A2. Testimony of Kenzi Karasaki (referenced in Chapter 2). Excerpt from Hearing Transcript, Vol. 39, *Petitions of the Keweenaw Bay Indian Community, et al. on Permits Issued to Kennecott Eagle Minerals Company* (Michigan Department of Environmental Quality, July 15, 2008). (electronic only)

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.

APPEARANCES:

For the Petitioner Keweenaw Bay Indian Community:	MR. ERIC J. EGGAN (P32368) Honigman Miller Schwartz and Cohn LLP 222 North Washington Square, Suite 400 Lansing, Michigan 48933-1800 (517) 377-0726

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 title 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 B-2 --
A Yes.
Q -- of the environmental impact statement? And did you review Appendix B-3?
A Yes, I did.
Q And did you review Appendix B-4, 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 People versus Figgure, 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. Well, better yet, right at here the old -- the oil industry calls "sand phase" but it's not sand -- rock phase right here; that's where we want to monitor the pressure. But the -- typically it depends. This schematic shows it's monitored here. There's plumbing here that can constrict water flow that you can actually be monitoring the pressure in this inner pipe, not out here (indicating), which where we -- use our -- base our analysis on. And other things, it's similar. There can be well bore near well bore heterogeneity like this constriction in the fracture, or something gets stuck like a drilling might or cuttings that get stuck in near well bore. When you do well test -- I mean slug test 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 -- has 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 damaged 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 crushed 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 characterization. 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 have to 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 caliper. 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 caliper. 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 outpour 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 ten-meter 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 the 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 "resistors" -- basically the knobs one could tweak in the model, and --
Q What do you mean by "tweaking knobs"?
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 the 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 bound 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 this 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 knob 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 knob, put it back. Let's go to another; tweak your knob 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 knob, 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 tested 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 they 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 knob 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 and 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 "Y" 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 If it's from my report.
Q Yes.
A And again, I lifted the whole -- this whole slide from Mr. Wozniewicz's presentation. Maybe it was --
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 total 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 bluish 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 well 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 but --
Q What do you mean by "here"?
A "By here"? Probably to 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 as 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 permeability 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 have 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, "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 gpm 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 happily 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 a 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 on -- 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 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 rubblized 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 rubblized 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 rubblized 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 at 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 at 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 at 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, radionucleids 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 surprises 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 they were older 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.

MR. HAYNES: 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, 04EA-73 and 04EA-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 04EA-47, 04EA-54 -- and that's the one we're talking about and another -- and 04EA-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 slide 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.

(Off the record interruption)

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 he 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 your 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 more accurate term.
Q Okay. Well, that's -- and you're the hydrologist, I'm not. But it's your understanding, sir -- tell me if I'm wrong -- that 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

roughly 10 to the 7th difference in terms of numbers, permeability of 10 to the minus 17 is, I think -- again, I can get corrected -- but 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 following 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 B-2, page 21, about a sentence that talks relating to hole 83 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 B-2, 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 the objection.

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 would 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 B-2, B-3 and B-4, --

A Yes; 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 direction for heat-pulse flow meter, nobody is going to call it a pumping test. But if you had a pump in there and you switched it on, then 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: