go to the next slide, if you plot it on here --
THE WITNESS: Could you click? This was the previous one.
A Oh, yeah, here, they will plot here. This is --
Q And when you say "here," we're on slide 29 -- your slide 29, and you plotted the lower bedrock hydraulic conductivity on what is slide 22 from the Wozniewicz slide, --

A That's correct.

MR. HAYNES: -- which, for the record, is Table -- is taken from Table 7.1 and 7.2 of the 2005 Golder Report.

Q What is the significance of this plot?

(Witness marks on diagram)

A Okay. Again, here's the well hole 107, and then this is the upper and lower bedrock boundary. And they did slug test between 97 to 113 or something here, and they got the transmisivity of 1.5 10 to the minus 6 -- 1.5 times 10 to the minus 6. If they had packer down here instead, they should have -- they will at least get this much anyway, because you are including this much of feature in your packer minimum. So I used this transmisivity and smeared it out, averaged it out over the entire lower bedrock. What you get is that pink line. So actually, without -- this is just simple arithmetic. If you had the packer down here -- well, as it is, it plots here very high in lower bedrock. But just had you had packer down here and tested it and got the same number, you would probably get large number but same number. The pink line is the lower bedrock permeability or the plot.

Q So for purposes of comparing the average permeability for the lower bedrock, you would, based upon Golder's data, move the average permeability --

A -- about one order.

Q -- about one order of magnitude; correct?
A Correct.
Q So it would be more permeable than what Golder shows?
A Correct, based on their data.
Q Based on their data. All right. Thank you. Dr. Karasaki, you testified earlier that you had a chance to review the testimony of Mr. Wozniewicz and Mr. Zawadzki and others. On slide 30 we have a -- two quotes from Mr. Wozniewicz and Mr. Zawadzki that deal with characterization of the rock mass. Can you read those quotes into the record with the page, and then give us your opinions as to the validity of those statements?
A Yes. Mr. Wozniewicz testified, saying that, "We define these bulk properties that represent the bulk of the majority of the rock mass because we could represent with the porous medium approach." And --
Q That's from page 4947 of the transcript; correct?
A Correct.
Q And what does that mean to you?
A I didn't see any basis for being able to represent the rock as porous medium. And again, upper bedrock Petitioner was inferred. And by packing off the entire section and getting one number and saying, "Oh, we can represent this as porous medium" without even testing, is very strange. And 107 that I showed that maybe we can go back, that table, that was the

only one that I could see that was tested in sections. And here you see a permeability spread of -- let's see -- at least -- if you go from here, minus 6 --
Q When you say "here to here," what do you mean?
A Oh. A depth of 97.54 to 114.24 meters. Section is 1.5 to the 10th of the minus of 6. I should use permeability; sorry. Scratch that. And the highest transmisivity of permeability -- 100 conductivity -- you know, I can use either way. But if you look at these -- I shouldn't say "these." Okay. From -- they were the scans and all consistent sections, as you can see, 17 meters' separations, so I can compare either numbers, transmisivity or hydraulic conductivity. My point is the spread is almost two orders of magnitude.
Q And would that suggest a porous medium?
A It's not homogenous. I have seen porous medium rock that has high heterogeneity but bedrock and having -- and this is very moderate. I think, if they go down to smaller sections, they will having seen, again, orders of magnitude spread. But even this -- looking at this it's hard to justify, "Okay. We can represent the whole thing as one porous medium block."
Q All right. Thank you.
MR. HAYNES: Let's go back to slide 30.
Q Dr. Karasaki, the second quote on slide 30 is one from Mr.

Zawadzki at page 4962 of the transcript. Could you read that into the record and give your opinion of that, please?
A "At the same time FEFLOW can simulate what's called equivalent porous media type of flow, which is flow that would be typically encountered in unconsolidated sediments like silt, salt or clays. And we decided that that approach would be valid for the upper bedrock and for the matrix in the rock matrix in the lower bedrock unit," Mr. Zawadzki, page 4962.
Q And what is your view about Mr. Zawadzki's point here?
A Again it's saying statements -- similar statement as Mr. Wozniewicz. And they decided that that approach would be valid. But based on -- I don't see supporting data to that statement
MR. HAYNES: Let's go to slide 31.
Q Dr. Karasaki, slide 31 is table 4.4 from Appendix B-2 at page 232 of DEQ Exhibit 32, and this is a table that deals with hydraulic tests in borehole 083. The title of your slide talks about an "A priority porous medium assumption." What do you mean by that?
A Again it's just -- I'm repeating almost the prior statement -- prior case. That was 84, I believe. But again, they test the entire section from 15 meters to 239 and then test a lower bedrock section or some section below, in this case 80 meters to 79.55 to 239.87, and they do the

subtraction and get the inferred upper rock -- bedrock permeability.

Q And what is the significance of that, Dr. Karasaki?

A Again it's our priority assumption that you can treat the upper bedrock as one unit of one parameter, one number.

Q And in your view, is that a proper way to conduct these analyses?

A No.

Q Dr. Karasaki, the next slide is taken from Mr. Wozniewicz's slides. It's page 37 of his presentation and which contains conclusions from the pumping tests -- his conclusions from the pumping tests. And do you have views about each of the points that he makes here?

A Yes, I do.

Q And let's read the first conclusion into the record, and then I'd like to hear your view about Mr. Wozniewicz's conclusion.

A Yes:

> "The large drawdown (196 meters) for a pumping rate of only 1.6 g.p.m. for the highest localized hydraulic conductivity zone consistent with low hydraulic conductivity for bulk of rock mass in vicinity of proposed major mine openings."

Q And, Dr. Karasaki, what is your view about his statement there?

A Again, I talked about the borehole and the near well bore skin constriction. Large drawdown can be caused by plumbing or near well bore heterogeneities and --
Q All right. And let's go to the second point from Mr. Wozniewicz. Could you read that into the record, please?
A "The moderate hydraulic conductivity zone isolated for pumping test in borehole 04EA-84 appears to be sub-horizontal and local in extent."
Q And what is your view about that conclusion?
A I don't think I am convinced that it's limited extent or low permeability based on their match of the derivative plot and also their recovery regular time line plot that they -- the mismatch of it.
Q And Mr. Wozniewicz's next point -- and I'll read this into the record.
A Okay.
Q It says:

"The high TDS suggested feature not well connected to Upper Bedrock where much lower TDS observed (due to relatively low hydraulic conductivity of the bulk of the rock mass."

What's your view about that conclusion, Dr. Karasaki?
A Well, yes. TDS difference --
Q And by the way, what is TDS?
A Total dissolved solids.

Q All right.
A And in their case, in the lower -- in Eagle Rock case, in the lower bedrock there's high salinity, high conductivity -- electroconductivity water -- high dissolved solids in that. And upper bedrock ore in the quaternary it's fresh water. And there's a difference in contrast in TDS, but that doesn't mean that there's -- they are isolated.
Q And why is that?
A Well, their data show their environmental head there is at -- hydrostatic, meaning there's no driving force. So if you don't have a driving force between zones, no heads, it'll happy sit if you can -- you can have saltwater at the bottom. You can have freshwater at the top. It'll happily sit there without a driving force. You can have a big conductor in between. So it's not a conclusive evidence that there is a division, or somehow big resistor has to be there in between.
Q Mr. Wozniewicz's next point is that, "The interpretation of the measured hydraulic response suggest feature on the order of 145 meters in length." What's your view about that conclusion?
A Again, as I showed in the previous -- or few pages back -- slide, their match is actually poor in a Cartesian plot. And even in log-log that squishes everything for high

numbers and high time -- long time, everything is squished because it's log-log. You can see a signature of the curvature that's going -- heading down, that -- meaning it's finding water source, finding connection. So I think the match is poor, and the conclusion, based on the match, is -- in my mind, is very poor.
Q Mr. Wozniewicz's next conclusion is that, "Very small responses observed in host rock in Lower Bedrock to the east near proposed decline in the Upper Bedrock." What's your view about that conclusion, Dr. Karasaki?
A Yes. I made this point previously too. Simply put, it's said myth. You see small response doesn't guarantee you low permeability. It can be high permeability and you have low response.
Q All right. And then Mr. Wozniewicz's last point is that:
"Rapid drawdown indicates moderately conducted fractures of limited extent and drains quickly, so system reduces to drainage from the bulk of the rock mass with low hydraulic conductivity."
What's your view about that conclusion, Dr. Karasaki?
A Again, if you pump fast and water can't keep up with it, it appears that there's low-permeability. But again, if you have new borehole or well bore plumbing constriction, you -- the water can't keep up coming in. And it's a good indication. This could be a nonlinear problem. Their

recovery couldn't match it. The drawdown they were able to match with low permeability, but the recovery --

THE WITNESS: If we can go back to that plot. Maybe it's too time-consuming?

A But the recovery --

Q I think that'll be too time-consuming.

A Their model could not keep up with the speed of recovery of real data.

Q Now, Dr. Karasaki, you have some additional comments based upon your review of the testimony of Mr. Wozniewicz and Mr. Zawadzki. On slide 33 could you -- well, I'll read into the record what Mr. Wozniewicz testified to, and then I'd like your comment on it. Mr. Wozniewicz testified at page 4856 of the transcript as follows:

"So what that suggests is that that moderately conductive feature is in poor hydraulic communication with the upper bedrock, which has a much higher -- much lower TDS, so there's -- so it's consistent with our conceptual model, where we have relatively low hydraulic conductivity for the bulk of the rock mass."

And what's your view about that comment by Mr. Wozniewicz?

A Yes. This is almost a repeat from the previous comment, but that TDS numbers are different doesn't mean that water -- there's no connection in between. Because as their data show that the uniform environmental head, there's no pressure difference between rocks to drive the water. But actually, if the -- it's in -- environmental head is in hydrostatic. That means they are connected, but I have seen markedly different pressures, high -- abnormal pressures, high pressures, abnormal low pressures in formations that indicate no connection or low connection between formations. But if you have hydrostatic uniform equivalent -- environmental head, that means actually the system is connected.

Q So in your view, the -- is the lower bedrock connected with the upper bedrock hydraulically?

A I think so.

Q Next we have some other testimony from Mr. Wozniewicz on slide 34, and I'll read that, and I'd like your view about Mr. Wozniewicz's testimony. First, he says:

"The very small responses in the host rock in the lower bedrock to the east indicates relatively low hydraulic conductivity material between the pumping zone and the eastern monitoring zone."

That's at page 4865 to -66 of the transcript. Next he says,

"We considered the hydraulic -- we put a borehole out on towards the decline for the test, and the results of the pump test is a relatively low hydraulic conductivity between the pumping zone and that zone towards the decline" at page 4892 of the transcript.

What is your view about his conclusions there?
A Again, this is one of the points I made previously that it's a myth that the small response means low hydraulic conductivity. It can be totally opposite and have high hydraulic conductivity in between.
Q And next, Mr. Zawadzki testified at page 4975 of the transcript:

"We wanted to more reasonably simulate that leakage in the revised model, so we replaced that boundary with what's a head-dependent boundary, which in some way is like specified head boundary but introduces another resistance to flow but is related to the hydraulic conductivity of the overburden material."

And what is your view about that conclusion, Dr. Karasaki?
A Yes. He mentions resistance. That's the key. If you put -- and he didn't tweak that resistance in his -- the sensitivity study, which he should have, I think, in my mind. So if you have a high resistance, there's hydraulic separation between -- you can put artificial hydraulic separation between upper -- no -- quaternary to upper bedrock or to fault zone if the fault goes to the upper bedrock.
Q Now, Dr. Karasaki, you also testified that you reviewed Dr. Carter's testimony, did you not?
A Yes, I did.

Q And Dr. Carter talked about apertures; is that right?
A Yes.
Q And in your view after having read Dr. Carter's testimony, can you identify the assumptions that Dr. Carter made concerning the apertures and the calculation of apertures in the crown pillar?
A Yes. He assumed that all fractures conduct water and all fractures have equal permeability.
Q And in your view, are those assumptions correct?
A No. As I pointed out, with my experience -- and I'm sure people in fracture hydrology all disagree with that.
Q With each of those assumptions?
A Yes.
Q And why is that?
A Because probably -- as I said -- and they pointed out, structures -- not -- all structures don't conduct water. 1 out of 100 or 200 conducts water fracture. And fractures, as I said -- they showed you the example data -- they have distribution. So assuming that they have all constant permeability and fractured rock is -- it's -- we don't do that.
Q Dr. Karasaki, you have also prepared some conclusions, and I'd like you to go through those. First, in terms of the characterization effort that you've reviewed, in your view, has it been adequate?

A No.

Q And can you describe -- can you explain your conclusions in view of the single pump test -- the single seven-day pump test that was performed and how that relates to the characterization effort?

A You know, it's acutely inadequate, in my mind, to have just one pump test in one zone that you happen to test and in base model 87 square kilometers of rock and assign one parameter to all the knows -- you know, the discretized (phonetic) elements in the model, probably hundred thousands of them to assign one number based on seven-day one pump test.

Q And was the pump test -- as far as you know, was the radius of that pump test approximately 200 meters --

A Well, that's what I can't --

Q -- the radius of influence?

A Yes, radius of influence. I think it was in one of the testimonies he said 200 meters. So it took seven days to get to 200 meters in that.

Q And how is the radius of influence of a pump test related to the time of the pump test?

A Okay. If you want to go to 10 times bigger radius, you have to pump 100 times longer.

Q That is, the length of time is the square of the radius?

A That's correct.

Q And so for the one pump test that we know covered a radius of influence of 200 meters, if you were to cover a mile, how long would that pump test have to occur?
A It takes over 14 month.
Q All right. And for the 87-1/2 -- 87 square kilometers that were modeled in -- by Golder, what would be the length of a pump test -- of a single pump test that would have to -- what would be the length of that pump test in order to model 87 square kilometers?
A Well, theory says -- in practice it's different. But if you just extend that theory, it's about 6 miles per side. Then it's -- you have to pump 64 times longer -- no -- 36 times longer, so 14 months times 36, about 50 years. But before you do 50 years, you hit the boundary, either -- or some features, and it becomes pretty much steady state. You can't really influence using one borehole to influence all, you know, 87 square kilometers.
Q And do you have experience with designing the distribution of such pump tests?
A Designing and making suggestions, yes.
Q Yes. And for the area that was modeled by Golder here, is there a distribution that you can recommend for performing pump tests?
A Again, if we talk economics and not really many more new holes -- and I would select different holes or at least more

holes than are already there but I'd barely -- you would drill outward wells for observation purposes as well too.

Q And one of your other conclusions deals with the existence of permeable faults. What is your conclusion, Dr. Karasaki?

A Again, when there's -- I have seen some mentioning in the testimony and reports and the possibility of existence of faults, and my experience has been at least faults have draw properties having low permeability in the core and high permeability around -- parallel to the plane. You cannot -- the tests that they have done -- from the tests you cannot deny the existence. You have to really go in there and test existing boreholes or other boreholes or drill other holes to make sure there are now big killer features.

Q And also, one of your conclusions deals with the adequacy of the current bedrock model, Dr. Karasaki. What are your views about -- what are your conclusions about the adequacy of the current bedrock model?

A Again, the input data they used is based on one pump test. And slug tests, again that looks at having problems with limited radius and the skin effect. So the input data is inadequate, and the match to their input data, in my mind, is poor.

Q And what about the combination of the sensitive parameters?

A Oh, that's another thing. They predict one inflow and one Upper Bound inflow, but ideally you should first collect

data that has distributions and sample from distributions and predict the distribution of inflows.
Q And do you have a conclusion about the likelihood of the size of the inflow into the mine based upon the data that you reviewed and the testimony that you reviewed?
A Yes.
Q And what is your conclusion?
A It's very likely that inflow is much, much higher than the prediction.
Q And lastly, Dr. Karasaki, you have several recommendations that you would give to properly model the bedrock flow at this site, and what are those?
A First you have to -- it's the characterization that's important. You have to use existing wells properly or, if you can afford it, drill wells and conduct additional longer-term pump tests. It might hit boundary, so it may get steady state at some point. But at least over a month -- ideally two or three months -- would give you larger radius of influence and look at larger volume of rock.
Q And do you have a recommendation concerning the circulation data from drillers' logs?
A Oh, yes, that's -- if you can't afford to do pump tests, the first thing I would look at is drillers' logs lost circulation. That's an indication of a fault zone, a

high-permeability zone.
Q And what do you mean by "lost circulation"?
A Oh. When you're drilling, in order to cool the bit -- cutting bit and also carry up the cuttings, you use fluid, and you circulate it. But if there's a large permeability zone, you -- as you push in and pump and circulate the drilling fluid, it gets lost in the formation, and the drillers typically note those occurrences. And that's a very good indication of a high-permeability zone in existence. And I wish -- and usually we would. We do look -- take a look at it before we even design a pump test.
Q And would you perform stochastic modeling?
A Yes.
Q And what is stochastic modeling?
A Yes. Again, this is -- again, there's no really one number to be predicted, because the parameters are so spread. So again, modeling is only last resort, and I'd rather do more characterization than just use a model. But if you do modeling, you can't just decide on one parameter and get one number out of it. You have to -- again, as we know it, fractured rock is highly heterogenous, so those cells -- and they -- they're the numerical grids -- that they assign parameters instead of the same -- I mean, just one parameter to lower bedrock and one parameter to upper bedrock. You distribute it and make it heterogenous as the real world and

do stochastic modeling and see what the result spread would be.
Q And would you test the sensitivity on the combination of parameters?
A Most definitely I would.
Q And what about constructing a model for the quaternary and bedrock flow?
A That's what I would do, you know. If you have a model that has -- is limited capability, maybe you can split it. But it's one system, and artificially dividing into two models and transferring input inflow or flow between the two, that already a priority decides input to the other, so it's odd. You should really do it in one model.
Q And what about regional models? What would you do there?
A Yeah, that's what we typically do too. When we look at the large volume of rock, there are, you know, boundaries that topographically controlling the pressure that -- or water coming in to the area. So monitors like to cut the boundary just based on, you know, size of their memory or the convenience of how fast it'll converge to a solution. You artificially set up boundary to your liking. But actually, there's nature, and the system is such that it's all connected. It's probably connected all the way to the higher mountains. And what -- typically done is to set up a larger area that gives you better control over the boundary

and do larger-scale modeling, regional-scale modeling, and they use that as a boundary condition for inner model for their 87-kilometer model, which actually, if you can do it all one, that's the best, but today's computer capability is still not there. So if I were to, you know, do a staged model, I'd do a big regional model to assign a boundary condition, at least test the boundary condition that you assume. In their case it's no-flow boundary conditions to the bottom and to the sides. That's no flow. But that again, is just by convenience decided.

MR. HAYNES: Thank you, Dr. Karasaki. I have no further questions at this time.

MR. EGGAN: Dr. Karasaki, I do have a few questions for you.

DIRECT EXAMINATION

BY MR. EGGAN:

Q And I want to begin with the recommendations you offer on slide 37, and look at the second bullet point, which is "to conduct pump tests in hole 54, 62, 77, 107 and others with broken zones." Why did you select those particular holes, 52 -- excuse me -- 54, 62, 77, 107? Why did you select those?

A Those were the ones that -- out of 9 holes, supposedly hydrology characterization holes, that they didn't test so -- and I see features -- based on their logs, some

features in there, especially like the one I showed in 107 at a depth of 97 meters to 114 meters. There's a big feature there. So I would certainly go in there and test them if I was limited to the holes that there already are.
Q Well, that would have been my question. Do you think that -- if you were doing this, would you feel constrained to just use those holes, or might you select other locations for pump tests?
A Most definitely I -- if I had, you know, my way, I would drill places where faults are suspected.
Q Okay. One of the witnesses who came and testified in this case -- and I believe it was Mr. Trevor Carter -- indicated that it really isn't standard to investigate fracture systems before construction begins. Essentially -- and I'm paraphrasing what he said. But essentially he was suggesting we can just wait until after the mine construction begins and test from beneath. Do you have an opinion about that?
MR. LEWIS: Objection to the form of the question. I believe that mischaracterizes Dr. Carter's testimony.
MR. EGGAN: Well, I can give you the transcript pages, Counsel. It's 3644 and 3645. And what he said was essentially, "We can wait until we finish and test it from below." I said I'm paraphrasing.
MR. LEWIS: Well, let me look at those pages, Mr.

Eggan. All right?

MR. EGGAN: Fine.

MR. LEWIS: Why don't you let me look at them? I don't think I brought that transcript today -- if you'd be so kind.

MR. EGGAN: I think Mr. Haynes has them.

MR. HAYNES: What page are we on?

MR. EGGAN: 3644 and -45.

MR. HAYNES: Mr. Lewis?

MR. EGGAN: I'd be happy to just rephrase the question. All I'm trying to --

MR. LEWIS: Fine with me --

MR. EGGAN: -- get at is just --

MR. LEWIS: -- excuse me, Mr. Eggan -- if you're willing to do so.

MR. EGGAN: What I would suggest is that I rephrase.

JUDGE PATTERSON: That's fine.

MR. EGGAN: The testimony does speak for itself.

Q Essentially what I'm asking you is, should -- in your opinion -- do you have an opinion about whether we should wait until construction begins to begin this sort of analysis and testing?

A Yes, I do have an opinion. In our field it's almost a cliche. It's full of surprises. That's -- in fractured bedrock. So in order to minimize surprises, it's best to do a characterization as much as you can from the surface. It's like --

Q When you say "in order to minimize surprises," what kind of surprises are we talking about?

A Meaning basically big killer fractures. You do some predictions based on your model or limited data -- input data characterization. You make a prediction. You go down in there, and you find totally opposite things or totally unthinkable things. That's pretty common in our field. And doing, again, one pump test is like -- again, this is almost like cliche now in the field too. It's like asking five blindfolded men touching an elephant, and in this case only one man is asked to describe an elephant. And so you really have to drill more than one -- or test -- conduct more than one pump test and try to characterize the system in fractured bedrock and faulted bedrock.

MR. EGGAN: I don't have any other questions. Thank you.

MR. WALLACE: I just have a couple, Dr. Karasaki. My name is Bruce Wallace.

THE WITNESS: Yes.

MR. WALLACE: I represent Huron Mountain Club.

DIRECT EXAMINATION

BY MR. WALLACE:

Q In this trial we have on many occasions looked at photographs of certain core samples that were taken from around the perimeter of the orebody, and they showed various areas of broken rock and levelized rock and so forth. And I'm trying to understand, if we wanted to know how much water could be predicted to flow through that broken-up rock that we see in these core samples, would we want to pump test on a number of -- at a number of places over an extensive period of time around where those samples were taken? Is that what you're saying?
A Yes. But if you are on a limited budget, those levelized ones are probably connected. So if you go into one and pack it off and do a long-term pump test, I would feel actually reasonably comfortable having more observation points as well. But the more the better. But sometimes those levelized zones, it may be so permeable, you know, your equipment may not work sometimes. But, yes, that's where you want to go after. Because again, big one kills -- it dominates the whole thing.
Q So you're saying, if you have a sample -- a core sample that shows a lot of broken rock, that you could save money, at least, by pump testing right there; is that --
A Correct.
Q And did that occur in this case, as far as you know, sir?
A No.

MR. WALLACE: Thank you.

MR. LEWIS: Hello, Dr. Karasaki. I'm Rod Lewis.

THE WITNESS: Hi.

MR. LEWIS: We met yesterday. I represent Kennecott Mine Company in this proceeding.

CROSS-EXAMINATION

BY MR. LEWIS:

Q I ask you, when were you first contacted to do any work on this matter, Doctor?

A When?

Q Yes.

A It's a memory test? I think it was -- wow -- either May or June. I don't remember.

Q Who contacted you?

A Dr. Prucha.

Q And were you ultimately -- did you have a discussion with a counsel for one of the parties about being retained to work on the case?

A Yes.

Q And which party was that, or which attorney?

A I had a discussion with --

THE WITNESS: Oh, I'm sorry. I don't know your last name.

A -- Michelle. That was the initial discussion.

Q And when was that, sir?

A Wow. Sometime in June, I believe.
Q And what were you asked to do?
A I was -- it's possible that I might be called for -- they might want me to be an expert witness on this case.
Q When did you first receive any materials to review?
A Those are the -- again, sometime in May, I think. I can look that my e-mail records, and I might be able to tell you exactly.
Q And you listed earlier the material that you reviewed, Dr. Karasaki, and my list is that you reviewed the testimony of Mr. Ware, Mr. Beauchamp, Mr. Chase, Mr. Wozniewicz, Mr. Zawadzki, Mr. Wiitala and Mr. Council, and you also listed a Mr. Thomas. Can you tell me who Mr. Thomas is?
A Memory test? I could guess, but I can't.
Q And in addition to that testimony that you reviewed, you reviewed the Golder Report's Appendices B-2, B-3 and B-4; correct?
A I remember B-2 and B-3. B-4 is the -- if you give me the title, I think, yes, I did.
Q It's titled "Bedrock Groundwater Inflow Model"?
A Yes, I did.
Q And other than that testimony and those reports, did you review any other materials as to the mining project itself in relation to your testimony?
A No.

Q In looking that your CV, Mr. Karasaki, it looks like all of your work experience in this field that you've been talking about after college has been with this laboratory; is that correct?
A Yes.
Q You've had no other work experience other than working at that laboratory?
A Yes. There was part-time work that I did for a Japanese company that inspects pipeline.
Q Was that while you were employed by the laboratory?
A Yes.
Q Other than that did you have any other job experience other than working at the laboratory and the other thing you just mentioned since your college was completed?
A I wouldn't call it work. It was similar to this. I have been paid to attend and review papers or be a panel member, and there was an -- associated with it by Japanese companies and also companies from Finland.
Q Are you being paid for your work on this case?
A For this one, yes; not yet.
Q Have you been a paid witness in other legal cases?
A No.
Q You've never worked in the mining industry, Dr. Karasaki?
A No.
Q You've never been involved, I'm assuming, with

characterizing the potential hydraulic conductivity of an area surrounding a mine before the mining commences?
A No.
Q In other words, what I said is correct?
A Correct.
Q Thank you. Now, in your discussion about your experience as far as -- I think it was characterized as fractured rock, hydrogeology -- it appears that it's all been related to research; is that correct?
A Yes.
Q And it's also been related, it looks like, to looking than potential repositories for nuclear material?
A That's correct.
Q And this Yucca Mountain was one of the examples of that?
A Yes.
Q Can you tell me for the investigation of bedrock hydrology for a potential nuclear repository, what's the time scale that's being considered for the -- let's call it safekeeping of those materials?
A It's debatable, depending on which side of the fence you're on; anywhere from 10,000 to a million years.
Q And you know what the time scale for this mine is, do you not?
A Operation is 10 years.
Q And you understand that, when the mining is completed, that

the mine will be backfilled and then allowed to re-flood?
A Yes.
Q Now, also on the -- as far as your work that you've done and your experience in research as it relates to nuclear repositories, what's the ultimate concern about the safekeeping of those materials?
A Radioactive, radionuclide escaping and contaminating the groundwater, getting to people's well waters and getting people exposed to radiation.
Q Now, you've talked about some of your experience in this research involving characterization of fractured rock for nuclear -- potential nuclear repositories. And I take it from your testimony, Dr. Karasaki, that you don't feel you can ever really properly characterize the hydraulic properties of the fractured rock to suit you?
A Well, there are many boundary conditions. One is budget, time, within that restraint and constrains. You do the best.
Q But ultimately, even if you do the hundreds -- I think you referred to doing hundreds of drillings and pumping tests and so forth -- or maybe you said more than hundreds -- you still conclude that there may be surprised underground; is that right?
A You try to avoid that as much as you can. Yes, I said that.
Q And I think you talked also about some of your experience in

some -- and I think it they were over mines which are no longer in use; is that right?
A Correct.
Q And those are essentially a research laboratory?
A Correct.
Q Those are -- I assume they're mines that have open voids beneath the earth?
A Yes.
Q And they're within fractured rock?
A Yes.
Q How many such older mines have you worked in? I forget. You had two or three examples, I think; is that right?
A You mean in relation to my research of fractured rock on an older mine?
Q Yes, the research; yes.
A Three.
Q Three? What were the conditions as far as water in those mines?
A Stripa, it depends. Now, initially -- some are wet, some are dry. But initially we actually worked with Golder to look at the actual flow in a Stripa Mine. And we all went in there and did the fractured network modeling and all. But we found basically what matters is the fault. It's not the little fractures that we happily model and put it into simulator and crank numbers. It's actually the big guy

controls -- there's a feature that controls the big one. So in answer to your question, some sections of the mine is dry; some section is really wet.
Q And you worked with Golder in doing some of that work?
A What do you mean work with?
Q At the Stripa. You just said at the Stripa Mine.
A That is like -- we were one of the participants in the research program -- multinational research program, and DOE is -- was funding us and I believe Golder too. But it's not like we were working for Golder.
Q No, I didn't mean to imply that.
A Okay.
Q My question was, you worked with them.
A Yeah. It depends on how you mean "with," but we worked on the same dataset.
Q Okay. I think you indicated earlier too, Dr. Karasaki, in reference to your ability to use some of these older mines as underground laboratories, that there was an advantage in doing so -- is that correct? -- as opposed to characterizing the mass from the surface, is what I'm getting at.
A Yes.
Q And why is there an advantage to your ability to characterize the hydraulic properties of the rocks surrounding the mine by being underground?
A Well, you can look at the fractures, which actually, in

terms of predicting mine inflow, it probably won't help you much at all. But if you are really into -- I'm not the only one who worked on this research topic, of course, nuclear waste repository program. There are a lot of people who actually want to look at fractures in their hand and do really microscopic analyses on that or rock mechanics people who wants to look at how fractures develop around mines. They want to be in the real mine. But for me, I -- when I want to look at a big picture, going in under -- in the mine may not help that much. But for other disciplines in some other applications, yes, it's very beneficial to be in and around.

Q Mr. Karasaki, I wanted to ask you about one of your papers. It's titled, "Project Summary." It's got -- on EPA letterhead -- an EPA symbol on it, and the title is "Hydrogeologic Characterization of Fractured Rock Formations. A Guide for Groundwater Remediators." Are you one of the authors on that paper?

A I believe so.

MR. HAYNES: Counsel, just for the record, what's the date of the paper?

MR. LEWIS: May 1996.

Q I wanted to ask you on page 11 of that paper, Dr. Karasaki, about a couple statements there. There's a section titled "Borehole Flow Logging." And the first paragraph says:

"Flow logging is a critical necessity in the characterization study. It provides a means to identify and quantify the transmisivities of only the relatively few fractures or fracture zones which are in fact conductive."

You agree with that, I take it?

A My knowledge has advanced since -- not entirely. But still, borehole loading, freeloading is -- as I mentioned, it's the first thing you do.

Q So do you now disagree with that statement?

A Not entirely agree now or -- transmisivity part is very difficult. So for that part, if it says -- and it sounds like it says -- I'm probably a fourth author on that; right? That if it says, "From flow logging you can get permeability or transmisivity," I don't agree with that.

Q Did you agree with it in 1996 when the paper was published?

A Whenever somebody offers to be a coauthor, it's an honor, and I do review it but not word by word to an extent -- and again, my knowledge and understanding of fractured rock evolved, so at that time, yes, I have; yes.

Q In that same section further down it says:

"After this initial profiling, the method of profiling multiple wells during the pumping of a single well should be implemented. The highest-yielding well should be used as the pumping well."

Do you -- I take it you agree with that?
A In the context of -- when you're single pumping means pumping one well at a time. I agree with that. But you should pump then to another well and do the test, and that's what we did actually at that site. That was the early research project that was partially funded by EPA, but there was a bigger funding from DOE that continued on, and we learned more.
Q So your thinking has changed on this point as well?
A If it says you can just get away with one single pump test, I totally disagree. But if it says you pump from one well at a time, I agree.
Q Well, I'll read it again just to be clear:

"After this initial profiling" -- and it's referring to the flow logging -- "the method of profiling multiple wells during the pumping of a single well should be implemented. The highest-yielding well should be used as the pumping well."

A Yes, pumping single well, well, instead of pumping two wells.

JUDGE PATTERSON: Mr. Lewis, would this be a good time to break? It's noon. I have to meet with the technical people here.

MR. LEWIS: Sure; fine with me, your Honor; yes.

JUDGE PATTERSON: Back at 1:00?

MR. LEWIS: Yes.
(Off the record)
JUDGE PATTERSON: Mr. Lewis?
MR. LEWIS: Yes, thank you.
Q Dr. Karasaki, have you had any experience with mine engineering methods for controlling potential water inflows in mines?
A No.
Q One of your slides, Dr. Karasaki, you talked about -- offered some opinions about the duration of testing that you thought ought to be done here. Do you recall that?
A Yes.
Q And remind me -- you threw out a couple numbers there -- do you recall what they are without looking at the slide again?
A I suggested over a month would be good. Seven days is short.
Q So the difference of opinion is between seven days and over a month?
A The longer the better.
Q Sure; sure. Always more the better as in everything having to do with rock characterization, I take it.
A To look at longer -- larger volume of rock, we have to do longer term test.
Q And I wanted to ask you also, sir, a couple of things. I think you indicated that it was your impression that there

was no pumping test done on a couple of holes. And I wanted to ask you about that. Two of the holes you said -- and you had some slides on this -- that you indicated there were no pumping tests was hole 54 and hole 77. Do you recall that?
A The fact that I showed the slide or the content of it?
Q Let me see if I can find it here, Doctor.
JUDGE PATTERSON: It's 14 and 15.
MR. LEWIS: Thank you, your Honor.
JUDGE PATTERSON: Or 15 and 16.
MR. LEWIS: Yes.
Q Slides 15 and 16, you talked about hole 54 and hole 17 and you say they should have been tested. Okay?
A Yes.
Q And when I look at the Golder Report, Appendix B-2, on page 12, and this has been I think Mr. Haynes already probably referenced this perhaps as a DEQ exhibit, but just for reference to the record, these appendices B-2, B-3 and B-4 are all in Intervenor Exhibit 7. They've been identified in the record before. And this is the Appendix B-2, Dr. Karasaki, one of the reports you indicated you had reviewed for your testimony. And if we look on page 12, it says near the bottom of the page, they talk about heat-pulse flow meter testing of various holes, Dr. Karasaki.
MS. HALLEY: Your Honor, if counsel wouldn't mind, I'd like to have the witness look at the page?

JUDGE PATTERSON: Yeah; sure.
Q Sir, are you on page 12? I may have misspoke and said 21. Page 12, sir?
A Yes.
Q And near the bottom of the page, the section on heat-pulse flow meter, do you see that?
A Yes.
Q It indicates in the first paragraph, second sentence, "For all of the boreholes, no flow or very minor flow was recorded under static conditions;" right?
A Yes.
Q And then if we go to the next paragraph, it says, "In two of the boreholes, O4EA-73 and O4EA-77, it was not possible to establish a constant flow rate, and the borehole fluid levels could only be drawn down to the pump inlet." Do you see that, sir?
A Yes.
Q So it does indicate that pumping was done, but there was so little pumping to be done that no constant rate could be established.
A Pumping for heat pulse flow meter and pump tests are different -- two different things.
Q But it is pumping, is it not?
A Yes.
Q Okay. And if we look at the next page then, page 13, Dr.

Karasaki, we see there a reference to the other hole you indicated for which no pumping had been done. I believe it says for all -- or for boreholes O4EA-47, O4EA-54 -- and that's the one we're talking about and another -- and O4EA-84, the pumping rates maintained at approximately 3.8, 1.9 and 3.8 liters per minute, (1, 0.5 and 1 gallons per minute). Do you see that, sir?
A Yes.
Q And that indicates, does it not, that the pumping in the borehole 54 that you referred to was in fact done, and the rate indicated for that pumping was only 0.5 gallons per minute?
A That's what it says.
Q While we're on this document, Dr. Karasaki, I'd like to refer you also to page 21. And at the top of the page there -- and this is in reference to your earlier testimony that apparently you were under the impression that Golder did not have access to the drill logging information. In particular, you commented about that drill logging information about potential water loss during drilling might be important. Do you recall that, sir?
A Yes.
Q And I wanted to read this to you, and again the understanding you reviewed these reports. But it says, does it not, at the top of page 21 that in addition to the single

packer test, a double packer test was performed between 41.45 and 44.19 meters? This interval was selected based on partial loss of circulation in this depth range that could indicate a localized zone of relatively high hydraulic conductivity. That's what it says, does it not?
A Yes.
Q So it appears that Golder did in fact use such information and did in fact target their investigation on such zones, does it -- doesn't that -- isn't that what that indicates to you, Dr. Karasaki?
A Yes.
Q On another point, Doctor, I believe you offered some testimony as to perhaps the sensitivity analysis that Golder had done indicating that you felt they were incorrect not to have looked at the influence of the boundary conditions and incorrect not to have looked at that and removed the -- what you called the resistance? Was that your opinion?
A Could you repeat that, please?
Q Sure; sure. You showed on a slide what you called resistance to flow, I think. Do you recall that?
A Yes.
Q And I believe you indicated -- tell me if I'm wrong -- that you believed that one of the parameters that Golder should have varied in their investigation was to remove any resistance to flow at the boundaries of the model. Is that

your opinion or not?
A No.
Q Do you understand that they did in fact do that in their various modeling analyses?
A Yes. This figure? You're talking about this figure?
Q Yes; yes.
A I don't have any resistance to the boundary except -- this is not even boundary either.
Q What slide are you on, sir? What number?
A 20.
Q Thank you.
A I thought this was what you were talking about.
Q If we look at the next slide, 21, your slide 21, --
A Yes.
Q -- and you see the sensitivity parameters that Golder looked at are labeled along the bottom; true?
A Yes.
Q I thought you had indicated that for the one that's labeled "boundary conditions," that they had failed to remove the resistance to flow and you were being critical about that.
A No.
Q Okay. So you understand that they did remove the resistance to flow, both at the top of the model and the sides of the models during their sensitivity testing?
A To the top, with a modified value condition, they are

talking about -- I don't recall them tweaking the resistance. Other boundary conditions are insensitive with the rates.
Q   All right. Could we look at Mr. Zawadzki's slides, please? Slide 16, I think. This is a slide that Mr. Zawadzki used to review his testimony, Dr. Karasaki.
A   Yes.
Q   And this particular slide is where he was discussing the sensitivity analysis. And you'll see the bottom item number 6 as to boundary conditions, it says, "Top and lateral boundaries replaced with specified head boundary," does it not?
A   It says so; yes.
Q   And by doing that, you're removing any resistance to flow, are you not?
A   The way this says sounds like it, but in his testimony he says he replaced with a modified boundary condition where you have a resistor. I think I have his quotes in here. My 34 slide, he said "which in some way is like specified head boundary but introduces another resistance to flow."
Q   And you understand, sir, I think we're talking about two different things. One thing Golder did was they modeled the prediction for mine inflow. You understand that; right?
A   Yes.
Q   And they came up with a number which was ultimately 60

gallons per minute inflow. Are you aware of that?
A Yes.
Q And I believe that Mr. Zawadzki, what he was talking about where you referenced him is what they did to the model for the ultimate predictions that derived the 60 gpm. Are you aware of that, sir?
A Yes.
Q And what I'm talking to you about now is not what went into the model for the ultimate predictions, but the sensitivity testing that Golder did on the model; right? And that's the slide we were looking at earlier. And if we go to your slide, sir, slide 21 of your slides, that -- well, let's go to slide 17 of Mr. Zawadzki. Your slide 21 was this same slide; right? And this slide represents the results of Golder's sensitivity testing. You understand that?
A Yes.
Q Okay. And again the parameter on the right-hand side of the chart there on the bottom is boundary conditions; right?
A Yes.
Q And we just looked at Mr. Zawadzki's prior slide, and again he's talking about the sensitivity analysis now -- right? -- not the final prediction of mine inflow but the sensitivity analysis. And he says there again that the top and lateral boundaries were replaced with a specified head boundary. Are you with me so far, I think, aren't you, sir?

A Okay. Yes.
Q And that is the source then, if we look back at this graph, what he's showing us there in the yellowish bar on the right for boundary conditions is when he did that, when he removed the resistance to flow, how much did that change the picture; right?
A Yes. That's my whole point of bringing up this resistor cartoon. If you have a resistor between upper bedrock, the feature, and upper bedrock or the boundary, you don't have flow. So you have less flow. So --
Q Right. And so he looked at that in his sensitivity analysis.
A Not in combination.
Q Well, let's go back. We're just talking about the boundary conditions, aren't we, sir?
A Yes.
Q I understand your point about not in combination. I'm not asking you about that.
A Oh. Okay. Then, yes, he did. I understand; yes.
Q Okay. Just on the boundary conditions. And what I was trying to get to, sir, is that the results of the sensitivity analysis, when he removes any resistance to flow from above or the sides of the mine, it shows that the model does not change very much. The prediction does not change very much.

A Yes, that's because upper bedrock is held to low permeability. So it's now acting as a resistor. So taking out outer resistor doesn't make you any change.
Q Right; right. Can we go to Mr. Wozniewicz slide 19, please? Something else you said confused me a bit, Dr. Karasaki. And I thought you indicated more than once that Golder only performed pumping tests on one hole; is that your understanding?
A The parameter they ended up using for the model; yes.
Q But you're aware that they did do pumping tests on more than one hole?
A Actually I'm not. I thought it was only 84, but I stay corrected if --
Q Okay. Well, that's why I showed you this slide. And this was Mr. Wozniewicz' testimony where he reviewed the various testing they relied on for their modeling, and you see that he says on the second bullet point or he did say, "As part of the flow logging, they performed short-duration pumping tests over the entire open borehole length for five boreholes." You were not aware of that?
A I don't know. I think the sentence reads -- flow logging, I know they did the entire borehole. I know the short-duration pump tests are now only done -- what I can look at. Maybe there are other data that I didn't get to see. From the reports I can read, I didn't know but --

Q So if it's in the reports, it's just something you missed or didn't notice?
A No. If it's short-duration, they ended up not using it and probably was important.
Q Well, do you know that they didn't use it, Dr. Karasaki?
A Yes.
Q In fact Mr. Wozniewicz testified they used all this information. Do you have some greater knowledge about this?
A They didn't use the parameter. And the way I read it, they -- again, I -- if you could show me which results they got from pump tests? And pump tests sometimes -- yes. Sorry.
Q Let's go back to slide 19 unless we're still there. Well, let's not. Let's look at slide 20, please. This is the next slide after the one we just looked at, Dr. Karasaki. By the way, were you -- you said you reviewed Mr. Wozniewicz' testimony and Mr. Zawadzki's testimony. Did you review that in some detail?
A Yes, as much as I can.
Q Were you given copies of their slides to review?
A Yes.
Q So you would have reviewed these slides?
A Yes.
Q And as to these pumping tests that you apparently did not know were done, you'll see in the second bullet point there,

Dr. Karasaki, that they give more detail as to those short-duration pumping tests. They tell us where they set the pumps; they tell us they pump from the entire open interval, and they tell us about the results, that "In two of the boreholes, the sustainable rate from the entire borehole was below the lower limit of pump, 0.5 gallons per minute for a drawdown of 15 to 20 meters, and that in three of the boreholes, pumping rates between 0.5 to one gallon per meter were maintained for several hours for a drawdown between 15 and 20 meters. Measured flow rates consistent with low hydraulic conductivity." You were not aware of that when you testified today either, Dr. Karasaki?
A For this short-duration pumping test, no.
Q And it sounded like perhaps you were not aware that Golder had, in fact, looked specifically at the so-called identified structures that were identified in the drilling for this operation. And I wanted to ask you, were you aware that Mr. Wozniewicz testified that they did, in fact, target and identify those structures for testing? And we can see on the next slide the results of the -- the first bullet point that Mr. Wozniewicz talked about again as reflected in his report was that they could only identify one localized moderate conductivity interval, that being in the massive sulfide in the lower bedrock. And you understand that was the hole 84 that they selected for the longer term pumping,

don't you?
A Yes.
Q And then as to the second point that they did, in fact, target these 18 structures, the identified structures in the rock, and that they found no apparent correlation between the 18 structures identified in the core and zones with moderate hydraulic conductivity, were you aware of that before you testified today?
A When you say "target," what do you mean "target," please?
Q All right. Let's look at slide 23. Now, this is some of the information that Mr. Wozniewicz presented. It's not all of it. This happens to be a table that you talked about earlier today; right?
A Yes.
Q And it is a table that's titled "Comparison of Structure Data With Hydrogeologic Data"; right?
A Yes.
Q And, in fact, what they did here and what Mr. Wozniewicz talked about was they specifically went after these so-called structural zones identified in the drilling to look at them as far as their potential conductivity. And it shows, does it not, the conductivity in these various zones on this table, Dr. Karasaki?
A Again could you define "target"?
Q My question now is, this table shows the conductivity for

these identified zones. You can see that, can't you?
A Yes. I showed it.
Q Yeah, I know you did. I know you did. That's why I was a little confused as to why -- I thought you indicated that Golder had not investigated the zones.
A They inferred. But again the purpose of this table appears to show that these features and structures don't conduct water. But that's totally wrong. Features do conduct water. Not all features conduct water.
Q Well, they show the conductivities on the graph, do they not, on the table? They've got on the right-hand margin, you know, the units we've been talking about, the 10 to the minus 9, 10 to the minus 8 units as far as meters per second conductivity; right?
A They were inferred maybe.
Q Well, are you guessing, Dr. Karasaki? Because their testimony was these are measured conductivities.
A Okay. Let's go back. This -- I should answer your question. Please ask me again.
Q This slide shows, does it not, that they actually did measure and report the conductivities for these structural zones?
A Measure, I'm not sure. But they list features and they associate inferred permeabilities to it.
Q All right. Now, Dr. Karasaki, you talked earlier about your

experience in fractured rock in connection with research having to do with repositories for nuclear wastes. That -- tell me if I'm wrong here, but most of your experience has been in what you call granitic rock?
A Some sedimentary rocks.
Q Some sedimentary?
A Yes.
Q Did you, in connection with your review of the case materials in preparation for your testimony, investigate the nature of the conductivities of the sedimentary rocks around the proposed mine?
A Around the proposed mine? Nature of metasedimentary rocks?
Q Yes, in terms of their hydraulic conductivity.
A If there are separate reports measuring those hydraulic conductivities, I'm not aware of. The ones that are reported -- the ones I saw, yes, I am aware.
Q And what's your understanding about the various reports about the hydraulic conductivity of sedimentary rocks in the region around the Eagle Mine?
A Metasedimentary, very low permeability, matrix -- rock matrixwise, low permeability, very much like granite.
Q And are you aware of the literature about the fractures in the metasedimentary rocks in the region around the proposed Eagle Mine and as to their potential conductivity, Dr. Karasaki?

A Only the ones that are mentioned in the documents I reviewed.
Q All right. So you did not go beyond what was reported in the -- for the actual drilling and hydraulic testing around the mine?
A Could you repeat that again?
Q You only looked at the data that was collected in terms of doing the hydraulic investigation for this mine area?
A Correct.
MR. LEWIS: Could we look at slide 25, please? Could you blow up the bottom half, please?
Q Can't blow it up, Dr. Karasaki.
A That's okay. I can go take a look.
Q This was presented earlier again as part of Mr. Wozniewicz's testimony. You spent a lot of time talking about fractures. And I think you said one or two out of a hundred can be conductive?
A Yes.
Q And you spent some time talking about the potential fractures around the mine and offered your views as to whether they would be conductive or not conductive. And I wanted to ask you if you were aware of this literature talking about the nature of the fractures in the metasedimentary rocks in this region. In particular, if we look at the second bullet point, reference to technical

report number 3, groundwater investigations in Marquette Iron Mining District, Michigan, Intervenor Exhibit 141, wherein they state that:

"No large open fractures have been reported in any of the operating mines, although hydraulically tight faults are common in the area, interconnected supercapillary fractures in the bedding of the major structures probably account for the largest percentage of water found in the mines where subsidence has not disrupted the flow pattern for the bedrock remains intact. No relation is apparent between the amount of water pumped from the mine and the head of the water in the initial overburden."

Were you aware of this characterization of the metasedimentary rocks in this region, Dr. Karasaki, before you testified today?

A I read this slide from Mr. -- yes, I read this side before I came here. Yes.

Q Now, granitic rocks, they are not sedimentary, are they, sir?

A No.

Q And you understand that the host rock around the Eagle deposit is, in fact, a sedimentary or metasedimentary-type rock?

A Yes.

MR. LEWIS: That's all I have, your Honor.

MR. REICHEL: Good afternoon, Doctor. My name is Robert Reichel. I represent the Department of Environmental Quality. I have just a few questions for you, sir.

THE WITNESS: Okay.

CROSS-EXAMINATION

BY MR. REICHEL:

Q I believe you testified earlier today, sir, that you were first contacted about this proceeding of this case by Dr. Robert Prucha; is that correct?

A Yes.

Q How do you know Dr. Prucha?

A I think it dates back to 1986, '87. He was a graduate student at the same time I was at Berkeley -- UC Berkeley.

Q And when Dr. Prucha contacted you about this case, what did he tell you about the nature of this case?

A Nature?

Q What did he tell you this controversy or dispute was about?

A He said he -- it's very complimentary. He thinks I'm the expert in fractured rock bedrock hydrology. So he wanted me to look at the reports that Golder produced and wanted to hear my opinion. If --

Q Go ahead.

A That's okay.

Q Did Dr. Prucha tell you at that time -- and I believe you

said this would have been about May of this year approximately?
A Yeah. My --
Q This is not a memory test. But sometime within the last few months?
A Yes.
Q Okay. Did Dr. Prucha tell you at that time when you first learned about this controversy that he had already testified in this case criticizing the decision of the Department of Environmental Quality to issue this mining permit?
A No.
Q He didn't?
A Maybe then my time line is off. Maybe it was before -- when he talked to me, there was no mention about him testifying.
Q Okay. Did he -- did you come to understand at some point that he has testified in this case?
A Yes.
Q And when he talked to you about this situation, did he tell you that had formed certain opinions about the nature of the characterization -- the hydrologic characterization that had been done at this site?
A No, not really. He really wanted me to express and hear my opinion on the way the characterization was done and if there was anything I would do differently. That was the way he put it.

Q Now, in your various slides today and testimony, I noticed that sometimes you refer to the term K, the capital letter K; correct? And what does that stand for, sir?
A Permeability. Oh, actually hydraulic conductivity is the accurate term.
Q Okay. Well, that's -- and you're the hydrologist, I'm not. But it's you understanding, sir -- tell me if I'm wrong -- K is a -- in your profession is a term -- has a specific technical meaning, does it not, hydraulic conductivity?
A I would use that hydraulic conductivity with a capital K.
Q Yes.
A And usually a small k means permeability. And that's a meter squared unit. And it's intrusive to the rock. And hydraulic conductivity includes the properties of fluid mainly in this case water. So there's a subtle difference.
Q They're not necessarily the same thing, are they?
A I would -- for people who are not in our field, I would use it synonymously except for the magnitude like they are a 10 to the 7th difference in terms of numbers, permeability of 10 to the minus 17 is, I think -- again, I can get corrected -- buy hydraulic conductivity of water is 10 to a minus 10. So there's a unit conversion.
Q I'm just trying to understand, sir. In your opinion, is permeability -- are permeability and K interchangeable?
A Roughly, yes, unless it's highly, you know, changing fluid

properties, yes. And knowing you have to know the fluid property to tell about hydraulic conductivity. But again that usually means that water properties of density and gravity term and viscosity term, which don't change much over the temperature range we are talking about here.

MR. REICHEL: Nothing further at this time. Thank you, Doctor.

MR. HAYNES: Dr. Karasaki, I have a few questions follow up on some questions that counsel asked you.

REDIRECT EXAMINATION

BY MR. HAYNES:

Q Mr. Lewis inquired about your experience in characterizing the hydraulic conductivity around mines. Do you recall that line of questions? Whether you had experience in that area?

MR. LEWIS: That's not what I asked him, Mr. Haynes.

MR. HAYNES: Well, that's what my notes say. Maybe my notes aren't accurate.

Q Let me ask directly, Dr. Karasaki. In your view, is characterizing the hydraulic conductivity of fractured rock around mines any different from characterizing hydraulic conductivity of fractures in any other area?

A No. You drill boreholes and you do pump tests.

Q Mr. Lewis asked you about Appendix B2, page 21, about a sentence that talks relating to hole 083 about partial loss

of circulation at a range that was picked for a packer test; do you recall that on page 21?
A Yes.
Q In your review of Appendix B2, did you see any other references to ranges where packer tests were performed based upon loss of circulation other than this particular -- this item for any of the other holes that had packer tests done?
A Not that I know of, no.
Q And so in your view picking a packer test interval one time for the holes that were used here, is that sufficient -- is that a sufficient quantity to do it once?
MR. LEWIS: Objection to foundation, your Honor. First one would have to know how many occurrences there were of such a thing to form an opinion as to whether one is sufficient or not.
MR. HAYNES: Well, I think the witness has a foundation. He's read the reports. I'm talking about a finite number of boreholes. And I'm asking whether performing one test based upon one reading of loss of circulation in the hole is sufficient.
MR. LEWIS: Well, same objection. If there was only one, I would assume that would be sufficient unless he knows how many such instances there were. There's no foundation for the question.
MR. HAYNES: I asked -- yes, there is, your Honor.

I asked the witness if he had seen any other instances of packer tests performed where there was a loss of circulation in the other boreholes in this report. And his answer was no. So that lays the foundation.

JUDGE PATTERSON: Okay. I'll overrule it.

Q Dr. Karasaki?
A Yes. I lost your question. But maybe --
Q Let me restate it.
A Yes.
Q You testified on direct examination in response to some of my questions that you'd expect to design the investigation using the driller's logs notes for loss of circulation; correct?
A Yes.
Q And you testified that, in your review of the reports, you noted that there was only one such interval design from the loss of circulation?

MR. LEWIS: Objection to the form. He testified he reviewed one report and did not notice any such other instances.

MR. HAYNES: I think that's the same thing, your Honor.

MR. LEWIS: No. You said "reports." I assume you're referring to something more than this individual report. And that's all he said that he reviewed. He

further testified he didn't recall seeing this instance. But at any rate my objection is that you're asking him about having reviewed other reports and looked for such information. And he hasn't testified that he has done so.
Q Let me lay the foundation, Dr. Karasaki. In your review of Appendices B2, B3 and B4, --
A Yes.
Q -- did you see any other information suggesting that the packer test intervals were based on the interval where there was a partial loss of circulation water other than for hole 83?
A No, not that I can recall.
Q Okay. And in your view, Dr. Karasaki, if one has the driller's logs -- strike that. I'll move on to another question. Mr. Lewis asked you about the short duration pump tests that Mr. Wozniewicz testified about. What is your understanding of what a short duration pump test is?
A Well, I was surprised they call it pump test. Because in pump tests you measure -- and maybe they didn't record -- but not recorded the time versus pressure or drawdown. And this was done. When you do heat-pulse flow meters in order to induce inflow to the borehole, you want to draw down a little bit so that water will come in. They do it two ways; natural ways without pumping and pumping. And pumping, yes, you pump a little bit. But they're calling it pump tests,

it's interesting. And, yes, if you do it a long time, you know, it can be very low inflow. If you do it a long time, you begin to see beyond the heterogeneities and you begin to see through the small or low permeability and then see a large picture. But short duration like this and especially for this alternative to just induce flow so that you can measure flow duration for heat-pulse flow meter, nobody going to call it a pumping test. But if you had a pump in there and you switched it on and they call it a pump test, maybe a pump test. But it wasn't analyzed.

Q It wasn't analyzed. And is that kind of, as they call it, a short duration pump test equivalent to the pump test that you recommended then at least 10 be done at this site?

A No, nowhere near.

MR. HAYNES: Thank you. No further questions at this time.

MR. EGGAN: No further questions, Judge.

MR. WALLACE: I have nothing further.

/ MR. LEWIS: Nothing further, your Honor.

MR. REICHEL: Nothing, Judge.

JUDGE PATTERSON: Thank you very much.

(Off the record)

MR. HAYNES: Your Honor, before we start with the next witness, I neglected to do one bit of housekeeping with Dr. Karasaki. Petitioners move to admit as a demonstrative exhibit only the slides from Dr. Karasaki, which would be Petitioner's Exhibit 188 for demonstrative purposes.

MR. LEWIS: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: No objection, it will be entered.

(Petitioner's Exhibit 632-188 received)

MR. HAYNES: Petitioners call Dr. Ann Maest in rebuttal.

REPORTER: Do you solemnly swear or affirm the testimony you're about to give will be the whole truth?

DR. MAEST: Yes, I do.

ANN S. MAEST, Ph.D.

having been called as a rebuttal witness by the Petitioners and sworn:

DIRECT EXAMINATION

BY MR. HAYNES:

Q Dr. Maest, you testified before, so we don't need to go through the introductory and foundational work and we'll get right at it. Dr. Maest, you prepared a group of slides for your rebuttal testimony today?

A Yes, I did.

MR. HAYNES: And for the record, these will be -- the slides are Petitioner's proposed Exhibit 189 for demonstrative purposes.

Q Dr. Maest, in preparation for your rebuttal testimony, did you review the testimony of certain witnesses in this hearing?
A Yes, I did.
Q And who were those?
A The main ones I reviewed were Mr. Logsdon's transcript and presentation information, Dr. Miller, Dr. Eary and Ms. LeSage.
Q And did you also review the Power Point presentations of those witnesses if there were any?
A Yes, I did.
Q And, Dr. Maest, have you prepared a summary of the issues based upon your review of those transcripts and those demonstrative exhibits related to water contaminant issues?
A Yes.
Q And what are -- what is -- if you could summarize those issues, Dr. Maest, what is your summary?
A Okay. The summary is provided on this slide. The first issue is the sulfur content of kinetic test samples that were selected during the geochemical characterization program. The second point is disseminated ore that was ignored in much of the discussions about the geochemical characterization. The third point is the crown pillar and its impact on water coming into the mine and how that affects water quality in the mine. The next point is

assumptions about inputs to water quality prediction modeling. There are a couple of slides that I'll have on that. The next point is acid -- acid drainage or acid mine drainage, acid rock drainage and how this can be produced without the presence of oxygen. The next is assumptions about the re-flooded mine. This is after mining is over and it's backfilled and everything is re-flooded. There are some points I wanted to make about that. And then neutralization issues and timing of acid production. And then the last point is assumptions about the effectiveness of the mitigation measures.

Q All right. Turn to the next slide, Dr. Maest. The third slide that you have is a chart that I believe came from Mr. Logsdon's presentation; is that right?

A Yes.

Q And what is your understanding of what this chart shows?

A Okay. This chart was shown by Mr. Logsdon and also by Dr. Eary. It was shown at least twice in the geochemical presentations to the judge. And this is -- on the vertical axis is the amount of total sulfur in the sample. And then on the horizontal axis is the number of samples that were collected where total sulfur was measured. And this black line, you can see that they measure many, many samples, over 6,000 samples for total sulfur. But of those, in red, these are the sulfur context of the column tests or the kinetic tests that part of the geochemical characterization.

Q And what is the significance of the red -- of the placement of the red dots?

A All right. Mr. Logsdon presented testimony that, when there's a change in slope here, that there's a change in rock type. Okay. However, Kennecott Exploration, which is Appendix C of the mine permit application, describes these different rock types, massive ore, semi-massive ore and disseminated ore and gives ranges. And also Mr. Logsdon gives total sulfur ranges for those. Massive ore is between about 32 and 38 percent sulfur. And you can see that there's one kinetic test for the massive sulfide ore. The semi-massive ore -- semi-massive sulfide ore is between about 12 percent and 15 percent total sulfur. And according to Mr. Logsdon, there were two samples of semi-massive sulfide ore. But the one with the highest concentration of sulfur is actually the only one that's in the right sulfur range for semi-massive ore. And then disseminated ore is not really talked about much, although Mr. Logsdon was asked about it during his testimony and he said that it could be mined or it may not be mined; they were uncertain at this point.

Q And just so that we can have the record clear, what is your understanding of what disseminated ore is?

A Disseminated ore has a lower sulfur content that the main orebodies, the massive sulfide ore and the semi-massive sulfide ore. And as I understand it, those two, the massive and the semi-massive, comprise the target for this deposit. There's also disseminated ore that may or may not be mined depending on the metal content. And these -- they look different in the field. The massive ore and the semi-massive ore have a very high sulfide content. The massive ore is up to 100 percent sulfide and about 38 percent sulfur. And the disseminated ore is -- looks more like peridotite. And it has -- but it has a higher sulfur content and a higher sulfide content.

Q And when you say it looks more like peridotite, what does that mean? Can you describe it?

A I mean that it looks more like a granitic rock that has blegs of sulfide in it rather than having almost the entire rock be sulfide.

Q Dr. Maest, on slide 4, this slide talks about -- or references the sulfur range and kinetic testing. And you have some specific comments about Mr. Logsdon's testimony?

A Right. Mr. Logsdon said that the breakoff between ore and development rock is about 3 percent sulfur. However the disseminated ore according to Kennecott Exploration has up to 10 percent sulfur. And there's a large difference between 3 percent and 10 percent sulfur in terms of acid production potential and also metal leaching potential.

Q And that is that if have ore with 10 percent sulfur it's more than three times likely to produce acid than 3 percent sulfur?
A It's not exactly a one-to-one relationship like that. But, yes, it's more likely to produce acid, lower pH conditions and also higher sulfide concentrations and metal concentration.
Q And how is that difference in percentages relate to the kinetic testing?
A The kinetic testing -- if we can go back to the prior slide just for a minute. This sample right here which has a sulfur content of 2.9 percent is the highest percent sulfur peridotite sample that was used in the kinetic testing. However according to Kennecott Exploration, disseminated ore can have up to 10 percent sulfur. So this sample that was identified as semi-massive sulfide ore actually could be identified as waste rock and report to the temporary development rock storage area. So the leaching ability of this type of a rock in this range is important because rock with that high of sulfur content could possibly end up as waste rock at the site depending on whether or not they mine this disseminated ore. And I bring this up because one of the criticisms in Mr. Logsdon's testimony and Mr. Eary's and Mr. Miller was that I didn't -- I used too high of a sulfur content for my peridotite samples. And you can see that

this is the highest sample that was available to use. And that's --

Q When you say "this," you have to be more clear.

A Okay. This sample that I noted before with 2.9 percent sulfur that I've marked as the highest sulfur peridotite sample is the sample that I used to represent peridotite. But you could have peridotite samples as high as 10 percent sulfur.

Q I see. And --

A The other thing I should mention about this is that Dr. Eary said that the range of sulfur used in the kinetic testing was representative of the range of sulfur in the rock types. And the main point of this is to show that there's quite a big gap between the 2.9 percent sulfur sample peridotite and a 10 percent sample. And we can look at this sample right here of semi-massive sulfide ore and see what kind of leaching ability you would have for rocks in this range that may end up the development rock storage pile.

Q And the numbers of tests that are represented on this graph from Mr. Logsdon between 2.9 and 10 percent is represented by the black line going from about give or take 3,000 to give or take somewhere between 4- and 5,000; correct?

A Right. So that means that there are -- there's quite a number of rocks. There's quite a lot of rock that has sulfur content between 2.9 percent and 10 percent.

Q And it was not pulled out for testing?
A Not as peridotite or as waste rock, no.
Q And is there some relationship, Dr. Maest, to this lack of testing and the development rock and wall rock sulfur content?
A What do you mean a relationship?
Q Well, let's go to the next slide.
A Okay.
Q If we're looking at the fourth bullet?
A Yes. And I think I've mentioned this, that much -- depending on what happens with the disseminated ore -- and we don't know yet what's going to happen with that, whether it's going to be mined or whether it's not going to be mined, if it's going to be left in place, much of the development rock and the wall rock around the mine can have a sulfur content that's quite high and have a correspondingly high ability to leach metals and to make acid.
Q And what is the implication of that for the acid content of the mine water -- the metal and acid content of the mine water?
A The implication is that the metal and acid content of the mine water -- we're predicting that using these kinetic tests. And those are the only tests that we have that -- where we have leaching information on metals and acidity and

pH. And if those are represented by the highest end at 2.9 percent sulfur, that means that, if anything, we've underestimated the metal leaching ability and the metal content of mine water using the kinetic test results.

Q Let's go to the next slide, number 5, which deals with disseminated ore, Dr. Maest. And you have question here on your first bullet of whether or not disseminated ore will be mined. What is the significance of that question?

A Well, in Kennecott Exploration's 2005 report -- and this is Appendix C of the mine permit application -- they identify it as a type of ore, disseminated ore. However they say that the reserve is only the massive ore and the semi-massive sulfide ore. The disseminated ore, because it has such a high sulfur content, it's really important to know whether it's going to be mined or not. If it's not going to be mined, it'll be -- there will be a halo of this high sulfur material left in the mine. And quite a bit of it could end up in the development rock stockpile as well. And Mr. Logsdon said that it could be mined. He wasn't certain. And he thought that the cutoff would be about 3 percent sulfur. But according to Kennecott, it's 10 percent sulfur. And this ore is located at the margins of the intrusion. So yesterday we saw a picture of the orebody that somebody said looks like a shoe. That would -- so there's a halo of this disseminated ore around that orebody.

And there are also two sulfide zones known as the upper sulfide zone and the lower sulfide zone. And this disseminated ore is located above and below the upper sulfide zone and also above the lower sulfide zone. So there's quite a bit of area around the ore that has a high sulfur content that may or may not be mined.
Q And if it's not mined, the implications of that are what?
A If it's not mined, the wall rock will be more highly mineralized than I've probably taken into account in my modeling.
Q And what does that mean?
A The implications are that the mine water quality could be even worse than I predicted or than Kennecott predicted.
Q So if the disseminated ore is removed as waste, then it would increase the sulfur content of the TDRSA; correct?
A That's correct.
Q And if it's not mined, it will increase the potential for acid mine drainage in the mine?
A Right. And I think we've seen kind of cross-sections of what this mine would look like. There are ramps coming down. And those would go through the disseminated ore as they go into the orebody. And that would be removed. That certainly would be removed as waste rock. So we know that there's going to be disseminated ore that will report to the TDRSA.

Q And do you have an example of the kinetic test that has a sulfur content labeled as the semi-massive sulfide unit?
A Yes. As I showed on the previous graph, there were two samples labeled as semi-massive sulfide ore. And one of them had a high enough sulfur content that was above the range that Kennecott says is semi-massive sulfide ore. And the other one had a lower percent sulfur. It was 8.13 percent. So if we look at the next slide, we can see the results from the kinetic column testing. These are the longer term column leach tests where they took the samples and broke them up and put them in columns, poured water over them and looked at the leachate coming out the bottom to simulate what would be happening in the TDRSA or in the mine walls.
Q And so if this semi-massive ore -- the rock represented by this semi-massive sulfide unit had 8.13 percent sulfur becomes waste rock, what will the kinetic tests shows in terms of the acid potential?
A It shows that -- the upper graph on the left is pH versus week. And these are similar to the graphs I shared before in my original testimony. These tests were taken after a long period of time out to about 150 weeks. And the vertical axis is pH. So acidic conditions are below 7-1/2. And that line there is the water quality standard, 6-1/2 for the State of Michigan. And you can see it starts out at a

neutral pH actually above, you know, neutral at pH 8. And then by the time it gets to 30-some weeks, it goes below 6-1/2 -- a pH of 6-1/2 and then continues down and gets to a low of a pH of 4 and remains kind of at a steady state condition around pH 5, which is an acidic condition.
Q And for this potential waste rock, what do the tests show in terms of the nickel concentrations?
A I show nickel here because that's one of the main contaminants of concern for the site because it's a proposed nickel mine. Nickel concentrations in milligrams per liter up to 60 milligrams per liter are shown on the vertical axis and in again weeks this time up to 120 weeks on the horizontal axis. You can see that there is a lag period here. Up to about 30-some weeks, we get very low leaching of nickel. Above that you can see that it increases quite dramatically and goes up to 60 milligrams per liter, very high concentration of nickel.
Q And what is the implication of that for the operation of the mine?
A This is the material that could be around the walls of the underground mine, so that will be exposed to oxygen and it will leach nickel after a certain period of time. And that will increase the nickel concentration in mine drainage water. Also some of this material will report to the temporary development rock storage area where it will

increase nickel concentrations and decrease pH.
Q Dr. Maest, Mr. Logsdon testified concerning the water quality coming to the crown pillar. And do you have some comments about his testimony in that regard?
A Yes. Mr. Logsdon sais that the crown pillar really wouldn't make that much of a difference in terms of the water quality in the underground mine. And he said that this is because he didn't think there would be that much oxygen and water flowing through the crown pillar. So Kennecott did not take the influence of the crown pillar on water quality into account, and I did take it into account. So I believe that he was presenting testimony talking about why he didn't take it into account.
Q And should it have been?
A I believe that it should have been.
Q And why is that?
A Because we now have a new thickness -- a larger thickness of the crown pillar to make the mine more stable than it was going to be before. And in order to do that, you have to leave some ore in the crown pillar; in other words, it's not all going to be taken out of the underground mine. There will be some semi-massive sulfide ore and some massive sulfide ore remaining in the crown pillar. And my -- based on my experience and I believe that Dr. Vitton has the same experience and talked about this, there will be oxygen in

the crown pillar because of all the blasting fractures and faults through that area. And water will be flowing that into the underground mine. Therefore it will be influencing -- adversely influencing mine water quality. And, in fact, much of the contaminant load to underground mining comes from underground workings and fractures and faults above the mine. Water goes through the mine -- and this is especially true when you're pumping from the bottom of the mine for years on end, which is what is proposed for this site.
Q This is a well documented fact?
A It's very well documented. And I presented two publications which are in my mine permit report here to support that.
Q The references on the fourth bullet here on slide 7 are references that were in your report submitted in October 2007?
A Yes.
MR. HAYNES: Which is an exhibit, your Honor, but I don't have the number. It's been admitted.
Q In any event -- Dr. Maest, Mr. Logsdon and Dr. Eary talked about accounting for solubility controls in their testimony.
A Yes.
Q And you reviewed that, have you not?
A Yes, I did.
Q And can you respond to their criticisms of your failure to

account for solubility controls?
A Yes. What they said and what this means is that, you know, if you have a certain concentration of metal and solution, at a certain point it will precipitate out of solution and it won't be in the water anymore. It'll be present as a solid. And I did not account for solubility controls in my modeling. And the reason I didn't account for those is because the kinetic test results that we based the modeling on were already filtered by the laboratory. And this is in the mine permit application appendix. When you look at Mr. Logsdon's appendices, he presents many, many pages of analytical data from the laboratory, and they all say "dissolved metal concentrations." And what this means is you have the column filled with the -- you know, with the ore material or the peridotite. And you put water over it. And you collect a sample at the bottom. Well, when that sample comes out, it has dissolved metal in it, but it also has some particulate solid metal in it. So what they then do is they take it to a filtration device, and they put it through a filter. And only what's processed through the filter then goes to the lab. So those particulates are left behind. So I did not account for those particles. I ignored them, because there are no analytical results presented for total metal concentrations.
Q So in other words, were you being consistent in your

analysis with the testing that you saw and the reports?
A Yes. I used the information that was available to me. The total metal concentrations were not available. And if the pH is very low, usually there's not a big difference between dissolved and total metals in a sample. But if you have a slightly higher pH or somewhere near neutral, there can be quite a large difference between the particulate -- there can be quite a bit of particulate metal in there. And the point is that, if the pH drops by exposure to pyrite or pyrrhotite or some of these minerals that will make acid conditions, those particulates will then dissolve and get added to the mine water that we're looking at both from the development rock storage and in the underground mine. So in nature, there is no filtration.
Q And in that regard, what would you call a reasonable worst case scenario for geochemical modeling and solubility controls?
A I believe that -- and this is what I did. A reasonable worst case scenario is not to put the data into a geochemical model to look at solubility controls, because that shows you how much precipitates out of solution. Because we're already starting with filtered samples. And I've seen this done in a lot of mine sites by mine proponents. They'll say, you know, "We could put this into a solubility model right now, a geochemical model. But to

be conservative, we're not going to do that." And that's the approach that I took.

Q That is a conservative approach?

A That's a conservative approach because, you know -- that is not what Kennecott did, though, in this case. Mr. Logsdon put it through a geochemical model to look at how much would precipitate out, and I did not do that.

Q Dr. Maest, you said in your introduction that there are some questions about -- brought up by Mr. Logsdon about the need for oxygen in order to produce acid mine drainage?

A Yes.

Q And what is your view about that testimony?

A Well, it is true that you need oxygen to start off the reaction for acid mine drainage. There's no doubt about that. However what Mr. Logsdon did not bring up is that oxygen is an oxidant. And it makes the pyrite, which is the iron sulfide or the pyrrhotite, which is also iron sulfide, oxidize. And it makes acid, and it makes sulfate and it makes dissolved metals. But what's even a stronger oxidant is ferric iron, which I've represented here by FE3+. And under low pH conditions, which we would have at this mine, ferric iron is produced and acts as even a stronger oxidant than oxygen and also creates a lot more acid than oxygen does.

Q And you have a formula on slide 9 that I'd like you to read

into the record so that we have that.
A Okay.
Q First, what does the formula represent?
A The formula represents the oxidation of pyrite or pyrrhotite by ferric iron.
Q And what is the formula?
A The -- I'm just going to read it in words; right?
Q That's fine.
A I'm not -- okay. It's pyrite or pyrrhotite and iron sulfide of some type plus ferric iron and water produced reduced iron, often known as ferrous iron, and sulfate and acid. The H+ is acid. And these two combined, the H+ and the sulfate, combine to make sulfuric acid. And if you had the same reaction with oxygen, you would create about half as much acid as you do with ferric iron.
Q So in other words, oxygen is not required to produce acid mine drainage?
A Well, it is initially. But after the initial oxygen is present, you can have this reaction going in the absence of oxygen.
Q Would you expect that at this mine?
A I would, because there's a lot of iron present. There's pyrite in the siltstone, and there's pyrrhotite in all the other rock types. And low pH conditions are going to be produced based on the results of the kinetic tests. So I

would expect this reaction to be occurring in the mine water and also in the temporary development rock storage area leachate.
Q And over what period of time would that occur?
A You mean for how long or how long would it take to start?
Q How long would it take to start first?
A It would start almost immediately.
Q And how long would it occur?
A It can occur -- I mean, the thing about the acid drainage reaction is that it's called autocatalytic, which means that it -- the reactants that are produced go and become -- I mean, the products that are produced go and become the reactives. And they keep this cycle going for a very long period of time. And that's why it's such a difficult reaction to turn off once it's started. So the length of time would depend on conditions at the site. But, you know, under oxygenated conditions, it can go on for hundreds of thousands of years certainly. And, you know, without oxygen, it won't go on for as long a period of time. But this can be produced in the absence of oxygen.
Q And is it a well documented fact that ferric iron can be present in the absence of oxygen?
A Yes.
Q That is something that you would expected Mr. Logsdon to know?

A I'm sure that he knows that.
Q Now, Dr. Maest, Mr. Logsdon had some comments about -- some testimony about the re-flooded mine and the pH of the re-flooded mine. Have you reviewed that testimony?
A Yes, I did.
Q And what did Mr. Logsdon say?
A Well, these -- the former slide and this slide kind of go together. Mr. Logsdon said that the pH of the re-flooded mine will be near neutral and have low metal content because of limestone addition and also because of a lack of oxygen. However what happens when you re-flood a mine when you've had it open for a period of time and you have a lot of oxygen present and ferric iron, you produced salts, metal-rich salts that, when they dissolve, can release high concentrations of metals and also acidity into the underground mine.
And we don't have a lot of record of re-flooding of mines to see what, you know, the results look like. But what we have seen is that , when the mines are re-flooded, usually there's a big pulse, an increase, in metal concentrations and a decrease in acidity. Because all these salts that were on the walls of the underground mine and on the surfaces of the waste rock become dissolved. So these metal-rich salts release acid and metals upon the initial flooding of the mine. So initially it actually gets worse

when you re-flood a mine.
Q And does that relate at all, Dr. Maest, to the pH of the water in the mine during the mining operations?
A Yes.
Q And how is that?
A Because during mine operations, there's going to be essentially no limit on the amount of oxygen that will be in the underground mine, because it will be an open void. There will be lots of oxygen coming down the ramps, et cetera. There's also ventilation in the underground mine. So there will be no limit -- it's not oxygen limited. There will be a lot of salts forming as a result of the oxidation of all these sulfide minerals that are down there. And during operations, there will also be water coming into the mine because it will be pumping. There will be water coming down from the top through the crown pillar. There will also be water coming in from the sides. And when that water comes in, that will dissolve some of these metal salts.
Q And what is the expectation for the pH in the mine during the mining operations?
A It will definitely be acidic based on the kinetic testing results that we have. And, in fact, Mr. Logsdon conducted a modeling estimate of the pH during mining operations and estimated -- and this is without the backfill. Okay. This is year three without backfill -- that the pH with -- during

mining would be 3.6, so quite low.

Q And then for purposes of the re-flooding of the mine, what's your understanding others how the mine will be re-flooded and with what kind of water?

A I'm not really sure what kind -- what the source of the water will be. But my understanding is that they're talking about or planning on a kind of accelerated flooding -- re-flooding where they would add water to the underground mine and fill it up with water to exclude oxygen and to, you know, bring the water levels up to pre-mining levels.

Q And if the water used to re-flood the mine is surface water or if it wetland water that infiltrates the mine, what will be the effect?

A One of -- this is kind of an interesting thing. Because of the organic acid content in wetland water and a lot of the surface water in this area. If you look at, for instance, the Salmon Trout River water, it has quite high dissolved organic carbon content because of all the organic acids in the wetlands. And if that water is used to refill the mine, it's possible that those organic acids will bond up with the metals in these metal salts and keep the concentrations of metals high; in other words, prevent the precipitation of metals, which is one of the ways that metal concentrations decrease when you flood a mine. so I'm not sure what kind of water they're planning on using. But if it's surface

water with organic acids, that's a result that could occur.
Q And then if this occurs, then there will be higher metals concentrations in the re-flooded mine; correct?
A Well, higher than --
Q Higher than if they did not use surface water?
A If they use water with elevated concentrations of dissolved organic carbon, yes; that's right.
Q And then how would the -- so then we would -- would we or would we not have that high sulfate and metal concentrations in the re-flooded mine?
A Yes; yes, we will.
Q We would. And what's the importance of that for purposes of this mine application?
A When you re-flood a mine, you do expect a decrease in concentrations of metals and sulfate and somewhat of an increase in pH. And I believe that I presented some information in my direct testimony about the Butte Mine. And I looked at re-flooding of those underground workings. And you saw that the copper concentration decreased quite a bit but the sulfate concentration really did not decrease that much because it just decreases by dilution. So my expectation is that the re-flooding workings in the underground mine will still have elevated sulfate concentrations and metal concentrations.
Q And how is that relevant for purposes of determining if

there will be pollution, impairment or destruction from the mine?
A The implication of that is that, at some point, the groundwater flow conditions will re-establish after re-flooding of the mine. And that water with the elevated sulfate and metal concentrations will then move downgradient to outside of the mine area.
Q And have you seen any study either in the documents that you have reviewed or the testimony you've reviewed that has studied this potential effect?
A No, I have not.
Q Dr. Maest and Mr Logdston talked about neutralization of acid mine drainage by addition of limestone. Do you recall reviewing that testimony?
A Yes, I do.
Q And what did Mr Eary -- excuse me -- what did Dr. Eary say about that?
Dr. Eary said that armoring, he kind of dismissed the issue of armoring and he said that that's not a problem here, because it most commonly occurs when acid drainage is generated in one location and then downgradient somewhere you have -- or downstream you have the limestone. And I think he gave an example of a limestone drain. So you would have a source of contamination with low pH and metals, and then you would put that in this kind of passive system where you have limestone, have it

running over limestone. And he said, well, in that instance it would armor the limestone probably.
Q And in fact, is that a common occurrence in your experience?
A Which?
Q Well, the limestone at the back end of the drainage.
A Well, it's a common occurrence to have armoring in the actual source where you mix the limestone with the acid-generating material. And in fact, it's common practice to add more limestone to waste rock than what you would absolutely need to account for this armoring and to account for, you know, the covering of the limestone by the precipitation.
Q And did Dr. Eary have -- excuse me. Did Mr. Logsdon talk about the amount of limestone that he would add to neutralize the acid mine potential?
A Yes, he said that he would add 30 percent more to account for unavailability as a result of armoring and other processes.
Q And what did Dr. Eary -- how did Dr. Eary comment about that addition?
A He said that -- well, he didn't comment about that addition, but Dr. Eary also said that the limestone addition didn't make a difference for Mr. Logsdon's results for the prediction of water quality, because the concentrations were quite low.

Q Concentrations where?
A The concentrations I believe what he -- he didn't say specifically where, but he was referring to the concentrations in the predicted mine water quality. And in this case it would the temporary development rock storage area leachate water quality estimates.
Q And does -- and reviewing the testimony of Dr. Eary and Mr. Logsdon does the limestone addition make a difference for certain contaminants?
A It does for some. It makes a difference for copper. You could see -- what Mr. Logsdon did when he modeled the temporary development rock storage area drainage, he had one table that showed what the concentrations would be without limestone addition and then he had another table representing what the concentrations would be if you mixed in limestone with the development rock. And it did make a difference for copper. The copper concentrations were lower in the -- you know, the example with limestone. However, sulfate it made no difference. And nickel, which is one of the major contaminants at the mine -- and the concentrations were quite high. There were eight milligrams per liter, 8,000 micrograms per liter; made no difference.
Zinc, which is another contaminant of the mine and a known aquatic toxin, about two milligrams per liter or 2,000 micrograms per liter, made no difference to add

limestone. And arsenic, 83 -- that should be a microgram per liter. I think it didn't work out in the font, but that's 83 micrograms per liter, which is eight times the water quality standard; no difference there for added limestone as well.

Q And did Mr. Logsdon and Dr. Eary talk about the -- your alleged failure to take neutralization potential of silicates into account?

A They did. They said that I didn't take that into account and that the idea here is that in the peridotite and in the ore, the massive sulfide ore and the semi-massive ore, there's very little calcite, which is really the most effective neutralizing agent at mine sites that could be used to decrease, you know, the acidity of mine water. There's really very little calcite, but what they do have is silicates and there's certain silicates that can neutralize some acid depending on pH and other conditions. And this was taken into account as a result of the kinetic test results. If you look at some of the kinetic test results for peridotite you see that sometimes the pH remains high for a while, especially in the lower sulfur samples and then it takes a drop down. And that's a reflection of these silicates buffering the acidity for a while and then it runs out of gas and the pH drops. So I used the kinetic test results from steady state conditions which would take that buffering into account.

Q Now, in your review of Dr. Eary's testimony and Mr. Logsdon's testimony did you -- and also the documents at issue in this case, did you notice that there were any bench tests done of the -- for the limestone and the waste rock?

A No, and this is -- I mean this has certainly been done at other sites. And what you can do is do a bench scale test of what you're mitigation measure is and the main mitigation measure proposed for the temporary development storage area is this mixing with limestone to increase the pH and decrease metals.

Q And just for the record, what is a bench scale test?

A "Bench scale" means something -- or a field scale. This is something that is -- you know, could be done at the lab where -- an example of it is the kinetic test that was done. Or you could set up a very large column outside or a pile where you mix in the limestone with the development rock and you see what happens. You know, you look in the field instead of, you know, estimating and modeling and all of that you can actually mix this in and see what happens. And none of those bench scale tests or field scale tests were done to simulate this mixing, this very important mitigation technique that's proposed for the mine.

Q Now, does the addition of limestone have perhaps detrimental qualities as well as beneficial qualities in relation to

neutralization?
A It can.
Q And what are those?
A Although it is known to increase the pH and decrease the acidity, if you -- there are certain metals, metal-like substances that it can increase the concentrations of depending on their presence in -- you know, in the mine and the pH that it goes up to. But arsenic, selenium and antimony are three metal-like substances; they're called metalloids or oxyanions when they're in solution. And those have the opposite reaction to the way metals do. When you increase the pH with metals they take a drop and when you increase the pH with arsenic, selenium and antimony they can be leached out of the solution and the concentration can actually go up. So when you add lime it's kind of careful balance; you have to -- it depends on what the contaminants are. And for those three it actually makes things worse.
Q Dr. Maest, Walter Eery testified that leach tests accelerate leaching by about ten times over what you would observe in the field. Do you have a comment about that testimony?
A He was referring to information on the humidity cell test. And this has been a debate that's been going on for a number of years among geochemists; like what -- how can we best represent these tests, the field conditions through test. And it's true that there's some acceleration when you break

a material up into small particles. However, the column tests that were used by Mr. Logsdon used a larger grain size than the humidity cell test. You note that he doesn't call them humidity cell tests; they're column tests or kinetic tests. And furthermore, Mr. Logsdon says that he believes that the sulfides will start reacting within the life of the mine and also within the life of the temporary development rock storage area. So in terms of lag time or acceleration, you know, these sulfides will react within the life of the mine.
Q And what is the -- what is the relevance of the timing in relation to the acid drainage reaction?
A Well, I believe there's been some testimony and also some information in the reports saying that there'll be a lag time before the acid is produced and you just have to put, you know, this -- as long as you're just going to have this waste rock out there for a short period of time and put it back into the mine, the acid drainage reaction won't start. But according to the kinetic tests and Mr. Logsdon who put together this whole geochemical testing program that's not true. The lag time will be short enough that the acid will be produced during the life of the mine.
Q And once the acid mine drainage -- or acid drainage reaction has started is it easy or is it difficult to stop it?
A It's difficult to stop it.

Q And why is that?
A It's what I talked about before. The products then go and react with more pyrite and more pyrrhotite and make more acid. And as long as you have oxygen around or ferric iron around then you will have acid drainage.
Q Dr. Maest, Mr. Logsdon testified that the amount -- the size of the concentration -- or rather the exceedence or non-exceedence of the concentration really doesn't matter if it exceeds standards. In your view is that correct?
A Yeah, this is more of a -- almost a philosophical point and Mr. Logsdon said a number of times in his testimony and also in his documents that, you know, what he's concerned about -- and this is just general modeling estimates. If it's higher than a standard, then it all needs to be handled as special handling waste. If it's lower, then it doesn't need to be. And he said that the concentrations are high enough, the pH is low enough that all of this material needs to be handled as special handling waste. But if it's just a little bit above or very much above that it really doesn't matter. And I disagree with that.
Q Why is that?
A I believe that the contaminated leachate from the waste rock in the mine -- the issue is whether or not the contaminated mine water escapes. Okay? If it escapes at all, if anything leaks, if anything fails at all then if it's a

little bit above or if it's a whole lot above it really does make a difference; it's a lot worse if it's a whole lot above the standards. And Mr. Logsdon used -- if he had out to more -- you know, higher weeks in the humidity cell tests he would have used higher concentrations and he would have predicted higher concentrations in his mine water quality. And he addressed that in his testimony. He said that "I used what was available to me at the time," but you see a lot of these concentrations actually increased quite a bit after the 40 weeks that he used.

Q And for example, you prepared slide 14 of your presentation, which is one of Mark Logsdon's slides from his presentation dealing with nickel concentrations and the kinetic test samples over time. What's the relevance of this?

A Mr. Logsdon used nickel concentrations from about 40 weeks. Some of them were a little lower; some of them were a little higher. And you can see that for a lot of these samples the nickel concentrations don't actually start to level off and get as high as they do until 50 weeks or sometimes even a hundred weeks. So this is about a year, 50 weeks. Well, a couple of years here. So it really does make a difference. This one, for example, if you picked 40 weeks you're going to get a hundred micrograms per liter of nickel; whereas, over here you're going to get 20 milligrams per liter of nickel. So it really does make a difference which tests you

pick, which weeks you pick of the kinetic testing results.
Q Dr. Maest, Mr. Logsdon testified that the management program that he reviewed for Kennecott is designed to minimize impacts?
A Uh-huh (affirmative).
Q Based upon your knowledge, training and experience, do you have an opinion as to the quality of the design here to minimize impacts?
A The --
MR. LEWIS: I'm sorry. Counsel, I'm sorry. I missed the question. The quality of design of what?
MR. HAYNES: Design of the management program.
MR. LEWIS: Oh, the management program. I don't know what Dr. Maest intends to get into here. As long as she -- well, again, we went through this before, your Honor. If her opinions are going to get into the design and operation of the water treatment system and there's no foundation or qualifications. I don't know if she intends to get into that or not, but she ought not.
MR. HAYNES: Well, I think we did go through this before and as I recall you overruled the objection that Dr. Maest cannot testify at all about impacts and about treatment systems, because in fact she had studied those in her papers and is qualified to do so. I don't intend to ask her about the details of the water quality treatment plant,

but certainly we can talk in generalities here.

MR. LEWIS: Well, as your Honor may recall we've had experts in here on the water treatment system to testify including experts from the DEQ, experts from Kennecott and experts from petitioners including Mr. Glen Miller most specifically. And Dr. Maest has not been presented as a water treatment expert, nor has there been foundation or qualifications that I'm aware of and she's outside her expertise here.

MR. HAYNES: And lastly, your Honor, we are not having -- calling Dr. Maest nor will she testify about the technical aspects of the water treatment plant. What she is responding to here on rebuttal is some statements by Mr. Logsdon about the -- whether or not a design will be protective of the environment in general.

MR. LEWIS: Mr. Logsdon did not talk about the water treatment plant, your Honor.

MR. HAYNES: He did talk about the management program at great length though.

JUDGE PATTERSON: I'll let her testify. There's been sufficient qualifications to at least address the constituents going into the --

Q Dr. Maest, in response to Mr. Logsdon's testimony about the management program being designed to be -- to minimize impacts and be protective, what is your opinion about his statement?

A Okay. Well, by the management system -- I'm talking just very generally -- at the mine, like the plan to add limestone to the waste rock; the plan to have a liner under it; the monitoring system at the site. I'm actually not talking specifically about the wastewater treatment plant. But Mr. Logsdon is very careful to qualify his opinions in saying that if the mine is managed carefully there will be no impacts. And I believe he characterized his responsibility as kind of ending when, you know, he presents, "Here's the water quality that I think is going to be produced as a result of mining this deposit." And that -- those numbers go into -- are used in the wastewater treatment plant as inputs, but he's very careful to say that it has to be managed carefully for there to be no impacts at the mine.

However, the point here is that Kennecott has presented no evidence that the system will protect the environment or that it has at other mines. So that's what I'm talking about here is that it may be designed to protect the environment in their opinion, but whether it will or not is still an open question.

Q Dr. Maest, Mr. Logsdon testified about the Greens Creek Mine. Are you familiar with the Greens Creek Mine?

A Yes, I am.

Q And what -- and how are you familiar with that?
A This was one of -- I mentioned in my direct testimony that I had done a couple of reports on impacts of hard rock mining on water quality, and in our report -- this is the Kuiper's-Maest report, comparisons report where we looked at what the predictions were and environmental impact statements in terms of mine water quality and then what actual impacts were. We had 25 case study mines in that study and the Greens Creek Mine in Alaska was one of our 25 case study mines.
Q And in your study, which is Exhibit 60- -- I'm sorry. I'm looking for the right exhibit. I'll connect that up later. In your study, Dr. Maest, the Greens Creek Mine is operated by Kennecott; is that right?
A Yes.
Q And what were the -- in that study what were the predictions -- let me back up. Mr. Logsdon testified that "the Greens Creek Mine operates very much better than almost any old underground mine that I could come up with." That's at transcript page 4262. And based upon your study, Dr. Maest, what did you find about the operation of Greens Creek Mine?
A Okay. Well, just to back up a little bit also, I believe in the transcript Mr. Logsdon -- you know, the testimony was asked, "Can you give me some examples of mines that are

operating currently that are good environmental performers?" And he was having a hard time coming up with them, but he did say the Greens Creek Mine; he mentioned the Greens Creek Mine in Alaska. It is the Kennecott mine. It's currently operating. It's a -- mostly a gold mine, gold and silver, but it also produces lead and zinc. And unlike a lot of the other mines in the west that are kind of in an arid area this is in a moist area the same way Michigan has humid conditions and a lot of rainfall where rainfall exceeds evaporation.

And there were a number of predictions that were made at this Kennecott site. One was the lag time for tailings to go acid. So very much what we're talking about with the temporary development rock storage area. They use the kinetic tests and they use the oxidation rate from the kinetic tests and they said that "based on that, we think there'll be a lag time of between 10 to 33 years until the tailings go acidic." And then they used that data and they did a model; they did a hydrogeochemical model and they said that based on this model that it's actually going to be at least 500 years before these tailings become acidic.

Q And when, in fact, did the tailings become acidic at the Greens Creek Mine?

A The tailings became acidic in less than 20 years at the mine.

Q And what was the mitigation measures -- what were the mitigation measures proposed at the Greens Creek Mine?
A They were similar to what -- first of all, there's -- there are no tailings at -- proposed to be at the Eagle Mine, so that's different, but there is waste rock proposed to be at the Eagle Mine. The main mitigation measure for the waste rock was to mix neutralizing material into the waste rock and to hopefully decrease the propensity of this material to make acid and leach metals. And then the other mitigation measure was to cap the tailings, so after the tailings were put in the tailings impoundment they put a cap over the top to exclude oxygen, which would decrease acid drainage because of the lack of oxygen.
Q And what would the -- what were the measurements for the waste rock drainage in terms of acidity and zinc concentrations?
A Well, the waste rock --
MR. LEWIS: Wait a minute, Dr. Maest. Sorry.
THE WITNESS: Sure.
MR. LEWIS: I want to put an objection on the record here. Dr. Maest is apparently going to talk about water quality issues outside of this mine judging by the next bullet point on the slide, and I want to place an objection to that, your Honor, and the objection is this: that all I believe that she can talk about is a potential

association between this mine and what's being reported here as sulfate and sulfide material apparently measured somewhere outside the mining area.

But without the foundation and evidence of the cause and affect relationship I believe that kind of testimony is both not relevant and it's -- any relevancy it has is outweighed by its prejudice; in other words, there has to be -- there has to be evidence of a scientific foundation that one thing caused the other before it ought to be admissible.

MR. HAYNES: Well, on the contrary, your Honor, certainly in this case we have not -- we've had a lot of testimony all around the room about correlations rather than causes and effects, predictions and so on. And so the witness can certainly testify based upon her knowledge and study of the Greens Creek Mine and -- but I certainly lay a foundation to have her testify about the results of the testing that was done at Greens Creek to show that the point being that predictions often underestimate actuality.

MR. LEWIS: Well, we've already heard about the predictions; that's not the basis of my objection. Again, the head point on the slide is what I'm objecting to and without -- she can associate elevated sulfide in the water in the washroom here, but unless she can prove that, you know, it was caused by -- the source of it is the Greens

Creek Mine I don't believe that's very relevant, nor -- and there is not that kind of foundation for what she intends to talk about on this next point, your Honor.

MR. HAYNES: Well, --

JUDGE PATTERSON: Did you want to pursue a foundation?

MR. HAYNES: The point of this -- of the testimony, your Honor, is to rebut Mr. Logsdon's apparently unequivocal statement that the Greens Creek Mine operates better than almost any old underground mine that he could come up with. And the point is that if -- as Dr. Maest will testify, that if we have concentrations in these amounts that is not better than almost any other old underground mine that he could -- that Mr. Logsdon knew about.

MR. LEWIS: Again, she's covered that point, your Honor. That's not the point I'm objecting to.

JUDGE PATTERSON: I think Mr. Lewis's objection is to her anticipated testimony about elevated sulfide and zinc in small streams without some foundation that it was generated by the Greens Creek Mine.

MR. HAYNES: All right. Well, I can lay that foundation.

Q Dr. Maest, you've studied the Greens Creek Mine?
A Yes.
Q And you've studied the reports generated by others

concerning the operation of the Greens Creek Mine?

A Yes. Maybe I could just try to say -- try to -- I guess it's called lay a foundation for that. These small streams are on the mine site and there is some question about whether these were caused by material being outside of the capture zone or whether it's overland transport of contaminants from mined materials, but there's no question about the source of these increased concentrations being from the mine itself. There are no other sources up there.

MR. LEWIS: Your Honor, may I voir dire the witness a moment?

JUDGE PATTERSON: Sure.

VOIR DIRE EXAMINATION

BY MR. LEWIS:

Q Dr. Maest, you talked about this Greens Creek Mine in one of your papers; is that right?

A Yes.

Q And in the paper in you do not report any proven association between the mine itself and these elevated sulfide levels in the surface water. Isn't that also true?

A No.

Q Have you in your paper included scientific evidence that proves a cause and effect relationship?

A The information is from the 2003 Environmental Impact Statement that was written by the State of Alaska, and their -- they presented information about material lying outside of a capture zone.

Q Let me ask you this question again. Have you seen any scientific evidence proving a cause and effect relationship between this mine and the elevated -- what you report is elevated sulfide levels in groundwater wells or otherwise?

MR. HAYNES: I'll object to the question, because that's not the evidentiary standard that we have in this case. If Dr. Maest relied on the report that would be relied on by reasonably prudent geochemists, then she can testify about it.

MR. LEWIS: Well, not if the report itself does not contain the necessary foundation, your Honor, and I don't believe it does.

A It does contain -- you're referring to the Environmental Impact Statement?

Q I'm referring to your paper; I'm referring more generally -- my question is do you have any scientific evidence showing that there is a cause and effect relationship between this mine and elevated sulfide levels in the groundwater wells or elsewhere that you're referring to in this slide beyond a mere association that there's one thing and there's another?

MR. HAYNES: Same objection, your Honor. That's not the evidentiary standard in these proceedings.

MR. LEWIS: Well, again, she can associate it to anything she wants to, but without evidence that one caused the other is not relevant.

A   Well, there are no other sources up there.

MR. HAYNES: Well, the -- I think counsel's -- I think counsel's mixing his objections. The evidentiary standard is not cause and effect and it's certainly -- the question of the Greens Creek Mine operation is relevant to Mr. Logsdon's testimony that he believes that mine is the best operated that he could think of and what the witness will testify about is apparently it's not the best operating mine compared to her -- based upon her review of other mines. And that, by the way for the record, is Petitioner's Exhibit 65, which was the Kuiper's-Maest comparisons report from 2006. It's already been admitted into evidence.

MR. LEWIS: Calling inadmissible evidence rebuttal does not make it admissible, your Honor.

JUDGE PATTERSON: I'm going to allow her to go ahead and testify.

DIRECT EXAMINATION

BY MR. HAYNES (continued):

Q   Dr. Maest?

A   Yes.

Q   The question is did the operations in your view of -- in your review of the Environmental Impact Statement of the Greens Creek Mine was there an association between the

operation of the mine and the acidic nature and the high zinc concentrations in the waste rock drainage?
A Yes, definitely.
Q All right. And were there any other associations based upon your review of those documents between the mine operation and the impacts on the environment?
A There were several impacts: one was the waste rock drainage that was mixed with the limestone did end up having acidic conditions. It was mixed with limestone to prevent acidic conditions, but the conditions were below six and a half. Also we had elevated zinc concentrations of 1.7 milligrams per liter or 1700 micrograms per liter. And let's skip down to the bottom bullet, "the tailings under drain and seepage waters." So this is -- they made a tailings comment and there was an underdrain underneath it, so this is water kind of infiltrating through the tailings and collected in the underdrain.
And there were also some seeps coming off of the tailings area and this is the tailings that was predicted to not go acid for 10 to 33 years or, after they did some modeling after 500 years. This water had pH between 5.8 and 6.7 acidic, had elevated sulfate concentrations up to 2,400 milligrams per liter, and up to 3.6 milligrams per liter -- again, that should be a "MU" not a micrograms per liter -- 3600 micrograms per liter, which is a high level of zinc.

And also elevated concentrations of copper, lead and selenium.

So this -- you know, the -- my point here is that the mitigation measures that were proposed for the Greens Creek Mine were not affective in reducing acidity and metal concentrations. And then the second to the last bullet is about the impact to small streams on the mine site that are downgradient of mine sources. And there is some -- and I've noted here there's some question about why these streams are acidic. There could be different mine sources and they're not sure but they -- the State believes that the most likely reason is that there's sulfide material either from the waste rock or from the tailings that was located outside of the capture zone. Okay? So they're trying to capture water from the waste rock and the tailings and the State believes that that was not effective. And that resulted in increased sulfate and zinc concentrations. And also in groundwater wells that are monitoring wells for this mine site, the concentrations of sulfate have not reached water quality standards but they are increasing relative to background levels.

Q	And how does the Greens Creek experience relate to the proposed mitigation at the proposed Kennecott mine?

A	Some of them are very similar for the waste rock material. It's exactly the same method that we're talking about at the

Eagle Mine, and that is amending the waste rock with some kind of neutralizing material, either limestone or lime.

MR. HAYNES: Thank you, Dr. Maest. I have nothing further at this time.

MR. EGGAN: Your Honor, I'm prepared to proceed. This is a natural break if you wish to take a break.

JUDGE PATTERSON: All right. It's up to you. Do you want a break?

MR. EGGAN: I'd like to forge on in the interest of pushing, getting things done.

JUDGE PATTERSON: Okay. Let's do it.

MR. EGGAN: May I go back to slide number 4?

CROSS-EXAMINATION

BY MR. EGGAN:

Q Dr. Maest, I want to take you back to slide number 4 and I want to cover a point that I believe was not discussed when you testified about this slide previously, and that is the last bullet point that you make on this particular slide relates to the content of the mine water and your view that it's likely higher than anyone has predicted. Is that an opinion that you have reached?

A Yes.

Q Okay. And why is it that you have reached that opinion and why is it on this slide?

A If we go back -- I think it's one slide before this. It has to do with this being the highest sulfur waste rock sample that was tested for kinetic testing. And again, the only source of data that we have to put into a model to predict water quality comes from the kinetic testing results. Okay? So all -- it's great that all these tests, all these samples were tested for sulfur, but none of those -- we can't use those in predicting water quality; it's just the kinetic test results. And you can see that this sample here has a sulfur content of 2.9 percent of total sulfur.

Well, the disseminated ore, which may or may not be mined, has a sulfur content up to ten percent. So that's why I looked at the metal leaching ability and the acid generating ability of this sample right here, because even though it's marked as a semi-massive sulfide it's got a sulfur range -- sulfur content in the range that would still be considered development rock. If the disseminated ore is not limed. And you'll note that there's a big gap here between this 2.9 percent which is the highest sample we have for kinetic testing from peridotite or the country rock, and up here at ten percent. So I think it's safe to assume based on all the results that we've seen from the kinetic testing that the higher the sulfur content, the higher the metal leaching ability and the higher the acid generating ability and we don't have anything in there for the country rock.

Q And how does that relate to your conclusion on the next slide that the metal and acid content of the water is likely to be higher than anyone has predicted? When you say "anyone," do you include yourself?
A Yes, and also Kennecott's experts.
Q I see. So it's likely to be worse than you had earlier predicted?
A Yes. I think, you know, Dr. Eary and Dr. -- and Mr. Logsdon said that I used rocks with too high of a sulfur content and that's why I presented this information here, is that actually I don't have enough information; I don't have, you know, samples to use that have a higher sulfide content that still would be present in the mine as development rock or left in the underground mine.
Q All right. I'd like to move forward now to slide 17. But again, before we get to this particular slide let me ask you an over-arching question about the information that you have reviewed and conclusions that you have reached, and that is based on the information that you have read, information that was presented in this case since you've testified, is there anything in any of those materials that would cause you to change your opinion? Does your prior testimony remain valid in -- from your perspective?
A Yes, it does. There's nothing that would change my opinion.
Q Okay. You did testify just a moment ago though that it may

be a little worse than you thought?

A If anything, I think if we had more samples we would see that the concentrations predicted for mine water would actually be worse.

Q Okay. Now, let's talk about the issues that you're going to testify about pertaining to groundwater discharge permit limits.

A Okay.

Q Your first bullet point relates to uncertainty of the TWIS effluent values; talk about that.

A Okay. This is the treated water infiltration system, so this is the water that's coming out of the treatment plant that is then being discharged at the TWIS and going into the ground. And the values there, the estimates of what the concentrations will be coming out of the treatment plant is what this bullet refers to and I'm saying that the uncertainty of that is high.

Q The next bullet point?

A The next bullet point is that -- and this relates to testimony by Ms. LeSage, and that is that for toxic substances -- in this case this would be toxic to human health or to -- especially to aquatic biota -- there are no limits -- there are either no limits in the permit for toxic substances that have the potential to exceed preliminary surface water effluence, or the concentrations aren't

protective enough. And I'll get into that a little more later.
Q Good. And your next bullet point relates to so-called COC's or contaminants of concern?
A Right. And this point is that the contaminants of concern for both surface water and groundwater are not addressed by relying on the effluent concentrations that have been predicted that have uncertainty, or the limits that are put in the groundwater permit.
Q And your next bullet point relates to monitoring locations?
A Yeah.
Q Talk about that.
A And this relates to something that was discussed in Ms. LeSage's testimony and that is the so-called groundwater/surface water interface and that would be a location where the TWIS discharge would go into the ground and then move toward the venting location in the east branch of the Salmon Trout River. And there are no monitoring locations just upgradient of where it would vent into surface water to -- there are no monitoring locations there at all.
Q Well, we'll talk about all of these points, but is that a summary of the issues that you intend to talk about today?
A Yes; yes.
Q All right. Let's move on then to the next slide, and that

is titled "TWIS effluent values have a high uncertainty." Now before you testify to this talk about what you mean by that term "uncertainty." What are you talking about here?
A That means that -- this is the -- you know, looking at the methods that were used to predict the water quality coming out of the treatment plant there are a number of uncertainties with things that make that number questionable. We don't really know the range.
MR. LEWIS: Your Honor -- I'm sorry, Dr. Maest, again to interrupt. Apparently she's now talking again about the efficacy of the water treatment system. I don't know why counsel wants to go down that road with her but apparently they do. She's talking about the TWIS effluent values and the uncertainty in that. So it apparently contemplates and includes her opinions about the efficacy of the water treatment system and there's no foundation nor qualifications for that kind of testimony.
MR. EGGAN: Well, actually that is not the intended purpose of her testimony. The purpose of her testimony is to talk about whether or not the values for the effluent that is discharged by the TWIS are accurate, and so that's the essence of her testimony. But again, you have indicated --
MR. LEWIS: Well, I don't understand how she can do that without talking about the efficacy of the water

treatment system.

MR. EGGAN: Your Honor, I think that you have indicated that this witness -- and she's already testified about these areas in her direct testimony and you allowed her to testify about that then. And there was an objection at that time and you indicated that because of her experience and background in geochemistry she has the ability to offer this kind of testimony.

JUDGE PATTERSON: So her testimony isn't so much the mechanics or the efficacy of the system itself?

MR. EGGAN: That's correct.

JUDGE PATTERSON: It's whether or not the predicted constituents are protected?

MR. EGGAN: Correct.

JUDGE PATTERSON: I think as a geochemist she can testify.

MR. EGGAN: Thank you.

JUDGE PATTERSON: I'll overrule.

MR. EGGAN: Thank you.

Q You were talking about that term "uncertainty"?

A Right. Right. And what this slide addresses is the uncertainty of the discharge numbers. Okay? And this is after it comes out of the treatment plant and it goes into the ground there are some numbers in the groundwater discharge permit about what they think the water quality will be coming out of the treatment plant, and that's what will be going in the ground and then moving in groundwater toward the surface water. And the uncertainty in that number -- there are many layers of uncertainty in that number. It includes the modeling that Mr. Logsdon done -- did for what's going into the wastewater treatment plant, which I discussed a lot in my direct testimony.

And in Mr. Logsdon's examination he talked about the modeling that he did as heuristic, which means that it's -- it kind of addresses the general behavior of contaminants and it's exploratory in nature, he said, and it's not meant to give an exact number. However, those numbers that Mr. Logsdon came up with, even though he may not have intended them for this purpose, were put into the wastewater treatment plant as inputs and those were used as exact numbers. And the wastewater treatment plant values when you look at Appendix G-1 -- in the groundwater discharge permit there's a long series of notes after that; it's a table. And at the end -- and this is revised Appendix G.

There was a former Appendix G and I'm talking about the revised Appendix G. And the main difference really is all these notes. They have a lot more caveats in there and they say that, "Look. You know, these values are based on a number of things. One of the things they're based on is 180 gallons per minute inflow from the mine." Well, we've heard other testimony saying that the inflow could be very much larger than that today. If that's true, then the wastewater treatment plant will operate differently.

It also says in the notes that these are estimated concentrations. Okay? We don't know exactly what they're going to be. And that the concentrations are based on vendor recommendation. They're based on engineering judgment. In other words, there's a lot of uncertainty, a lot of kind of slop in these numbers. And to take that into consideration, all these layers of uncertainty, Sarah LeSage conducted a -- what's called a reasonable potential analysis and that is an analysis to determine if there is a reasonable potential of discharge to exceed surface water quality standards once it gets there. And because she only had one data point -- and that's what's in Appendix G-1 of the groundwater discharge permit -- she said she decided to use the highest uncertainty factor that you can use in this analysis and that's 6.2.

So in other words, she multiplied whatever the input values were to the TWIS and that's what's coming out of the wastewater treatment plant. She said, "Well, I'm going to multiply those by 6.2 to account for the uncertainty in those numbers because I just have one data point." So this is just to give an idea of the uncertainty associated with these TWIS effluent numbers.

Q So it sounds like in addition to you there are others who have some uncertainty about the particular effluent values coming from the TWIS?

A Yes; that's right.

MR. EGGAN: Can we go to the next slide, please?

Q Now, let's talk about -- and this is a little bit out of order from the outline you gave us, but let's talk about the monitoring system, because I -- that's been an issue that has been discussed throughout this case and I think it's -- it would be helpful to have your comment on it.

A Okay. A number of the MDEQ witnesses have testified that the monitoring system -- and by this I'm talking about what's happening at the TWIS -- and the permit -- and that's the groundwater discharge permit -- are protective of the environment. They're saying there are a number of, you know, characteristics of this monitoring system that are protective. However, when you look at this monitoring system you see that it's really not designed for pollution prevention. And by that I mean stopping pollution as close to the source as you possibly can.

And this is an example of where I really feel that really bad is worse and this is a philosophical point where Mr. Logsdon and I differ. He says that if it's ten times higher than the standard or just a little bit higher than the standard it really doesn't make that much difference as long as everything is managed properly. But if you don't have a good monitoring system in place then you're not even going to be able to detect impacts to the environment and then it really does make a difference. If the concentrations are much higher than what's predicted it really can have a negative outcome for the environment.

Q Your next bullet point talks about the control of effluent once they've been discharged?

A Yes. And this is also a pollution prevention point and that is that it's difficult to control. Basically the farther away from the source the more difficult it is to fix the problem. And so at the TWIS we want to make sure that our first line of defense is really strong, so that would be the effluent, the effluent limits. Those should be very strong because that's when we know -- that's before it gets into the groundwater, and if we have a good first line of defense we can say, "Wait a minute. You know, we have to do something to fix this before it hits the environment."

And this is the same for the non-TWIS sources. Right at the whole area of the TWIS there are number of things going on. It's not just the treated water that's coming out there. There are a number of other facilities there that could, if things don't go right, have an impact on the -- adverse impact on the environment.

Q The next slide, which is slide number 20, is an overview of essentially the mine operations. Can you comment what -- how does this slide relate to the monitoring system?

A Okay. Well, this is at the treated water infiltration system and also some of the mine operations here. This rectangular box here (indicating) represents the treated water infiltration system. Here's the temporary development rock storage area. And here are two contact water basins and this is water that has contacted material that could generate acid or leach metals. And then there's a non-contact water basin up here, et cetera. So this has a number of "facilities," let's call them, that if there are leaks from these that could leak to groundwater and adversely impact groundwater.

And then on top of this we see that -- and this is from the groundwater discharge permit, attachment 5. It shows the groundwater flow directions, and these are the groundwater flow directions as we know them now. We're not really sure what will happen it appears after all the water is put into the treated water system. But we know that generally the groundwater is flowing to the northeast. And then I wanted to point out the monitoring wells. Okay? There are compliance monitoring wells right here (indicating). There's one right here, right by the --

Q You need to -- if you wouldn't mind --
A Okay. Sure.
Q -- draw them to a location on our depiction so that if someone reads this later on in the transcript they'll know what we're talking about.
A Okay. I tried to find a figure where you could read these a little better but I really couldn't find one, and this is from attachment 5 of the groundwater discharge permit. So there are alluvial monitoring wells on the left side of this diagram. There's a compliance monitoring well here on the left side in the middle.
Q That would be the far west on this particular depiction?
A Far west, yeah. North is to the top; west is to the left. You see another compliance monitoring well to the south here, south of the temporary development rock storage area. And then -- let's see. There's one -- I don't know if there are any others. Okay. I believe that's it in this area. And then you go over to -- so all these -- I'm sorry. There's one right here at the contact water basin; there's another well -- a monitoring well right there. So there are three wells in this whole vicinity that have the temporary development rock storage area which Mr. Logsdon has said definitely requires special handling, and also the contact water basins. Then over here at the TWIS -- maybe it's run out of battery I guess.

Q Let me give you this one.
A Thank you. All right. Over here at the treated water infiltration system we have these -- all these circles with the black and white designs on them are monitoring wells. So we see on kind of the northeast side of the TWIS we have one, two, three, four, five monitoring wells. We have another one kind of to the southeast of the TWIS. There's one under the TWIS. And then there's one to the northwest; there's a compliance monitoring well there. There's also one -- and I believe this is an up -- called an upgradient or side gradient well on the west side of the treated water infiltration system. And that I believe is the full extent of monitoring wells at the TWIS.
Q Is this in your -- from your experience and in your professional judgment adequate to protect the environment in this area?
A No.
Q Why not?
A It's too low of a number of monitoring wells.
Q If you were -- if you were designing a system that you believe would be protective, where would you have wells, how many wells would you have?
A Well, --
MR. REICHEL: I'm going to interpose an objection at this point. Whatever Dr. Maest's qualifications as a

geochemist, she's not by training or experience a geologist or hydrogeologist. I don't believe there's an adequate foundation for her to opine as to the adequacy of a groundwater monitoring system.
Q Dr. Maest, do you have experience in this area in terms of monitoring wells and compliance with regulations?
A Yes, I do.
Q And what is that experience?
A I've reviewed monitoring data from a number of mine sites and also actually I'm a geologist by training, so -- and I've managed and worked with hydrogeologists in, you know, reviewing information from monitoring systems quite extensively. And I'm not actually going to say, you know, I think there should be this many and they should be exactly here; that's not what the point of my testimony is. It's just to say that -- well, I guess I'd better wait.
MR. EGGAN: Your Honor, I think she's -- I think she's established a foundation for this. We'll get the answer to this question and just move on.
JUDGE PATTERSON: I think she has a -- I agree.
MR. EGGAN: Thank you.
Q Go ahead.
A Okay. My point though is that we clearly have a number of sources of high metal leaching, low acidity that are in this area. And there -- this is the current groundwater flow

direction, but once all the water is applied to the TWIS this will likely change. So we need to know the groundwater flow direction. There are a number of types of information that hydrogeologists would need to design a very effective monitoring program. But when you look at these sources and you look in what's a downgradient direction you notice that there really are very few, if any, monitoring wells. So that's what I'm talking about, is that the coverage for monitoring in this area of the mine is very low.

MR. EGGAN: Let's go to the next slide, please.

Q Dr. Maest, we're going to move on now and talk about the permit limits in the permit for what you call are -- what you call toxics and your conclusion that they are not protective of surface water. First of all, maybe we'd better identify what we mean by "toxics."

A Okay. These are -- and this is not my word; this is Ms. LeSage's word from her review that she conducted for the Department of Environmental Quality. She did a review where she looked at toxic substances and in this case she was looking for cadmium, copper, selenium and silver. And all of those have known toxicity -- certainly three of them at least: cadmium, copper and selenium for human health, but also for aquatic health, aquatic biota; because Ms. LeSage was interested in finding out if the groundwater system was going to be protective of surface water resources including aquatic biota. So she did an analysis where she compared the predicted effluent values.

Now, these are just the concentrations that are predicted to come out of the treatment plant with the surface water standards, preliminary surface water standards. And she used a hardness of 50 milligrams per liter to calculate those standards, because some of those are hardness dependent. And she conducted this analysis for cadmium, copper, selenium, silver and nickel -- sorry -- cadmium, copper, selenium and silver. She said, "I'm also interested in looking at toxics that might be -- have concentrations in the effluent that are close to the surface water standards. Even if they don't exceed the standards, if they're pretty close to those limits, then I might recommend monitoring at a certain frequency," she said in her testimony.

And the one -- the two that she noted that were -- didn't exceed the standard but in the effluent coming out of the treatment plant were close to the surface water standard were nickel and beryllium. And if we look in the groundwater discharge permit and see what happened to these constituents we see that in the final effluent limits -- now, these are the limits that are put in the groundwater discharge permit; not the concentrations in the effluent but what the limits are in the permit -- the beryllium and

nickel their only report -- there are actually no numeric limits for those two. The other four that she reviewed, the effluent limits are higher or less protective than the surface water standards.
Q Did you create a table that will help us understand what your concern is with this issue?
A Yes.
MR. EGGAN: All right. Can we move to the next slide, please?
Q All right. Let's talk about the table that you have created.
A Okay.
Q Explain how it is that you created the table, where the values came from, where the parameters came from, and explain to Judge Patterson how this all came about.
A All right. Well, this information was derived from a couple of sources and including Ms. LeSage's testimony and the groundwater discharge permit, and also a Foth and Vandyke memorandum from September 15th, 2006 where Kennecott asked them to evaluate this issue. You know, what would the surface water standards need to be? And the hardness; what kind of hardness might we expect to gain? Because the hardness coming out of the treatment plant is very, very low. So the parameters I listed on this table are ones that Ms. LeSage reviewed in her analysis for the Department.

Q And the parameters are here on the far left?
A The far left column. And they are barium, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver and zinc. And these parameters or constituents that have surface water standards and they're also in one way or another in the groundwater discharge permit. The second column is called, "Expected effluent quality," and this is the number of -- that I was talking -- these are the numbers that I was talking about earlier that have a high uncertainty associated with them. These are the numbers that are expected to come out of the water treatment plant that have the -- that have layers of uncertainty from what's going into the treatment plant and also the treatment plant itself.
Q Where did the expected effluent quality numbers come from? Who generated them?
A These were generated by -- I believe it was Foth and Vandyke. And some of these are also in attachment -- I believe it's attachment 1 of the groundwater discharge permit. The ones with the little "c" are not in attachment 1. Then the third column here I multiplied these expected effluent quality values by 6.2 to account for the uncertainty. And this is what Ms. LeGrange did in her analysis.
Q Ms. LeSage?

A Oh, I'm sorry, LeSage.
Q Ms. LeSage.
A LeSage did in her analysis.
Q Now, was this part of her reasonable -- didn't she do a reasonable potential value analysis and --
A A reasonable potential analysis, yes.
Q Reasonable potential analysis.
A Right. And --
Q There was a memorandum that she created that is an exhibit in this case. Are these the numbers that would have been generated multiplying the expected effluent quality by 6.2?
A Yes. Yeah. And then the column -- the next column is called, "Final effluent permit limits," and this is just right from the groundwater discharge permit. And this is, again, the first line of defense. This is -- you know, what are the limits in the effluent itself as is leaves the treatment plant. And then the next column to the right is the downgradient groundwater permit limit, again, just taken right out of the groundwater permit. And then the last column on the right is the surface water standard at 50 milligrams per liter of hardness because some of these standards depend on hardness. And those values -- most of them come from this Foth and Vandyke memo that I mentioned, the September 2006 memo. However, there are a few where Ms. LeSage has calculated a different higher number for the

surface water standard and I put those on the table as well.
Q And tell us if you will what this table tells us about the permits.
A Okay. This is just to kind of go through what Ms. LeSage was thinking here and did in her analysis. The relevant comparison here is the surface water standard with the final effluent permit limits and the downgradient groundwater permit limits. And also we can look at the effluent quality and see if there's a reasonable expectation that that would exceed the surface water standards. So if we look at the downgradient groundwater permit and these downgradient groundwater monitoring wells are only about 150 feet downgradient of the TWIS. And those limits are here (indicating), so for barium, for instance, the limit that's allowed is a thousand micrograms per liter.
Q That's allowed by the permit issued by the MDEQ?
A Yes. Yes. So in other words, you can have up to a thousand micrograms per liter of barium at the downgradient monitoring well. Well, that's a lot higher than the surface water standard. And you see that that's true for almost all of these. You look at beryllium; the downgradient permit -- groundwater permit limit allows three micrograms per liter, but the standard for protection of surface water is .41 micrograms per liter. Cadmium allows three micrograms per liter in the groundwater permit, but the standard is at the

highest 2.8 micrograms per liter.

And if you look down pretty much all of these with the exception of lead, the downgradient groundwater permit limit is a higher number than what's protective of surface water. And probably the highest, the biggest discrepancy is here for zinc. 1200 micrograms per liter is allowed in the downgradient groundwater, but the surface water standard is only about 66 micrograms per liter. And then if we back up a bit to the final effluent permit limits we see that a number -- for a number of these metals and contaminants there are no numeric limits; it's just report.

Q You say "there are no numeric limits; it's just report." What does that mean if you're Kennecott? What are they supposed to do?

A They take samples of the effluent and they measure the concentrations and they report them. Now, some of these, if the concentrations are five times these expected effluent quality numbers, then they have to have a conversation with DEQ. That's my understanding.

Q I see.

A Now, for the ones where there are numeric limits you can see that right at -- this is our first line of defense for protecting groundwater as it comes out of the treatment plant and goes into the TWIS. The standard is higher. The final effluent permit limits at the effluent is higher than what's allowed in surface water for cadmium; that's 5 versus 2.8 at the highest. For copper it's over, you know, three or four times the surface water standard. And then selenium is five times -- the final effluent permit limit is five times the hardness -- I mean, the surface water standard. Silver is quite a bit higher, over ten times higher than the surface water standard. So the point of this is to show that the groundwater permit standard as issued right now is not protective of surface water.

Q Why?

A Because the allowable limits are higher than what is protective.

MR. EGGAN: Go to the next slide, please.

Q This slide is titled, "COC's" -- constituents of concern I take it?

A Yes.

Q -- "in surface water not addressed by effluent values or limits." What is the significance here?

A This is -- in Sarah LeSage's testimony and also in her written materials she had three approaches for making the groundwater permit protective of surface water. And the first one here she said that -- in her testimony she said, "I might have a provision for these six metals," and she listed them as nickel, lithium, barium, chromium, strontium and zinc. And these are constituents that have a numeric limit in the downgradient permit -- part of the permit, but they don't have a numeric limit in the effluent limits, so these were the report ones. Not all of these are on the table before, but some -- most of them are.

And she said that "if the values are five times the estimated effluent concentrations, then I might suggest that DEQ be notified." And that actually is in the permit. That is, you know, part of attachment 1 of the permit. There's a list there of these constituents and if the concentrations are five times higher or above then you have to have a conversation -- the mine has to have a conversation with DEQ. However, if you multiply those expected effluent values by five, zinc would still exceed the surface water standards, so you could be in a situation where you were still not protective of surface water.

The second approach that she investigated in her materials is that -- to have the composite effluent -- that's the effluent coming out of the treatment plant -- to control it and monitor it to assure that the acute and chronic values -- these are the surface water standards -- would be met at what's called the groundwater/surface water interface. And this is what I mentioned before; this is kind of just upgradient of where it would vent into surface water and that would be the groundwater/surface water interface location. And say -- you know, so let's have something there that would allow us to control and monitor the effluent right before it gets into the surface water. That was not done in the permit.

Another approach that she talked about is let's use the more restrictive of the groundwater and the surface water values and she mentioned that on page 7711 of her transcript. In other words, if you compare the groundwater and the surface water standards, as I did in that previous table, let's use the more protective of those two, and that was not done in the permit either.

MR. EGGAN: Let's go back to the slide with the table, which is -- there we go.

Q   If you are to use the more protective of the two or use the surface water standard, is that what happened in the permit and is that what eventually happened with respect to all these values?

A   No. The only one that meets that criterion is lead. You know, the downgradient groundwater permit for lead is three micrograms per liter and the surface water standard is 4.8, so that would be protective. The other ones are either right at the surface water standard or quite a bit higher than it.

Q   Thank you. Let's go back now and talk a little bit about monitoring, but this is a different area of monitoring. This is monitoring or limits in the permit for the groundwater/surface water interface. Can you please talk about what your point is with this slide?

A Okay. Well, during Ms. LeSage's testimony she was asked, "Do you think that the discharge coming out of the TWIS is hydrologically connected to the seeps or the springs at the east branch of the Salmon Trout River?" She said, "Yes, I do. I believe that those are." And it's quite apparent that Kennecott believes this as well, because they had Foth and Vandyke do an analysis to look at surface water standards. And so I don't think there's a question about whether or not the TWIS will -- the discharge from the TWIS will reach surface water at some point in time.

And also in Ms. LeSage's testimony at 7720 she said that the goal of Part 31 is to prevent the discharge of substances into waters of the state that are or may become injurious. And in order to assure that that's done you have to have a good monitoring system in place. And I talked a little bit about the monitoring system and at least as it stands right now there are monitoring wells downgradient of the TWIS at about 150 feet and then there's nothing between that and the surface water. The comparison of the effluent limits with surface standards, when you did the comparison which I just showed you see that the groundwater allowable limits are higher than what's protective of surface water. So there is an issue with this.

And there is no groundwater/surface water interface monitoring locations or limits, so we don't really know. It's kind of like the permit is saying let's monitor close in, which is good in terms of pollution prevention, but the values are not protective of what would happen downgradient. And we also see that our first line of defense, which is right at the effluent, the effluent limits are -- a lot of them are actually not even numeric; they report.

MR. EGGAN: The next slide, please.

Q All right. Let's talk about a summary of the points you've made on rebuttal.

A Okay. The first is that the waste rock can have a sulfur content up to ten percent sulfur and the highest waste rock sample that was tested in the kinetic testing only has 2.9 percent sulfur. So there's quite a bit of range between that and ten percent sulfur that was not represented in the kinetic testing. The second point is that the disseminated ore is a big kind of wildcard, question mark. It's not clear whether it's going to be mined or not. If it is that has certain implications; if it's not it has certain implications as well. It undoubtedly will be present in the development rock storage area and will also likely be present in the walls of the underground mine.

The next point is that the crown pillar will have an impact on the water coming into the mine; the quality of water coming into the mine. And that was ignored by Kennecott's modeling. And I did include that in my modeling. I made estimates of water quality coming through the crown pillar during mining operations. The fourth point is this kind of philosophical point that has I think big implications for monitoring at the site, and that is that "really bad" does make a difference to the environment. If it's just a little bit above water quality standards or if it's ten or a hundred times higher, it does make a difference because we know that the monitoring fails. There's almost always going to be a failure of the mitigation system, the monitoring system and that sort of thing. And the monitoring system is not designed to detect these impacts. The surface water and aquatic biota protection was analyzed by -- not only by Ms. LeSage but also by Kennecott. However, it appears to have been completely entirely ignored in the groundwater permit.

Q I was going to ask that question. Did Ms. LeSage's recommendations find their way into the permit?

A The one that she mentioned in her testimony of, you know, if the expected effluent is five times higher then have a talk with the Department of Environmental Quality that was included, but the other ones where you're actually comparing the numbers and saying, you know, "Let's get a number in here, a solid numeric value in the permit that will be protective of surface water," that was not included.

And then the last point is that the monitoring locations will not detect impacts to groundwater or surface water and I've showed these at the TWIS and you see that there are a lot of sources there, most notably the temporary development rock storage area, and also discharge from the treatment -- treated water infiltration system. And the monitoring system in my opinion is not adequate to capture or detect impacts either to groundwater or to surface water.

Q Dr. Maest, during the course of the testimony in this case a witness who testified for Kennecott said that Kennecott has evidence that -- "a commitment to the environment of the highest level" and followed it up by saying that "Kennecott will go the extra mile in terms of environmental protection." Is that something that you would agree with?
A That they will do that?
Q That they will go the extra mile.
A I don't -- well, whether they will or not I think in their -- certainly in their monitoring program and their mitigation program it does not show that they've gone the extra mile.
Q Okay. Do you think that the information that you have read and the documentation in this case evidence a commitment to the environment of the highest level?

A I think if they had a commitment to the environment of the highest level there would have been more characterization and a better monitoring program.
Q Thank you.
MR. EGGAN: Your Honor, I do have one request, and that is the table that Dr. Maest created, which was a part of her slide show -- it's slide number 22 -- I would like to have that be an exhibit in this case. It's titled, "Comparison of Expected Effluent Permit Limits and Surface Water Standards." And I would ask that that be an exhibit in this case, marked as Exhibit -- what's our next number? -- 190. Just a minute, please.
(Counsel reviews documents)
MR. EGGAN: What we're going to do is we're going to offer the slide program as Exhibit 189, and the table itself as 190.
JUDGE PATTERSON: Okay.
MR. REICHEL: Your Honor, may I have an opportunity to voir dire?
JUDGE PATTERSON: Sure.
VOIR DIRE EXAMINATION
BY MR. REICHEL:
Q Dr. Maest, do you have slide 22 available to you there?
MR. REICHEL: Counsel, this is what you want to offer as a separate exhibit?

MR. EGGAN: It is.
Q You prepared this document?
A Yes, I did.
Q In preparing this, I think you've already testified where you got your expected effluent quality and expected effluent quality times 6.2. Let me ask you about the fourth column over, "Final Effluent Permit Limits."
A Yes.
Q Now, you've testified you've reviewed the permit; correct?
A Pardon me?
Q You've testified you've reviewed the permit; correct?
A Yes.
Q Is it your testimony that what you have under "Final Effluent Permit Limits" accurately reflects the contents of the permit at issue in this case?
A I believe so.
Q You're aware, are you not, Dr. Maest, that under Michigan's regulations regarding surface water quality there are provisions for both acute and chronic limits?
A You're talking not about the groundwater permit now but surface water?
Q Yes.
A Yes; yes.
Q Have you looked at those regulations?
A I have not reviewed the regulations, no. But I'm familiar

with chronic and acute, the differences. And the --
Q Is it your testimony that the final effluent permit limits in column B are acute or chronic values?
A Those are neither. Those are just the values in the permit that are permit limits for the effluent -- for the final effluent. If you look at the column on the far right, the surface water standards at 50 milligrams per liter hardness, those are chronic values, calculated 50 milligrams per liter hardness.
Q Are the values -- in the column headed, "Final Effluent Permit Limits," are those daily maximum or monthly average?
A Those are daily limits, maximum daily limits. And the reason I used the maximum daily limits is because that's what the downgrading groundwater permits in the next column are, so that those are then -- we've got apples and apples we're comparing. The other reason I used the maximum daily limits is because that's a closer estimate of the time frame for both chronic and acute values than a month.
Q Are you -- let's go to the last column, "Surface Water Standard at 50 Milligrams per Liter Hardness." Where do you understand those values to have been derived?
A Well, the ones that are not in parentheses are from the Foth & VanDyke September 15th, 2006, memorandum that was prepared for Kennecott, where they evaluated surface water standards and any potential gain in hardness of the TWIS discharges

that move through the aquifer.
Q Do you have any understanding as to whether those standard -- values for those standards are related to chronic versus acute?
A Chronic. Those are chronic.
Q So you're comparing in the right-hand column -- well, first of all, is it your belief, Dr. Maest, that the values you have in this table under surface water standard at 50 milligrams per liter hardness are consistent with the requirements of the rules promulgated by the Department of Environmental Quality for such standards?
A It's my understanding that they are.
Q Have you looked at those rules --
A And this is at 50 milligrams per liter of hardness.
Q Okay. Understood. Have you looked at those rules?
A No, I have not.
Q Have you attempted to independently verify whether those values are consistent with the chronic toxicity-based standards?
A Those are -- no, I have not. I have, however, used the 50 milligram per liter hardness to calculate chronic values and acute values for the federal standards, which are somewhat similar. And a number of those are identical. Some of them are different, though.
Q But again, you don't -- as you sit here today, you can't

testify that the values you have in that right-hand column are necessarily consistent with the requirements of the rules promulgated by the DEQ under Part 31?
A No.
MR. REICHEL: Your Honor, I don't think there's -- I think there's a substantial question as to the foundation for this document since it purports to represent what the surface water standard at 50 milligrams per liter of hardness is, and the witness has testified that, by her own admission, she hasn't looked at the regulations under which the statute these standards are developed or verified that they are consistent with that.
A The numbers come from the Foth & VanDyke memorandum which did use those -- you know, there are a number -- there's a table in there where there are formulas for calculation of surface water standards using the Michigan criteria, and they calculated those at 50-milligrams-per-liter hardness. And that's what the numbers that are not in parentheses are from and -- as I noted on the bottom here. And in "D", the values in the parentheses are from a memorandum -- MDEQ memorandum from Ms. LeSage to Mr. Chatterson. So I'm assuming that she would know what the values should be.
Q Directing your attention to the last column on the right, do you know if those -- for those parameters, are those expressed in terms of dissolved metals or total metals, if

you know?
A I believe those are dissolved metals.
Q Do you know, with respect to the fourth column over, "Final Effluent Permit Limits, are those expressed in terms of dissolved or totals?
A I did not see an indication about dissolved versus total there.
Q Do you know what -- did you read the permit here?
A Yes.
Q And you're saying the permit doesn't indicate whether those are total or --
A I don't recall seeing -- that's -- I'm saying that I don't recall seeing whether they were totaled or dissolved values. This -- those numbers are coming out of the treatment plant, so they're filtered many, many times over, and those are allowable concentrations in the water coming out of the treatment plant. So the water that they're going to be testing certainly will be filtered many times over.
MR. REICHEL: Well, your Honor, I still think that there's a substantial question as to the foundation for the sum of the values in this document, and for that reason I don't think it's admissible substantive evidence.
MR. EGGAN: Well, your Honor, I suspect that counsel will have every opportunity to point out the errors, if there are any, on cross-examination. We are offering

this document as evidence in this case. It is subject to cross-examination. If it's inaccurate, they can point it out, and we might take an opportunity to correct it if there are errors. But I haven't heard anything to suggest that there are errors here.

JUDGE PATTERSON: Well, I agree with you, Counsel, and I think there's a proper foundation. If there are errors, that can be pursued on cross-examination if it's inaccurate, but I think there is a proper foundation, and on that basis I will admit it as Intervenor's 190?

MR. EGGAN: 190, yes, your Honor. And then --

JUDGE PATTERSON: And the remaining as Demonstrative Exhibits comprised of 189?

MR. EGGAN: 189. That's correct, your Honor.

(Intervenor's Exhibits 632-189 and 31-190 received)

MR. EGGAN: Witness that, I have no further questions.

MR. WALLACE: I have three quick things, your Honor.

DIRECT EXAMINATION

BY MR. WALLACE:

Q First, did I hear you testify as to the acidity of the water in the re-flooded mine? Do you know whether it will be acidic or how acidic?

A The prediction by Mr. Logdston for the acidity in the re-flooded mine is, I believe, 6.8 and -- however, that's, you know, an estimate -- a modeling estimate. And my belief, based on my experience, is that around the walls of the mine -- the mine walls, that the pH will be quite a bit lower, because there won't be -- won't have very much neutralizing material there. Now, in -- right, you know, where the backfill is, they have cemented aggregate and then limestone-amended waste rock. In those areas the pH may be closer to neutral but near the walls of the underground workings, until there's a flow established through that, the pH will probably be very low.
Q Would that be closer to neutral because they're reacting with the cement?
A Yes.
Q Eating away at the cement?
A Well, that would --
Q Is that what makes it -- is that what brings the pH up?
A Dissolving some of the cement and dissolving some of the limestone, yes, is what allows it to become more neutral.
Q Okay. And my second question is, do you have some familiarity with how long acid mine drainage can go on in a mine?
A It really depends. I think I testified on my direct testimony that, you know, there are mines from Roman times

that still have acid drainage today so --
Q You mean, like, thousands of years?
A Yes. And because reaction is so difficult to turn off, it can continue for a long period of time; hundreds -- I would say hundreds to a thousand years or so. If you decrease the oxygen and push all the, you know, ferric iron and all that out of the way and -- then you can start turning that clock backwards on the acid drainage reaction, but that's -- there hasn't been a lot of information on that so --
Q And finally, you testified about some familiarity in a study you've done regarding Kennecott's Green Creek Mine in Alaska; correct?
A Yes.
Q Are you aware of, like, how many Clean Water Act violations that have resulted from that mine?
A I'm not aware of that. I believe that there actually are none currently. There have been increased concentrations, but they have not exceeded water quality standards in groundwater. Now, the small streams, what it said in the environmental impact statement is that they have exceeded Alaska water quality standards in the streams, and I'm not sure why a violation hasn't been issued, but that's my understanding.
Q Okay. Do you know whether or not this site has been graded in terms of the amount of toxic waste it generates compared

to other sites in Alaska?
A You mean under the toxics release inventory?
Q Or by any other rating.
A I am not aware of that. I don't know; I don't know.
Q In terms of thousands of tons or millions of tons of toxic waste, do you have any idea of what's been produced at the Greens Creek Mine?
A I really don't. I would just be guessing if I -- sorry.
MR. WALLACE: Thank you.
A But, you know, there's a large tailings impoundment. That picture that I showed on the upper left-hand side of the Greens Creek slide is an aerial view of the tailings impoundment at Greens Creek, and you can see that it's quite a large facility so --
JUDGE PATTERSON: Do you want to break before you start?
MR. LEWIS: If you do. Otherwise I'm fine.
JUDGE PATTERSON: Are you ready?
MR. LEWIS: Yeah.
JUDGE PATTERSON: I'm willing to go if you are.
MR. LEWIS: All right. Hello, Dr. Maest.
JUDGE PATTERSON: Are you okay, Doctor?
THE WITNESS: Yes; sure. Thank you. Hello.
MR. LEWIS: We met before. I'm Rod Lewis. I represent Kennecott Eagle Minerals Company.

THE WITNESS: Yes.

CROSS-EXAMINATION

BY MR. LEWIS:

Q On that last point, Mr. Wallace asked you about the calculated post-mining water quality pH figure from Mr. Logdston. It was 6.8?

A Yes.

Q And that was without the addition of limestone?

A That's right; that's correct.

Q As to this discussion about this disseminated ore, Dr. Maest -- and I think the general gist of your testimony was either two things could happen. Either it could end up in the TDRSA or -- relatively more or relatively less could end up there, or you could have relatively more or less of it left in the mine?

A Yes.

Q You're not sure what's going to happen?

A It's -- as far as I know, it's uncertain.

Q If relatively more of it is left in the mine, let's say, that's -- the water that collects in the mine of course is going to be collected, pumped out to the water treatment system?

A During operation, yes.

Q And if relatively more ends up on the TDRSA, the water that collects under the TDRSA is again going to be collected,

pumped go to the water treatment system?
A That's the plan.
Q Greens Creek Mine, did they have an active water treatment system like is planned for this mine?
A I'm -- I can't recall. I have to go back and look.
Q Butte Mine, did they use limestone amendment?
A In the underground workings? No, they did not.
Q In reference to a question that Mr. Haynes asked you, Dr. Maest, I wanted to clarify something. And the question was to the effect Mr. Haynes indicated and characterized Mark Logdston as having said that he wouldn't -- something to the effect that he wouldn't be troubled if the actual water quality reporting to the water treatment plant, in Mr. Hayne's words, "exceeded standards." And he referenced a particular page from that testimony, and I wanted to read you part of that, because you took that question and answered it, to see if we can clarify in fact what Mr. Logdston had to say. And if we look at the page referenced by Mr. Haynes, page 4189, Mr. Logdston was being asked about, I believe, your recalculated concentration numbers, starting with

"Q And does that explain in part why they recalculated numbers in terms of predicted concentrations of metals and so forth that were higher than the numbers you had in your report?

A Yes. They used the highest value, and I did not, because I was using earlier times.

Q And in terms of your final conclusions in the various reports -- and we looked at on a prior slide your conclusion as to phase-1 and phase-2, that being that there will be a need for active management of all rock types -- does the fact that longer-term leach test results would show a higher calculated concentration of metals in the water change that conclusion?

A Not at all."

Now, you went on to explain why that was. But he was not asked that question, nor did he answer that question in reference to any particular standards, did he, Dr. Maest?

A No, he did not. He --

Q He was asked that question in terms of whether the other predictions might be true if that would change his conclusions; right?

A Right; that's right. And -- but --

Q That's all I need, Dr. Maest. Thank you.

A Okay. Sure; sure.

Q You also talked about the Greens Creek Mine in terms of -- I think your point was that there were predictions made as to

the lag time for the development of acid rock conditions?
A Right.
Q And your point was, I think, that, whatever those predictions were, that they were over-predicted, I guess, compared with the lag time. They predicted more time than actually occurred?
A Right, for -- especially for the modeling number, which was 500 years.
Q And I think that -- I wanted to ask you -- and we can look at Mr. Logdston's testimony if we need to. But you do understand, Dr. Maest, that, in this particular situation, Mark Logdston identified the need for active management of the rock in the TDRSA?
A Yes.
Q He didn't say you can wait 30 years or 500 years before you have to manage that rock. He said you're going to have to do it now; right?
A That's right; that's right.
Q And he said the same thing about the water in the mine, did he not?
A Yes, he did.
MR. LEWIS: That's all I have. Thank you, Dr. Maest.
THE WITNESS: Thank you.
MR. REICHEL: If I may just have a few minutes,

your Honor. We'll take a short break.

JUDGE PATTERSON: Sure. Okay.

(Off the record)

JUDGE PATTERSON: All right. Are you ready?

MR. REICHEL: Yes.

JUDGE PATTERSON: Okay.

MR. REICHEL: Dr. Maest, as you know, I'm Bob Reichel. I represent DEQ in this matter.

THE WITNESS: Yes.

CROSS-EXAMINATION

BY MR. REICHEL:

Q I do want to go back to some issues that I sort of asked you about during voir dire on slide 22 that you prepared. First of all, let's start with the permit. Dr. Maest, I'm going to have projected up here on this overhead a page from the groundwater discharge permit, so you can take a look at that. But this -- the first question will be about the final effluent limitations that you testified to.

A Okay.

Q While we're waiting for this to heat up, Dr. Maest, I think I touched on this before. You're aware, are you not, that under the permit the effluent -- final effluent limitations are expressed both in terms -- for certain parameters in terms of monthly average limitations and daily maximum limits. You understand that?

A For certain parameters, yes.
Q Correct. And again, do you have an -- do you understand that the distinction for --
MR. REICHEL: I apologize, your Honor.
JUDGE PATTERSON: Elmo's not cooperating?
Q Dr. Maest, you've testified, I believe, that you have -- you are -- you're not specifically familiar with the requirements of the Michigan rules for the development of water quality based effluent limitations; is that correct?
A That's correct.
Q But you have some familiarity with federal regulations under the Clean Water Act on that subject; correct?
A Yes.
Q And you understand, I take it, there's a distinction between limits -- daily maximum-type limits that are addressed to issues of acute toxicity versus monthly average limits that are addressed to issues of chronic toxicity; correct?
A So you're saying in the permit --
Q No. This is in general.
A Yeah. Well, the way that acute and chronic values are calculated, I mean, you know, in terms of measurement and sampling of surface water, is that the -- at least at the federal level -- is that the chronics are four-day averages and the acutes are an instantaneous grab sample.
MR. REICHEL: Again, I apologize for the delay.

JUDGE PATTERSON: That's okay.
Q We're going to try it the computer way.
A Okay.
Q Dr. Maest, we've had projected Respondent's Exhibit 118, groundwater discharge permit, and I believe this is page 6 of 22.
A 32.
Q 6 of 32. Thank you.
A Uh-huh (affirmative).
Q Okay. Dr. Maest, directing your attention to the left-hand column there, and do you see the values for the various parameters are listed -- do you see that they are listed in terms of total -- for example, total arsenic, total cadmium and total copper?
A Uh-huh (affirmative).
Q Do you see?
A Yes, you're right; yes.
Q Is that correct?
A Yes, it is; uh-huh.
Q Now, with regard to -- and you see, while we're on this, that, for the -- looking at those values, looking at arsenic, for example, there's a monthly average limit of 6 and a daily maximum of 10; correct?
A Yes; yes.
Q Cadmium 3 monthly average, 5 daily maximum?

A Yes.
Q Copper 10, 21 daily maximum, et cetera; correct?
A Okay.
Q "Yes"?
A Yes; yes.
Q I'm sorry. We need to scroll that. I apologize.
A Yes, we --
Q Okay.
A Okay. There we are.
Q In your table -- strike that. You testified that you read the testimony of Ms. LeSage; correct?
A Yes.
Q Do you recall during her testimony as to whether or not she described the process that she followed in developing her recommendations?
A Which recommendations?
Q The recommendations that -- her recommendations for -- as you discussed on your slide 21, --
A There were several.
Q -- "for toxic substances with predicted effluent values greater than preliminary surface water standards include a limit in the permit or close monitoring at certain frequency." Do you recall that?
A Yes; yes, I do.
Q And do you recall, from reviewing her transcript, whether or

not she explained that that process that she followed was one that was provided for in administrative rules promulgated by the Department of Environmental Quality?

A Yes, I believe so.

MR. REICHEL: Your Honor, what I'd like to do, then, is, if I may approach the witness -- what I'm -- Counsel, what I'm going to show the witness is from Part 8, Water Quality Based Effluent Limit Developed for Toxic Substances promulgated pursuant to Part 31. And I'm going to read the Michigan Department of Environmental Quality Water Bureau, a version of the rules effective July 29th, 1997, latest revision effective to January 13th, 2006. That's the document. And, your Honor, may I approach?

JUDGE PATTERSON: Sure.

Q Dr. Maest, just to give you some context here, I'm going to direct your attention to the rule that has the heading "R323.1209 Development of Waste Allocations for Toxic Substances," and I want to specifically direct your attention to sub rule -- in sub rule 1 -- that is, 1209(1). There is a table 2. And this -- I'll read this so counsel can hear it. Table 2 has the heading "Dissolved to Total Metal Translators for Aquatic Life Waste Load Allocations." And then there's a listing of two columns. There's a heading "Toxic Substance" and "Translator T." And then for various parameters, including cadmium, chromium, copper,

lead, nickel and zinc, there is a translator provided.
A Uh-huh (affirmative).
Q In all fairness, I think you testified you hadn't looked at this rule before. But I wanted to bring to your attention the fact that at least this rule -- take a moment to look at it. Would you agree that it provides a mechanism for translating dissolved total metal concentrations. Does that appear to be the case?
A Yes. And there's a similar approach in the federal, you know, statute as well, so I'm familiar with this.
Q Okay. So you're familiar with this concept?
A And I do recall that Ms. LeSage talked about translators, yeah.
Q Okay. Now, in putting together the values in your slide 22, did you use a translator?
A I did not, no.
Q You did not?
A No.
Q Do you recall from reading Ms. LeSage's testimony as to whether or not she used a translator when calculating her numbers?
A I believe she did. And she mentioned what it was at one point in the transcript, yeah, but I'm not sure which one she used it for.
Q And if you recall Ms. LeSage's testimony, do you recall in

making -- in looking at a -- developing recommendations for a preliminary effluent limitation, whether she was proposing numbers that were based upon chronic toxicity versus acute toxicity?
A I don't recall right now. When you talk about preliminary effluent limits, are you talking about surface water?
Q Yes. I'm not trying to confuse you.
A Yes; right.
Q It's just is --
A Yeah, that is kind of confusing. I remember that testimony, yes.
Q Okay. That's fine. But I will represent to you -- we can bring the transcript out if you want.
A Okay. Sure.
Q But I believe the record reflects that her testimony was that this process, which you referred to in your slide 21, you talked about four toxic substances with predicted effluent values greater than preliminary surface water standards. That's -- I think that's the phrase you used.
A Okay.
Q I believe Ms. LeSage used the phrase, to be precise, "preliminary effluent values." Leaving aside that potential difference in nomenclature, do you understand and do you agree that Ms. LeSage's recommendations in that regard were comparing the predicted effluent values to preliminary

standards or effluent limits that were expressed in terms of value -- chronic toxicity? Correct?
A I believe it was chronic toxicity. I'd have to go back and look, yes.
Q You have no reason to disagree with that?
A No.
Q And I wanted to ask you to -- just bring to your attention another provision of the same rules I showed you before, these Part 8 Water Quality Based Effluent Limit Developed rules, and this one is Rule 323.122. Again, just to show you the context here --
A Okay.
Q I know this is a long rule. But the heading of this section of the rule is 323.1211 with the heading "Reasonable Potential for Chemical-Specific Water Quality Based Effluent Limits (WQBELS).
A Okay. Uh-huh (affirmative).
Q And I'm specifically directing your attention to sub rule 4. This states in part:

"If the analysis in sub rule 3 of this rule demonstrates that the toxic substance concentration has a reasonable potential to cause or contribute to an excursion above any water quality value, then a WQBEL or WQBELS shall be established in the permit."

A Okay.

Q And then it goes on to say:

"For the purpose of an NPDS permit, the chronic acute waste load, WLWA -- waste load allocation shall be equal to the WQBEL and shall be expressed using the following permit average methods. (A) Chronic WLA's or waste load allocations for protection of aquatic life, human health and wildlife shall be expressed as monthly average WQBELS."

Do you see that?

A Yes. That's talking about waste load allocation, though; right? And Ms. LeSage in her transcript talked about loading and more kind of what you're referring to as preliminary effluent limits, and those were two different things.

Q Do you understand, Dr. Maest, that the recommendations -- I just want to make sure we're on the same page here -- that, in making recommendations, do you -- I think we established just a moment ago that the values or the recommendations of the water quality based effluent limit recommendations that Ms. LeSage presented were expressed in terms of monthly averages; correct?

A I don't recall.

Q Do you have any reason to disagree with that proposition?

A You're saying that her preliminary effluent limits were expressed as monthly averages?

Q Yes; yes.
A You mean for the purpose of the groundwater discharge permit?
Q Yes, that's what I'm saying.
A Okay. I don't have any reason to disagree with that, but I don't recall that personally from her testimony.
Q Okay. Fair enough. Assuming that's the case, then the -- her recommendations; that is, surface water standards which would be geared towards chronic toxicity expressed in a monthly average; would be the relevant comparisons to use in the table that is --
MR. REICHEL: Can we go back up to --
Q Do you have your slides in front of you?
A No, I don't.
MR. REICHEL: We could project it, but just in the --
Q I want to direct you to your slide 22, Dr. Maest.
A Okay.
MR. EGGAN: We're talking about slide 22, Mr. Reichel?
MR. REICHEL: Correct, Counsel. And I'm directing Dr. Maest's attention to the right-hand column with the heading on her table "Surface Water Standard at 50 Milligrams Per Liter Hardness."
Q Okay?

A Okay.
Q And what I am -- the -- Ms. LeSage's recommendations following the process established under the party rules that I just referred you to were to look at surface water standards protective of or geared towards chronic toxicity.
A Okay.
Q And do you understand or would you agree that the -- for relevant purposes, the surface water standard for 50-milligrams-per-liter hardness that you have -- I mean -- strike that. The values that you have in that column are dissolved, are they not?
A I believe they are.
Q Not totals, as would be provided --
A That's my understanding, yes.
Q So those would not be the same as the recommendations that Ms. LeSage made; correct?
A Well, there's -- everything in that column that is not in parentheses is from the Foth & VanDyke September 15th memorandum. And I also included three of Ms. LeSage's numbers, and those are in parentheses, and they're from her October 26, 2006, memorandum to Mr. Chatterson.
Q Do you know if Ms. LeSage's numbers in parentheses are total or dissolved?
A I am not sure.
Q If I were to tell you that Ms. LeSage applied the translator

and made them total, would you have any reason to disagree with that?
A No.
Q As a scientist, would you agree that it would be appropriate to compare total metals to total metals?
A Yes. So -- well, never mind.
Q Now, looking at the -- what you have in the final effluent limits -- and I think we touched on this earlier -- the values that you put there are not the monthly average values based upon chronic toxicity but rather daily maximum values; correct?
A That's right.
Q Now, you've asserted that there is -- I'll look at my notes to get your exact testimony here. But I believe you've asserted that the permit does not provide for -- strike that. Again, you've testified you've read the permit; correct?
A Yes.
Q You understand that monitoring requirements under the permit occur at more than one location; correct?
A There are different monitoring wells, yes.
Q Right. And not just monitoring wells. Is it your understanding that --
A And the effluent.
Q Effluent, correct.

A And the effluent. That's correct.
Q When in fact there are certain requirements in the permit to monitor the quality of the water that leaves the wastewater treatment plant before it goes to the treated water infiltration system; correct?
A That's correct.
Q And then, in addition to that, there are also requirements in the permit for monitoring in the groundwater downgradient -- a short distance downgradient, about 150 feet; correct?
A That's right.
Q And that both of those, when water quality is measured at either of those locations, that would be the water quality well before that effluent -- treated effluent ever works its way to the groundwater surface water interface; correct?
A Yes.
Q Dr. Maest, again, based upon your review of Ms. LeSage's testimony, do you understand or do you recall that the monthly average limits for the cadmium, copper, selenium and silver were intended to be protective of aquatic life?
A In the permit?
Q The limits that -- yes.
A All right. Well, that's what this table is about. You're just talking about the monthly ones now or the daily?
Q I'm talking about the monthly average limits, yes.

A Yeah. The monthly average limits are still higher than the -- some of the numbers that Ms. LeSage has calculated. For instance, cadmium is -- the monthly limit is 3, and she calculates 2.8.
Q In the course of preparing for your testimony, did you review the testimony of any other DEQ witnesses involved in the development of the groundwater discharge permit?
A Portions of Mr. Janis- --
Q Janiczek?
A -- Janiczek, yeah.
Q And did you read any of the portions of the testimony by Mr. Creal?
A No, I don't think so.
Q Do you recall from reviewing Mr. Janiczek's testimony as to whether or not he testified that, for certain parameters where the effluent -- let's take an example -- the cadmium, which you've mentioned, where the monthly average limit is 3, --
A Right.
Q -- and in the right-hand column of your slide 22 it's -- the surface water standard is 2.8, do you recall whether or not or do you remember Mr. Janiczek testifying that he and other department staff included that, as a result of the advection and dispersion that was going to occur once that discharge occurred from the TWIS and the water migrated in excess of

4,000 feet to the groundwater surface water interface, that the resulting quality of the water at that point they determined to be consistent with or lower than the 2.8 standard? Do you recall reading that?
A I do recall that, yes.
Q And with respect to selenium, the --
MR. REICHEL: Will you put the permit back up, please? This would be page 732 of the groundwater discharge permit.
Q Okay. We have Respondent's Exhibit 118, page 7 of 32, which I would represent is a continuation of the page we had up before, Part 1, Section 2, Final Effluent Limitations.
A Okay.
Q I'd like to direct your attention, Dr. Maest, to selenium. Do you see that?
A Yes.
Q Total selenium; there's a monthly average limit there of 5. Do you see that?
A Yes. Could you just go up to the page beforehand? Is this in the effluent -- are these the final effluent limits?
Q Yes, it is.
A Okay. The final. Okay. I just wanted to find out where we were in the permit.
Q Sure. No, that's --
A Yeah. Okay.

Q Okay. So you see there at page 7 that the monthly average limit in the effluent from the treatment system for selenium is 5; correct?
A Yes.
Q Now, if you look at your slide 22, what did you understand the surface water standard at 50 milligrams for hardness to be?
A 5. That hardness -- selenium is not hardness-dependent, so the hardness doesn't affect --
Q But the number, in any event, is 5?
A But the number is 5, yes.
Q And with respect to sliver, looking at the permit that we have up on the screen there, the monthly average limit is 0.4. Do you see that?
A Yes.
Q And in your slide 22, the value -- you have two values there, .2 and then parenthesis 0.3. Do you see that?
A Yes.
Q And you note in your footnote D that that is from Ms. LaSage's October 26 memorandum; correct?
A Yes.
Q And again, do you recall whether or not from reviewing Mr. Janiczek's testimony whether he testified regarding the expected attenuation -- or excuse me -- induction and dispersion of contaminants in the treated effluent after

discharge -- after it's discharged from the TWIS and before it hits the groundwater surface water interface? Do you that?
A Yes.
(Counsel reviews document)
Q Dr. Maest, I believe you also testified during your direct examination today that you made the observation to the effect that a monitoring system is not a pollution prevention measure. So you're saying -- I'm paraphrasing roughly.
A I don't think I said that. What I said was that the monitoring system as designed is not a very good pollution prevention tool.
Q If a permit places limitations -- discharge permit places limitations on the quality of what is allowed to be discharged from a treatment system, you would agree, would you not, that that is a pollution prevention measure, is it not?
A If the limits are protective of whatever it is that could -- it could potentially injure, yes. And those are good, firm, numeric numbers, yes. That would just address the TWIS discharge, though. It doesn't address the non-TWIS issues that I also addressed in my testimony.
Q Well, that wasn't my question, Doctor.
A Okay.

MR. REICHEL: May I have just another moment, your Honor?

JUDGE PATTERSON: Sure.

(Counsel reviews documents)

MR. REICHEL: Thank you for your patience, Dr. Maest. I have nothing further at this time.

THE WITNESS: Okay. Thank you.

MR. HAYNES: Your Honor, I have a few follow-up questions.

REDIRECT EXAMINATION

BY MR. HAYNES:

Q Dr. Maest, during Mr. Lewis' cross-examination he asked you about testimony by Mr. Logdston concerning the predictions and calculations on transcript page 4189. And as you attempted to answer his question he cut you off. Do you wish to add something to your answer to his question about that?

A I believe what he was asking about was Mr. Logdston and standards. And he said that Mr. Logdston did not actually say in his transcript that it had anything to do with being above or below a standard, whereas I had characterized his testimony as having to do with a standard. And I think that what he was --

Q That's generally my question.

A Generally. Okay.

Q Do you have something to add to that, to your answer?
A What I wanted to add was that in Mr. Logdston's reports he -- and also in his Excel spreadsheets that I reviewed for his modeling he compares the concentrations that he predicts to water quality standards. And he, you know, says whether or not they're above or below. And, for example, nickle was very much higher than the water quality standard; sulfate was higher than the water quality standard. And that is what led him to say that these require active management.

MR. HAYNES: Thank you. I don't have any further questions at this time.

MR. EGGAN: Just a question or two, Dr. Maest. And, your Honor, what we're trying to do is complete her testimony today. So with the court's permission, can we continue?

JUDGE PATTERSON: Yeah; right.

MR. EGGAN: Ten minutes maybe?

JUDGE PATTERSON: Right; sure.

REDIRECT EXAMINATION

BY MR. EGGAN:

Q Dr. Maest, looking at slide 22, which is Exhibit 190, I want to look at that last column that Mr. Reichel has asked you about. And I'm particularly interested in the numbers in that column, the barium at 210; beryllium, .0 -- or 0.41, et cetera down the line.

A Yes.
Q Just so the record is absolutely clear, are these numbers that you created?
A No.
Q Who created these numbers?
A The numbers in the last column titled "Surface Water Standard at 50 Milligrams per Liter Hardness" that are not in parentheses are from the Foth & VanDyke 2006 memorandum. And I don't think you can see it very well, because it's black on blue down there. But it's table 2 of the 2006 Foth & VanDyke memorandum.
Q So these, at least the numbers that are not in parentheses, are numbers that were provided by Kennecott's consultant?
A Right; that's correct.
Q What about the numbers that are not parentheses?
A Those are all from Sarah LaSage's memorandum from October 26, 2006, to Mr. Chatterson.
Q Now, Mr. Reichel asked you about some Part 8 rules. And when he got to the end of that discussion, he asked you whether it was more accurate to compare total metals to total metals.
A Yes.
Q And you started to say something and didn't finish. Did you have an observation to make with respect to that comparison of total metals to total metals?

A I think the only thing that I wanted to add was that in the final effluent permit limits, those are -- you know, when you take that sample, you're taking it after it comes through the wastewater treatment plant where it would have been filtered who knows how many -- you know, a number of times. So I think there would be very little difference between total and dissolved concentrations in that final effluent limit number, and that would always be true.
Q Okay. Mr. Reichel asked you about the monitoring locations and the monitoring being -- that there are monitoring wells downgradient, 150 feet from the treated water infiltration system.
A Yes.
Q And you've indicated that there are none, then, until you get -- in fact, there are none after that?
A That's correct.
Q You've got this grid of monitoring wells. Isn't that protective? What is your position on that?
A It is a good idea to have monitoring wells close to the source. So I don't have any problem with that. But what I'm talking about is having more -- there are two things. One is having more wells downgradient. And just having no wells between the treated water infiltration downgradient monitoring system and the surface water, where you know it's going to end up eventually, seems not -- like not a very

good idea environmentally.

Q Why? Why?

A Because you want to be able to capture that water as it flows from there to the surface water. If there's some assumptions being made, as Mr. Janiczek said, about advection and dispersion, then you could check that out if you had monitoring well locations. At this point it's all theoretical. We don't have any monitoring well locations. The other part of that is that there are, in my opinion, not enough monitoring wells at other locations in that same area of the site. And that would be around the other sources, like the temporary development rock storage area and the contact water and the noncontact water basins. In all of those facilities there more wells are needed.

MR. EGGAN: May I have a moment, your Honor?

JUDGE PATTERSON: Sure.

(Counsel reviews documents)

Q One more question for you with respect to the table, Exhibit 190. After hearing Mr. Reichel's questions and listening to his cross, do you have any concerns about the accuracy of this table as you put it together?

A The reason I put this table together is to compare the permit limits at different locations and surface water standards, or as you refer to them, preliminary effluent limits in surface water. And there may be some modifications that would be needed to this table, but I still believe that the numbers in the table are accurate as I depicted them on this table and that it still shows a problem in terms of the protectiveness of the permit for surface water.

Q Is it accurate for the purpose that you testified to earlier, the issues that you testified on earlier?

A Yes, it is.

Q Okay.

MR. EGGAN: I don't have any other questions, your Honor.

MR. REICHEL: Your Honor, I want to follow up briefly on something that Mr. Eggan just asked Dr. Maest.

JUDGE PATTERSON: Okay.

RECROSS-EXAMINATION

BY MR. REICHEL:

Q Dr. Maest, Mr. Eggan just asked you about your concern with respect to what you believe to be the inadequacies in the monitoring wells at the site.

A Okay.

Q Do you recall that?

A Yes.

Q In the course of preparation for your testimony, in addition to reviewing the groundwater discharge permit that's been issued in this case, have you also looked at the mining

permit that was issued under Part 632?
A Yes.
Q Are you aware, Dr. Maest, that that permit requires -- has other monitoring requirements in it?
A For this area?
Q For the area of the surface facilities, yes, that you identified as potential sources of pollution.
A I can't recall right now if there are.
MR. REICHEL: Your Honor, the mining permit was previously entered into evidence as Respondent's Exhibit 117, I believe. Could we bring that up? Okay. And I'd like to go to special condition L-3. I apologize. I don't recall offhand exactly what page number that is. It's some pages into the document.
Q Dr. Maest, as we're scrolling through this, do you recall having looked at the permit itself as issued --
A Yes.
Q -- generally?
A Yes.
Q Okay. And do you recall -- again, as we scroll through this, Dr. Maest, do you know -- recall whether or not the mining permit regulates the construction operation of the contact water basins?
A Yes.
Q It does?

A Yes.
Q The TDRSA?
A Yes.
MR. REICHEL: If you could scroll down just to see what page we're on? I think this is -- I'm sorry. Scroll up. I apologize.
Q Condition L-3, that states,
"The permittee shall construct, utilize, maintain, and operate and abandon, as applicable, a comprehensive monitoring network identified in 6-1 -- Figure 6-1, the Permit Application and Special Permit Conditions L-5, -6 and -7" and then complies with --
Were you generally aware that this requirement existed, Dr. Maest?
A In number three?
Q Yes.
A Yes.
Q Okay.
MR. REICHEL: Could we please bring up Respondent's Exhibit I believe it's 213?
Q Dr. Maest, I'm having projected here what was previously admitted into evidence as Respondent's Exhibit 213, which I represent to you is a diagram of monitoring well locations. I don't know if you can see that or not from where you're at.

A Yes, well, I can't --
Q Okay.
A -- pick out words, but I can see it generally.
Q All right.
MR. REICHEL: Your Honor, I apologize for this low tech. May I approach the screen here?
JUDGE PATTERSON: Sure.
Q Dr. Maest, again, this exhibit is already in evidence. I wanted to ascertain, Dr. Maest -- well, first of all, have you ever seen this document?
A Yes.
Q Okay. And do you understand that according to the legend that there are certain well locations identified on this?
A Yes.
Q Do you understand that these well locations to be among those that are required under either the mining permit or the groundwater permit or both?
A That's what it looks like; yes.
Q And so, for example, do you see that in the area to -- located I believe, if my direction is correct, to the east of the TDRSA, do you see that, Dr. Maest?
A Yes.
Q There are a series of monitoring wells located there. Do you see that?
A Yes.

Q And I believe you testified that it's your understanding that the available information indicates that in general the groundwater flow direction is expected to be to the -- generally to the northwest from the service facility?
A That's currently -- under current conditions; yes.
MR. LEWIS: I think you meant northeast, Mr. Reichel.
MR. REICHEL: Northeast. Thank you.
A Northeast; yeah.
Q So, again would you agree that the well locations, monitoring wells locations identified on this figure are among those required under the mining permit and the groundwater discharge permit?
A Yes.
MR. REICHEL: I have nothing further.
MR. LEWIS: I have nothing further, Your Honor.
MR. HAYNES: I don't have anything further, Your Honor.
MR. EGGAN: Nothing, Your Honor.
MR. HAYNES: But before we finish today, there's a minor housekeeping matter with the exhibit that Dr. Maest testified to on direct examination. We had some colloquy it seems like months ago and maybe that's right about Petitioner's Exhibit 66 which was Dr. Maest's exhibit, and Mr. Lewis asked me to pull out the slides that were actually

testified to by Dr. Maest and put them into a new exhibit. I've done that. That's now Petitioner's Exhibit 154, and I've given that new exhibit with the redacted slides to counsel. If Your Honor wishes, I can read into the record the slides that are in that exhibit, or we can just let it go. It's up to you.

JUDGE PATTERSON: I don't think we need to do that. I assume there's no objection.

MR. LEWIS: Yes, Your Honor. It's based on I neglected to take the time to look through that again, but based on Mr. Haynes' representations that it reflects the agreements and understandings made on the record, I have no objection.

MR. REICHEL: And, Your Honor, Mr. Haynes did share those documents with me the other day, and it is consistent with what was previously agreed to so we have no objection.

MR. HAYNES: And that's, again, Petitioner's Exhibit 154, Your Honor.

JUDGE PATTERSON: All right. And there being no objection, then we admit it.

(Petitioner's Exhibit 632-159 received)

MR. EGGAN: Your Honor, before we all adjourn, what I'm wondering is, is there any thought to the possibility of starting at 8:00 a.m. tomorrow so that we could hopefully finish by the time you have to leave for your doctor's appointment?

JUDGE PATTERSON: I'm willing.

MR. EGGAN: Is everyone else willing? I realize that's placing a burden that --

MR. LEWIS: Now, if you still have a direct that takes us into the lunch hour and we have to adjourn, I'll be disappointed but starting at 8:00 otherwise --

MR. EGGAN: I am concerned about disappointing Mr. Lewis, Your Honor; however --

MR. HAYNES: I share the concern but not the disappointment.

JUDGE PATTERSON: Yeah, that's fine if you want to try it.

MR. EGGAN: Great; that would be great.

(Proceedings adjourned at 5:25 p.m.)

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