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

D R A F T T R A N S C R I P T

HEARING - VOLUME NO. XXIV (24)

BEFORE RICHARD A. PATTERSON, ADMINISTRATIVE LAW JUDGE

Constitution Hall, 525 West Allegan, Lansing, Michigan

Tuesday, June 10, 2008, 8:30 a.m.

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Lansing, Michigan

Tuesday, June 10, 2008 - 8:41 a.m.

JUDGE PATTERSON: Mr. Lewis, are you ready?

MR. LEWIS: Yes, sir. Intervenor calls John Wozniewicz.

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

MR. WOZNIEWICZ: I do.

JOHN WOZNIEWICZ

having been called by the Intervenor and sworn:

DIRECT EXAMINATION

BY MR. LEWIS:

Q Would you state your full name and spell it for the record, please?
A John Wozniewicz. The last name is W-o-z-n-I-e-w-I-c-z.
Q And John is J-o-h-n?
A Yes.

JUDGE PATTERSON: That's the easy one.

Q Mr. Wozniewicz, you're a hydrogeologist; is that right?
A That's right.
Q And you work with Golder Associates?
A Yes.
Q And you've done work on the Kennecott Eagle Mine project?
A Yes.
Q And your area of work in relation to that project has been

on the characterization of the bedrock above the mine and the gathering of data and testing for purposes of predicting the amount of water which might flow into the mine?
A Yes.
Q And I believe your colleague, Mr. Zawadzki, is going to testify perhaps today as well. Could you briefly characterize the division of labor there or the work that you did in relation to the work that Mr. Zawadzki did in terms of this hydrogeology work?
A Yes. So my role was I was responsible for the design and collection of data to characterize the hydraulic properties of the bedrock and also to develop conceptual models with my colleague willy Zawadzki. So we both were involved in the development of the conception model. And Willy took the data that we collected and input it into the model to predict inflows.
MR. LEWIS: And if we could show slide one.
Q Is this a summary of the topics for your testimony today?
A Yes.
Q And what are those?
A First I'll have some introduction what -- from the industry standard perspective what are important components for development of reliable groundwater models. Second I'll talk about some terminology to set the stage for the work that we did. And then I'll basically go in a sequential

order for -- chronologic order for how the work was performed. First, was the selection of the data that was used for selection of roles for the -- to be used for the collection of data on the site. And we did a phase 1 field investigation, and then based on that phase 1 field investigation we developed a preliminary model and looked at -- based on that phase 1 we looked at areas that were sensitive to inflow predictions and we used that to guide additional -- to design the next phase of investigation, which is a phase 2 investigation. And then I'll be talking about the -- after we collected the phase 2 investigation we compared the preliminary model with the additional data to see if it was consistent. Then we refined the model. And that's it.
Q And before we start down that road then I want to talk to you a little bit about your background, Mr. Wozniewicz. I guess we could start with where do you currently live and work?
A I currently live and work in Calgary, Alberta.
Q Okay. How long have you been in Calgary, Alberta?
A Five years.
Q Where were you before that?
A I was in Denver, Colorado.
Q And prior to that?
A Prior to that I was working in Europe in England and

Switzerland.
Q And were you -- where were you born?
A I was born in Pennsylvania.
Q And would you review for the court, please, your educational background?
A Yes. I received a Bachelor of Science from Slippery Rock University.
Q Where is that?
A That's located in Western Pennsylvania near Pittsburgh. And then I received a Master of Science degree from Eastern Washington University with a hydrogeology thesis.
Q And your bachelor degree -- I'm sorry -- did you say it's in geology?
A It's in geology. Yes, it is.
Q And do you have a -- some professional affiliations?
A Yes.
Q What are those?
A Yes, I'm a member of the National Groundwater Association. I'm a member of the International Association of Hydrogeologists, member of the Society of Petroleum Engineers, and a member of the Canadian Society of Petroleum Engineers.
Q And you've been with Golder Associates since when?
A Since 1989.
Q And could you briefly describe what you've done at Golder;

what have been your responsibilities since you started there up to the present time?

A Yes. So the first four years of my career I was primarily working on government sites in Idaho and Washington for characterization of contamination in the groundwater system from low-level radioactive waste. And then in '92 to '97 I worked in Europe on bedrock characterization programs for proposed nuclear repository sites in England, Switzerland, Germany and Hungary. My title would probably have been the -- would be test engineer responsible for the design, the performance interpretation of hydraulic tests and for the conceptualization of the bedrock fractured system or the plumbing system that controls groundwater movement in those systems.

So in '97, '98 I transferred to Denver office and I worked on a variety of projects, again, continue with the nuclear repository program, some in the U.S. in North Carolina. I had some work on and started to work more on mining projects, because Denver was more of a mining-based office. And then in 2002 -- 2001 I worked -- I moved to Calgary, Alberta and -- where I'm currently. My title in the office -- we have a 25-person hydrogeology group. I am one of the -- we have an associate in principal system in Golder. I am one of those associates and one of the persons in our group with signing authority for all the technical

reports that leave our group. So since in Calgary I've worked on quite a few mining projects where I've been the lead for the data collection and characterization of bedrock systems.
Q Have you had some experience also working in and below, around bodies of water, Mr. Wozniewicz?
A Yes.
Q Could you give us some examples of that, please?
A Yes. One example is work we did off the coast of Singapore for a proposed underground cavern for storage of liquid natural gas. It was under the ocean bed. Again, we were looking for the hydraulic properties around that proposed cavern to see, evaluate the connection between the cavern and the ocean above. Another job site where I spent a year and a half was -- basically on a year-and-a-half secondment full time to the Diavik Diamond Mine, which is a mine basically under a lake. The bedrock comes right up to the lake and that's an existing mine.
Q Is this is a list of some examples of your relevant experience, Mr. Wozniewicz?
A Yeah, this is a partial list. This is actually sites where I -- to say I got my hands dirty. I was actually at the sites for periods up to a year, a year and a half. Again, in charge of the design, the performance, interpretation of data and understanding the plumbing system of a fractured --

in a fractured rock setting. And Eagle is considered a fractured rock setting, because the majority of the groundwater flow occurs in fractures. So again, these are just sites where I was physically on the site and got my hands dirty in charge of the performance of the program.
Q And you have these examples listed under various headings including "Mining," "Tunneling," "Nuclear Repository," "Water Supply," and "Oil and Gas Projects"?
A That's right. And all these different disciplines have different disciplines -- I mean, different emphasis to the system. The oil and gas; what you're mainly looking for is high permeability zones or sweet spots to put your well to maximize oil production. And then you're also looking for low permeability sections in the reservoir for secondary recovery where you want to put an injector well and inject water to force the oil from the matrix to the well. The nuclear repository, you're looking at -- there's a -- you want to try to find a place to put the proposed cavern in a relatively low permeability rock, so basically you're -- the emphasis is hydraulic properties in the vicinity of the cavern.
So you have hydraulic isolation for a relatively long time. They keep it isolated from the environment. And then mining and dewatering properties; again, you're looking at characterizing the hydraulic properties around the

openings, which are sensitive to inflows. And also conductive features that connect to the openings and how those features connect away from those openings and their properties.
Q And if we could go to slide 3, I believe this represents an example of one of the projects you've work on under a body of water; is that right?
A Yeah, this is just -- this is a typical rig they might use at Eagle, a quarrying rig, and we -- you drill these basically inclined and then horizontal wells out under the ocean, and the idea is you're testing the hydraulic properties to look at the properties near the cavern and the connection between the proposed cavern and the ocean above.
Q And what was that -- what was the purpose of doing that in this project?
A This is a proposed liquid natural gas cavern off the coast of Singapore. So Singapore doesn't have much resources; they're looking for storage capacity.
Q And I'd like to turn next to a brief review of your reports. If we could go to the next slide. Is this a list of the various Golder reports that you've been involved with creating?
A Yes. Yes, I was -- I think all I signed as -- I helped the reports but I also helped review all the reports, but company policies you -- if you have a part in the report you

cannot be the official reviewer of the report, so we had somebody outside the project as an outside reviewer for the report.

Q Okay. And could you briefly review what these reports are and what the purpose of the report was?

A Yes. The first one was -- it summarizes the Phase 1 field investigation that was done, I believe, in 2004. The second report, it's summarizes the Phase 2 field investigation that was done the following year. The next report provides kind of a chronological development of the model from the Phase 1 to Phase 2 investigation and gives predictions for inflow. And then final report, which I was principally one of the reviewers on, updates the model to include the new permitted mine level, 327 and a half, and also it updates the stress induced permeability affects in the model.

Q And is that the work that Trevor Carter did and testified about earlier?

A That's right. Input from Trevor went into that model.

MR. LEWIS: And I believe for the record that that was Intervenor Exhibit 591 that was previously entered. No, it was 592.

Q And then if we could go to slide 5 we'll turn to, I think, the first topic you had on the list we talked about earlier, which is the components for the development of reliable models and could you explain what those components are in the next few slides, Mr. Wozniewicz?

A Yes, I can. So if you can go to the next slide. So there's -- in the literature there's two general aspects in developing models, especially for fractured rock, that are commonly cited. One is the -- one is the integration of data. So for -- especially for fractured rocks you want to develop your model based on different types of data, because each data type is sensitive to different parts of the system, and so you want to bring all the data together and kind of use the concept of converging lines of evidence. And this kind of -- this graph kind of illustrates this concept.

And if you look at -- we talked -- if you consider, for example, faults. I put that in the geology. Faults can have a wide range of potential hydraulic properties. So to kind of constrain the likely hydraulic properties of a fault you need to compare it with all the other types of data. And so we're -- all the other types of data you have maybe a small range for hydraulic properties of faults and you want to use the concept of converging lines of evidence. So that's one concept for development of reliable models.

The next concept is more of a -- next slide please. So you want to develop these models in a logical progression so you can allow for checking of the model as you collect data. And so basically have initial data collection and then based on that initial data collection you develop some preliminary models and you look for data gaps where you need to get additional data to increase the certainty. And then you collect an additional round of data and you check that preliminary model. Does that preliminary model make sense with the new model, or do you need to refine the model? So then after you collect the additional data, you compare that preliminary model to the second -- to the additional data and then you refine that model accordingly. And this process basically will continue -- typically continues through the life of the mine.

Q And before we go on, could we go back to the last slide a moment, Mr. Wozniewicz? And I just wanted to ask you to explain a little more the other components you have in this figure. You talked about the geology, but how did the other components relate to this integration you're talking about?

A So these are the components that we use to -- that we -- the model that we developed was consistent with the data that we collected on the site and these are the different types of data that we collected on site. So we didn't rely on one type of data in isolation. And we have water quality samples, we have packer testing and pump testing and we have flow logging, and then we also have the geology. So we tried to develop -- our model was developed to be consistent

with all those types of data.
Q And if we go on I think to slide 8, that's more explanation of the flow of the work plan; is that right?
A Yeah, this kind of gives a chronological development work flow of the model, and it's Figure 1.2 in the report. And we have basically a Phase 1 investigation where we collected a lot of flow logging data and packer testing data to determine the spatial distributions of properties in the area that are most important for mine flow predictions in the area of the proposed major mine workings. We developed a preliminary model, then we -- also we had some additional geotech data that we can compare. We got some structural data in the core holes that were used for the investigation and we could compare that structural data with the hydraulic properties to see if those structures were important in the core.
So based on our initial review of the data we decided we needed to get some water quality samples, we need to get some pump tests to get the large-scale properties and we needed to get monitoring that worked to look at the vertical gradients. So we had a Phase 2 round of investigations. Then we checked the preliminary model against the newly collected model and -- that was developed in Phase 1; we refined the model. And then we came up with our inflow predictions, which basically was the

responsibility of Willy Zawadzki.

Q Okay. And then the next slide please. Is this some quotations from ASTM standards?

A Yes. Yes.

MR. LEWIS: And by the way, for the court's reference that's Intervenor Exhibit 632 and Dr. Prucha earlier in his testimony referred to these ASTM standards and that's what the source of this is.

Q So could you explain this, please?

A Yeah, these are just --

MR. HAYNES: Your Honor, before the witness continues, I think counsel has mischaracterized Dr. Prucha's testimony, but we'll get into that on cross-examination. But I want to know for the record that -- I think Dr. Prucha did not testify about these ASTM standards.

Q Are these the ASTM standards that apply to the work that you've been talking about here?

A Yeah, these are -- I mean, these are standards. These are consistent with what we done, industry standards, what we follow. And basically it talks about -- you do a lot -- you do a lot of packer testing and flow logging. You do packer testing and flow logging across your site, establish where the low and high permeabilities -- relatively low, relatively high permeability zones are across your site, and then you do -- you like to do pumping tests on the

relatively high hydraulic conductivity zones to look at larger scale properties away from that well, away from that -- where the well intersected that feature.
Q Okay. And in your work here did you follow this basic methodology?
A Yes. Yes, it's more of an industry standard. Yes.
MR. LEWIS: I'd like to offer this exhibit, your Honor. Intervenor Exhibit 632 is this ASTM article and standards.
MR. HAYNES: No objection.
MR. REICHEL: No objection.
MR. EGGAN: No objection, Judge.
JUDGE PATTERSON: Okay. No objection it'll be entered.
(Intervenor's Exhibit 632 received)
Q And if we could turn then next to the next topic on your outline earlier, and that's to explain some terminology and some of that you've already been using. Let's go to the next slide and start with explaining what this term "hydraulic conductivity" means, Mr. Wozniewicz.
A Yeah, "hydraulic conductivity" is an indication for the transmitting capacity of the rock. And we got -- it can range over ten to fifteen orders of magnitude and where -- when I go through my presentation I'm going to use this relative reference for the different ranges of hydraulic

conductivity. And basically very low hydraulic conductivity is considered 1 times 10 to the minus 10, 1 times 10 to the minus 13 meters per second. Low hydraulic conductivity is considered 1 times 10 to the minus 7 to 1 times 10 to the minus 10 meters per second. Moderate hydraulic conductivity is 1 times 10 to the minus 4 to 1 times 10 to the minus 7 meters per second. High hydraulic conductivity is 10 to the minus 2 to 1 times 10 to the minus 4 meters per second. And very high hydraulic conductivity is greater than 1 times 10 to the minus 2. And that's kind of a relative scale for hydraulic conductivity that I'll be referencing throughout my presentation.

Q Okay. And just for point of reference, the first two there, the very low and the low; would that kind of hydraulic conductivity -- can that supply a domestic well?

A Yeah. I mean, there's generally a couple factors, but -- that go into flow, but generally if you're -- for a domestic well if it's completed in rock with this hydraulic conductivity wouldn't supply enough water to support a single home user.

Q And I think at this point we want to discuss and explain a little bit these terms you've been using: "flow logging" and "packer testing," and you prepared a little animation of that I believe?

A Yes, I did.

Q And I'd like to show that at this time. Before we see that could you go ahead and explain what the term "flow logging" means and what "packer testing" means?
A Yes. "Flow logging" term is a general term for -- geophysical logs are used to locate higher conductive features in the borehole. So typically in fractured rock there's a lot of fractures and there could be some structures, but many of them don't contribute significant groundwater flow to the system. So you want to locate those features that contribute measurably more water than the background.
Q Go ahead and explain "flow logging" please -- or do you want to use the animation at this point?
A Yeah, if I can talk with the animation it may be more clear.
Q Okay. Let's do that.
A So if you could restart it. So we get a lot of fractures in a typical system, but only a few may be contributing water greater than the background. So we put a pump in here and we create a stress and where the zones of measurable inflow come into the borehole you get a change in temperature, fluid resistivity; because the water coming in from those features is different than the water quality in the borehole. And then we run these geophysical logs up and down the borehole and where they pass a local zone where water is coming in the borehole you'll get a deflection and

maybe temperature resist -- fluid resistivity or velocity. So after they run these tools you produce these logs that are basically a variation of properties along the borehole. And where you have these local zones of higher inflow you'll get a deflection in the logs. So those are zones that we would want to concentrate on for subsequent packer testing.

Q This is flow logging?

A This is flow logging. So in this demonstration example we basically have low permeability rocks. Even though we have a lot of fractures, most of them aren't contributing much flow -- groundwater flow. We have one feature at the bottom of the borehole that's contributing measurably more flow than what I call the "background." So you have a lot of fractures but they may be disconnected and they're not -- they don't do much as far as groundwater flow is concerned. But you -- so what you still -- so in this case what we want to do is focus in on that part of the borehole to characterize the hydraulic properties, because we want to learn about the large-scale connection hydraulic properties of that conductive feature that's contributing water into the borehole.

But we'd also want to do packer testing to -- as confirmation that the zones above this feature are relatively low hydraulic conductivity. So this is basically -- so in Phase 1 you do the flow logging, and then -- the next animation please -- is packer testing. Packer testing are these inflatable bladders that you run. You want to encompass that conductive feature. You inflate them with nitrogen and isolate that section of the borehole. And then what you do is you displace water from the tubing and the rate of recovery gives you an indication for the hydraulic conductivity of the rock. So in this case we isolated -- we have good confirmation from the flow log and we isolated this feature, we came up with moderate hydraulic conductivity.

But again, you still want to confirm the zones above that flow logging said weren't hydraulic conductivity with additional packer testing. So here we isolate the zone above, and again, the recovery is fairly slow and it's just relatively low hydraulic conductivity for that rock consistent with the flow logging.

Q Is that the recovery of water after it's pumped out?

A That's right. And basically we did all of our testing -- most of these -- preliminary testing was slug test where you basically displace a volume of water and watch it recover. And basically in relatively low or mod -- you can perform those tests in relatively low or moderate hydraulic conductivity zones. When you get to the high hydraulic conductivity zones one you displace the water you get instantaneously -- instantaneous recovery. And we didn't

find any of those type of zones in that packer testing we did. So it was all relatively -- you displaced the water and you had at least ten minutes for the recovery to -- for the water level to recover back to static conditions.
Q So is the so-called slug test like the packer test, but you're not packing out away from it?
A So packer test is where you isolate a specific zone and a slug test is a test you perform in that isolated zone to determine the hydraulic properties. So basically you do the flow logging to give you indications of where the conductive features are in the borehole, and then you confirm that with packer testing, and then the final test is you look where you're conductive features are in the borehole; you'd isolate them for large-scale, large striation pumping test.
Q Long term?
A Long-term pumping test.
Q Okay. And is that the methodology that you followed in your work for the Eagle project?
A Yes, it is.
Q And I think the next slide you've got a photograph of how these tools look that you used in your --
A Yeah, this is just a photograph of a packer. So we've got a -- we basically have a rubber bladder here and these are the lines going to the packer. A nitrogen line, you hook that up to a nitrogen bottle at the surface and you inflate

those packers. And what they do is they isolate a zone in the borehole. And the key is for doing this -- these are discrete testing as you can correlate your results with the geology. So by breaking the system into small increments, small intervals you can compare the hydraulic response to the geology. So if you have a fault in the zone you can say it's conductive or not conductive. So and if the fault is not conductive, then it may not be of a concern; if it's conductive, then you may look for other faults in the area.

Q So faults -- the term "fault" does not imply that the zone is necessarily conductive?

A No, "fault" is just a geologic description and faults can have a range of hydraulic properties.

Q And I think the next slide takes us to the next topic, which is your description of how the boreholes you used for your studies were selected, Mr. Wozniewicz.

A Yes.

Q Could you describe that for us, please?

A Yes. If we can go to the next slide. This is a slide from Trevor Carter's report and it just gives you a feel for the dimensions of the orebody. The top one is looking west and it's a south-north cross section. And the dimensions of the -- it's about -- the mineable orebody's about 275 meters in an east-west, 80 meters at the widest point north-south, and 240 meters in the vertical direction. We basically have three main rock types, which are the host rock, the metasedimentary rock. We have the peridotite. And then we have the sulfides and massive sulfides. And we also have some hornfels at the contact zones. So these are the dimensions of the orebody. We've got three main geologic units. If you can go to the next slide, please.

So we used -- so here again is the summary. We've got the host rock peridotite, semi-massive and massive sulfides. The main structural grain at the site is basically east-west. We have these -- the orebody's elongated in the east-west direction. We have east-west dikes. We have contacts between the orebody and the dikes and the host rock. And then there's one possible northwest-southwest fault that intersects the orebody that was hypothesized early in the program based on the shape of the orebody.

Q I think you said "northwest-southwest," but it says "northeast-southwest"?

A Northeast-southwest. Sorry. Thank you. So the fracture data -- the pattern of fractures is similar and it's dominated by basically a subhorizontal fracture set.

Q "Subhorizontal" meaning what?

A Between horizontal and 45 degrees.

Q So closer to horizontal than vertical?

A That's right. And there's also a steeply dipping fracture set that -- again, it's consistent with that main east-west structural grain at the site. We like to -- we located the boreholes near the major mine openings where the hydraulic properties have the most significant impact on predicting mine inflows. So we located boreholes near the major mine openings. And we also wanted to test over the range of the elevation for the proposed mine, so -- which is basically a depth of between 100 and 300 meters from ground surface. So we've got the main structural grain, which is east-west. We have a possible fault that's more or less northeast-southwest. The background fractures; there's a lot of subhorizontal fractures.

Q   And then did you investigate through your characterization program all these various geologic units that you've identified: the potential structures and fractures and the dimensions of the orebody and the host rock, the peridotite?

A   Yes. All the boreholes went through the major geologic units. We covered -- the boreholes covered the range that was -- of the proposed mining. The boreholes were basically drilled -- most of the boreholes were inclined, so if you have these -- if you have these vertical structures you want to drill inclined to increase the possibility that you're going to insect -- intersect those potential conductive features.

Q   So this I believe -- this is a -- this was Intervenor

Exhibit 214, some slides, and I've noted here that Dr. Prucha used this in his testimony. In fact, we looked at every one of the slides in this exhibit. And can you describe what this shows in reference to what you're talking about now, Mr. Wozniewicz?

A Yes. The whole idea was to look at the -- get the background idea, the geology and structural geology and then design the boreholes -- or to do hydraulic characterization boreholes that intersect the potential conductive features based on the geology and structure geology. So on this diagram we have the traces of the boreholes used in the hydro -- bedrock hydrogeological investigation. This is a plane view map at the 275 mine level, so we're looking down at the 275 -- if you took a slice at 275 that's what we're looking down at.

Q It would be somewhat above the permitted crown pillar top right now, the 327.5 view?

A That's right. That's right. And these lines are -- these dashed east-west lines are basically the bounding structures for the orebody. The orebody is within those two dashed lines. Outside those dashed lines are -- to the north and to the south are the host rock.

Q Is that the peridotite or something else?

A That's the metasedimentary rock.

Q Okay. So is the peridotite within the dashed lines as well?

A Yes.
Q And then the orebody is within that?
A Correct. Correct. So most of the -- most of our boreholes are going east-west -- I mean, going north-south to try to intersect potential conductive features. Again, the main structural grain is east-west, so most of our boreholes are north-south with the intention of trying to intersect those potential conductive features. One of the boreholes is drilled east-west with the intention of intersecting any faults that -- or other structures or other potential conductive features that are oriented north and south.
Q How many boreholes are reflected on this?
A Nine boreholes.
Q And those are the red lines again; right?
A Those are the traces of the boreholes and they're -- because they're inclined -- if it was vertical you would just see a dot, but because they're inclined you see the traces of the boreholes.
Q And you've got one way over there to the right. Can you explain that one?
A Yeah, this borehole was basically put in after the Phase 1 investigation. We needed some data out towards the proposed ramp or decline, so we put one out towards the east and we used that for monitoring during the pump test to allow us to assess the hydraulic properties from the pumping zone

towards the decline.
Q And the structures or the dotted lines shown on this figure, what's the source of those?
A Those are Kennecott geological reports.
Q And the red lines; what's the source of those?
A Those are from -- Andrew Ware put those from his database.
Q And did you verify that they're in the proper location and orientation?
A Yes. I did a field check. Yup.
MR. LEWIS: Again, this was Intervenor Exhibit 214. Dr. Prucha reviewed these slides and I would -- but the exhibit was not offered, so I would offer this exhibit at this time.
MR. HAYNES: Just for clarification, just this slide or the entire 214?
MR. LEWIS: No; no. Entire 214. He looked at each one of those. We didn't need to show all of them. There are other plans used as you may recall, Mr. Haynes.
MR. HAYNES: What, in 214?
MR. LEWIS: Yes.
MR. HAYNES: I have it in front of me. Your Honor, I object to the entire 214 being admitted as this point, because this witness has testified in his presentation here of one of -- I think there are six figures in 214 and the figure that's shown on the screen here, which

is slide 16 of Mr. Wozniewicz's slide show is only one of the six figures in Kennecott Exhibit 214. So we haven't had this witness authenticate, describe, testify about the other five slides in 214. We've already seen portions of it, but they weren't -- as Mr. Lewis conceded, it was not admitted before nor offered before, so I object as to the other five figures in Exhibit 214.

MR. LEWIS: It's probably a minor point, your Honor, but I did note that Dr. Prucha looked at each and every one of those slides during his testimony. I've got the transcript page references here. And apparently Dr. Prucha relied on these and counsel led him through testimony about those slides. So I think that's sufficient to allow them into evidence.

JUDGE PATTERSON: I'll overrule the objection. I do recall Dr. Prucha's testimony.

MR. HAYNES: I'm sorry, your Honor. I didn't hear the last part.

JUDGE PATTERSON: I do recall that Dr. Prucha did utilize all of those.

MR. HAYNES: Thank you.

(Intervenor's Exhibit 214 received)

Q Now, if we go to the next slide I think that's another representation of the location and orientation of these boreholes, Mr. Wozniewicz?

A   Yeah, this is a isometric view looking north, and this gives you a sense for the density of the boreholes in the area of the major mine openings. Most of the boreholes are inclined. They go through the host rock, the orebody, and then on the footwall end up in the peridotite or the host rock to the south. So we're intersecting contacts with the orebody. We're intersecting major dikes that are east-west. Here's the borehole that we talked about, number 20, out towards the decline that we'll mention later that we looked for to -- we used that borehole to look at the hydraulic properties between the pumping zone and the decline. We also drilled one borehole -- this one 84 that was basically drilled east-west to intersect potential conductive features that are orientated north-south.

So we have a range of orientations to look for potential conductive features in the area of the major mine openings. So have north -- we have boreholes that are orientated north-south to intersect potential east-west conductive features, which is the main structural grain, and then we have one borehole that's striking basically east-west to intersect potential conductive features that are north-south in orientation. And we focused the boreholes around the major mine openings because that's where we considered the most significant impact for groundwater flows.

Q Dr. Prucha when he testified I think raised the possibility that there could be some vertical conduits for water next to the orebody or between the peridotite and the host rock. Do you recall that testimony?
A Yup.
Q And does your -- what you just talked about demonstrate how well you explored and characterized that area?
A Yes. I mean, all the contacts along the orebody and potential dikes, these inclined boreholes -- if you have vertical structures that are east-west or north-south, these inclined boreholes will intersect those structures. And we intersected the contacts between the orebody and the peridotite and the host rock at over ten locations, and then we looked at -- and I'll get into this during the Phase 1 investigation -- and then we look at the hydraulic properties of those contacts to see what the hydraulic properties of the contacts are.
Q Then I think we will turn to the next topic, which is a description of the Phase 1 investigation and what you did and how you did that, Mr. Wozniewicz?
A Yup. Phase 1 investigation; we did flow logging, which we demonstrated earlier, and packer testing. And what we wanted to do is try to identify the distribution of hydraulic properties and the possible -- for the conductive features their possible geologic controls. As part of the

flow logging we performed short-duration pumping tests in the -- over the entire open interval length for five of the boreholes. Packer testing we looked at over 3,000 linear feet of borehole, and flow logging we looked at over 4,000 linear feet of borehole.
Q How many boreholes did you use for the packer testing and the flow logging?
A Four boreholes were used for the packer testing, six boreholes were used for the flow logging.
Q And was that testing done in accordance with the ASTM standards that you referred to earlier?
A Yes. The sequence of flow logging, packer testing try to identify the conductive features that would potentially intersect the proposed mine workings and then perform a pump test then on that feature. So the work flow is consistent.
Q And I think your next slide discusses the general results of that Phase 1 investigation?
A Yes. So the Phase -- these are the results from the packer testing. All the intervals were low hydraulic conductivity, which if you refer back to that terminology is 1 times 10 to the minus 10 to 1 times 10 to the minus 7 meters per second. Except we had -- two results were very low hydraulic conductivity, which is less than 1 time 10 to the minus 10. And then we had one result which was moderate hydraulic conductivity and was consistent with the largest flow

anomaly. So we did flow logging. The largest flow logging anomaly was consistent with the highest local zone of hydraulic conductivity and that was moderate hydraulic conductivity. So during the flow logging we performed short-duration pump tests. We set the pump at 15 to 20 meters depth. We pumped from the entire open interval of that borehole. In two of the boreholes the sustainable rate from the entire borehole was below the lower limit of the pump, below 0.5 gallons per minute.

In the three remaining boreholes the pump rates -- pumping rate was between 0.5 to one gallon per minute. And those tests were performed for several hours with a drawdown of 15 to 20 meters. So the measured flow rates from those pumping tests when we compared were consistent with the low hydraulic conductivity that was measured during the packer test.

Q And I think the next slide continues the general results?

A Yeah. So we -- so again, the whole theme is to try to locate those features which are contributing measurably more water than the background of the rock mass. So we had -- one localized moderate hydraulic conductivity interval was located in the massive sulfides in the lower bedrock. So that one feature is the one that we focused on for the pump testing, because it was the highest local zone of hydraulic conductivity and it was the largest deflection or largest

flow logging anomaly that we encountered in those six boreholes.
Q And that was in the orebody itself?
A That was in the orebody itself; correct. And then after we did the -- after we did the testing we got information from -- we wanted to start to look at information from the geotechnical database, so we looked -- we got the boreholes intersected 18 structures as identified in the database. So we compared -- at the location of those structures we compared the flow logging and packer testing results. And I think the next slide shows you that -- sorry. That's okay. So we compared those -- where they found structures in the core and compared them to the measured hydraulic conductivity in flow logging and there's no correlation -- all the zones -- there was no flow logging anomalies and all the zones were low hydraulic conductivity.
Q Can you show -- describe while we're looking at this figure what it shows and what's on here?
A So this is from Tables 7-1 and 7-2, so this is -- again, you collect some data -- the process is you collect some data and then you develop a preliminary model. And so this was our attempt to, based on the data we collected, at this stage to develop a preliminary model. This is kind of a -- this is not all of the packer testing, but these are the -- kind of a synthesis of all the packer testing that was done

over large intervals. And so basically on the left-hand access is measured depth and on the right-hand is hydraulic conductivity. And it goes from basically 1 times 10 to the minus 7 to 1 times 10 to the minus 10, so that scale is basically the scale for what we're calling low hydraulic conductivity. So the test -- so the test in the upper part of the borehole showed a distinctly higher hydraulic conductivity than the test in the lower part of the borehole. So there seemed to be a change at about 90 meters depth.

Q That's below surface?

A Below surface. And so the average of those tests in the upper part of the borehole is approximately 2 times 20 to the minus 8 meters per second. The average of the test in the lower portion of the bedrock is 5 times 10 to the minus 5, so it's just -- we took -- basically took the measured data from all the packer testing, put them on this plot and based on that we developed a preliminary model which we called the "upper bedrock" which has a low hydraulic conductivity of 2 times 10 to the minus 8. Then about -- based on this data about 90 meters depth we have average hydraulic conductivity of 5 times 10 to the minus 5. So it was a preliminary model. We needed to collect some additional data to substantiate this model or refine the model, so this was after Phase 1 investigation.

Q You said 5 times 10 to the minus 5; is that right?
A 5 times 10 to the minus 10. Sorry.
Q Okay. And that's in what you're calling the lower bedrock?
A That's correct.
Q Okay. So that's how you derived then from these test results this division or boundary between what you're calling the upper bedrock and the lower bedrock at 90 meters below surface?
A That's correct.
Q And do you recall the MSL elevation at that 90-meter depth?
A I believe it's 345.
Q So in reference to the current permitted upper limit of mining, which is 327.5 meters, this is roughly 20 meters -- this division between what you're calling the upper bedrock and the lower bedrock is roughly 20 meters above that level?
A That's correct; yes.
Q And I think your next slide then summarizes -- earlier you had talked about that you found no apparent correlation between the 18 structures which have been identified in the geotechnical drilling program with moderate hydraulic conductivity, and I think this next slide is the table that you were referring to?
A That's right. We spent a lot of time trying to find conductive features, which are -- and the relationship to the geology. So we -- so after Phase 1 we only found two --

one -- two moderately -- one which we call a moderately hydraulic conductivity zone and that was in the sulfides. And there was another potential zone in the sulfides. So we -- the zones with moderate conductivity we only found in the sulfides. But we wanted to kind of look at it in another way is go -- we got the structural data from the geotechnical database and compared it to the measured properties. And because we're collecting discrete data we can go -- we can go to where these structures occur in the packer interval and see if there's any relationship between flow and structures identified in the core. And basically all the zones, when we compared them, they either showed no flow anomaly or a low hydraulic conductivity.

MR. LEWIS: And this is -- for the court's reference, it's a table we looked at earlier with Mr. Beauchamp when he testified. It was in one of his reports. And then I had also asked Dr. Prucha about this table during his testimony.

Q I think -- did you also as part of this -- and if I recall the earlier slide you had those colored circles, those four colored circles. Does part of this analysis include looking at regional geological data to see what's reported in the literature about the potential conductivity of this kind of rock?

A Yes. We try to find -- especially within the area of the

orebody we want to look at the regional geology of the structure, because that constrains what the local system is going to be -- fall within. So we want to -- again, the whole emphasis on those boreholes was try to drill them to intersect potential conductive features, so the measurements we got were representative of the hydraulic properties.
Q	I think in part because Dr. Prucha talked about some of the mines in the so-called "iron mining district" and others of petitioners' witnesses did as well I wanted you to ask -- I wanted to ask you about what you found in the literature in terms of this mining area. And I think the next slide describes that; is that right?
A	So the rocks at Eagle were -- if you would do any testing you would -- based on, you know, literature and experience the type of rocks, these metased, you would think that they're consistent with low hydraulic conductivity. But then we also looked in the historical data and these are quotes that are consistent with our results that bedrock, especially the host rock for the most part, is low hydraulic conductivity. And the first one is Exhibit 142 and it says -- there's not much information about the bedrock in that report, that summary report, because the bedrock is relatively low hydraulic conductivity and all the emphasis was on the overburden in this report. And bedrock in general it's only small quantities of water to wells.

Exhibit 141 says, "In field and laboratory tests the bedrock showed it to be generally very low."
Q It's low permeability?
A Low hydraulic conductivity, yup. And then the second lines says, "However, super capillary fractures and fissures in the iron formation greatly increase its ability to transmit water." So the iron formation is very different geologically from the intrusives at Eagle.
Q So the iron formation would be in effect the ore that's mined in an iron mine?
A That's correct.
Q Whereas here we have the sulfide rock orebody?
A That's right. The iron formation is a bedded iron oxide and chert and if you read through those reports it -- first of all, the primary porosity is -- the quote is, I believe, 30 to 35 percent and we -- the intrusive at Eagle has no primary porosity, so all the water occurs in fractures. And also the bedded iron formation has chert and they go through and they talk about the chert being permeable as one of the conduits for groundwater flow, and there's no chert in Eagle. So they're very different geologically and also from -- in terms of groundwater flow.
Q And that's in terms of the ore itself, the iron ore as opposed to the ore that we're looking at at Eagle. But in terms of the host rock surrounding these deposits, are these

papers talking about -- they're generally similar in terms of their permeability?
A That's right. I mean, the host rock is generally described as very -- the host rock next to the orebody is -- they quote as being very poorly permeable or low hydraulic conductivity and sometimes they even quote it as being impermeable next to the orebody.
Q And I think the next slide you have something about -- on the same subject I believe, Mr. Wozniewicz?
A This is more to talk about faults, you know, and the first one is from a book and the literature. And it just says faults can have a range of hydraulic conductive properties. And depending on their openness and the fill in between the fault. And the second line is from the literature from their experience is that a system of pervasive hydraulically connected faults is very rare. We also looked at for evidence that faults may be conduits for flow at historical mines, and basically from this Technical Report Number 3 it says no large open fractures have been reported in any of the operating mines, and they also say that although hydraulically tight faults are common, the super capillary fractures within basically the iron formation is transmitting water.
So basically in the literature we found no indication that faults are conduits for -- principal

conduits for groundwater flow at these historical mines in Marquette. And the last point on page three of that Technical Report 3 it says, "Where 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 glacial overburden." So when there -- where there's no -- basically where there's no subsidence there's no relation between pumping in the mines and the water level and overlying overburden, which says to me there's no vertical conduits in that -- in the area of the historical mines between the mine openings and the overburden to allow a direct connection. So there's restricted communication between the mine openings and the overburden.

Q And then these historical iron mines, how was that opening created generally?

A By collapse, by Legacy Mining methods my understanding is that the -- it was common to do cave type of mining where they actually tried to induce caving and subsidence.

MR. LEWIS: I'd like to offer these reference exhibits also, your Honor. We had included in our exhibits as Intervenor Exhibit 141 this so-called Technical Report Number 3 and as Intervenor Exhibit 142 a Michigan U.S. Geological Service report, "Water Resources of the Marquette Iron Range Area." And then I believe that's it. I would note for the record that the one -- the other report Mr.

Wozniewicz referred to, Technical Report Number 2 was earlier discussed by Dr. Prucha and I believe offered and admitted as Petitioner Exhibit 60. But we're offering Intervenor 141 and 142 at this time.

MR. REICHEL: No objection.

MR. HAYNES: Your Honor, could I have just a moment, please?

JUDGE PATTERSON: Sure.

MR. HAYNES: I've no objection, your Honor.

JUDGE PATTERSON: All right.

MR. EGGAN: No objection, Judge.

JUDGE PATTERSON: They'll be entered. Again, that was 141 and 142?

MR. LEWIS: Yes, your Honor.

(Intervenor's Exhibits 141 and 142 received)

Q And I think these next two slides -- this is another slide and this -- again, this is from the report that Dr. Prucha referred to, which was Petitioner's Exhibit -- Part 632 Exhibit Number 60 and I think it goes to this point you were making earlier, Mr. Wozniewicz, about the -- while the iron ore itself, those deposits are very much different than the deposit at Eagle that the host rock in fact is discussed in the literature as being very similar in terms of its permeability. So could you read what this says from this report, please?

A Yeah, this is a quote from the report. It says,

"Iron formation consists of somewhat porous ore, brecciated chert interbanded with more or less hydrated hematite and brittle unoxidized cherty siderite. The joining and brecciation of the chert make it permeable, probably a large measure permeable to the same degree of both parallel and perpendicular to the bedding; that is, it is hydrogeologically isotropic."

Q What does that mean?

A Basically the properties are the same in all directions. "Iron formation overlies stratigraphically some tens of feet of graphite slate which in turn overlies gray slate -- the formation underlies gray slate and in some places gray whacking. The beds stratigraphically adjacent to the iron are relatively impermeable, so the iron formation in which the mining must done is in large measure an aquifer included between impervious walls."

Q And the sulfide deposit at Eagle is not an aquifer?

A No. If you depend on your -- if you use the definition that an aquifer is -- needs to have sufficient water to supply a domestic water well from a water quantity basis, I would -- yes, I would say that it is not an aquifer from that standpoint.

Q And then I think --

MR. LEWIS: If we could, go to the next slide, please.

A So this kind of brings us up to the kind of in-between phase I and phase II investigations. So we developed some -- a preliminary model based on the data collection and phase I investigation. We needed some additional data to confirm or refute this preliminary model so -- but at the time to be conservative, when we developed the preliminary model, we only had local scale properties of that moderately conductive features. So what we assumed to be conservative at this stage, that that moderately conductive features was part of a pervasive, well-connected kind of fault system, and those faults were relatively long.

Q You didn't have data to support that?

A We didn't have data to support it so, when you don't have data to support it, you tend to be -- go on the conservative side. But we understood that that was sensitive to mine inflow, and that was the motivation to doing the pump test, to determine the extent and large-scale properties of that moderately conductive features. But at this stage, we've seen, to be conservative, that they were long and well-connected.

Q And then you made recommendations for additional data gathering?

A That's right. We needed to test that moderately conductive features to look at the connectivity of the large-scale properties of that feature. Because we knew it was sensitive to the mine inflows, but at this stage we were conservative. We needed to install a network -- a mining network to allow the assessment of vertical gradients and provide monitoring points during pumping. We needed to test additional data in the upper bedrock hydrostratographic unit. And then we also recommended to collect additional water samples to look at the change in water quality with depth. Because that profile would help us to -- also help us to develop a conceptual model of how the water chemistry changes with that.

Q And that takes us -- leads us into the phase II investigation, then?

A Yes, it does.

Q And could you describe what you did as that part of the work?

A So in three of the boreholes for the monitoring -- for the pump test, we installed these -- a monitoring system to look at -- to allow us to make an assessment of the vertical gradient.

Q When you say "a monitoring system" as opposed to the pumping location, --

A Yeah.

Q -- what do you mean, and how are those interconnected?

A So these are locations where we install piezometers.

Q Which are?
A Are -- they monitor basically water levels. They monitor pressure but -- which is -- it's the water level at that location. And we put one -- in three boreholes we installed one in the upper bedrock and one in the lower bedrock, the hydrostratographic units; at those three locations.
Q So you're not pumping at those locations?
A No.
Q And then are those to monitor what happens there when you pump at a particular location?
A That's correct. And also, those are -- monitor the conditions -- the relatively semi-stable conditions prior to pumping so we can make an assessment of the vertical gradient at the site. So we looked at those -- after we got the monitors -- these piezometers installed and after we allowed them to semi-calibrate, we looked -- we compared the -- basically the water levels between the upper bedrock and lower bedrock to get assessment of the vertical gradients for the site.
Q What do you mean by "a vertical gradient"?
A Whether -- at the site whether the water level -- there's no vertical -- where the water level is -- there's a -- the potential water gradient is going up, or there's a driving force down in the bedrock, or there's no driving force. So based on that data, we had one borehole that shows no

vertical gradient, one borehole that showed a small upward gradient, and one borehole shows a small downward gradient. And overall the data suggests there's a negligible vertical gradient for the site. That's how it was stated in the report. But we wanted to check that. As always, you need to do some consistency check with some other types of data. So we checked that hypothesis or -- based on the data, it suggests negligible vertical gradient. We looked at the chemistry for the site, and it shows a strong increase in total dissolved solids with depth. So the -- so in the upper bedrock, the TDS's are relatively -- I believe they're in the area of 100 to 300.

Q Unit?

A Milligrams per liter. And then lower bedrock we had a TDS of 3,000 milligrams per liter, so there's a significant increase in TDS with depth. So if there is a strong upward vertical gradient, that high TDS water from the depth would be discharging into the overburden, and you'd see some type of chemical fingerprint suggestion of that occurring in the overburden. There's no suggestion of high TDS water in the overburden. And also, the -- if there was an upward gradient, you wouldn't expect to see such a strong increase in TDS with depth. So the chemistry data is consistent with the negligible vertical gradient for the site.

Q So both the data from the monitoring gauges and the water

quality data are consistent in that respect?
A Yes, they are. And then we did one further thing. Again, we tried to check that vertical gradient with all the data, and we looked at the regional -- it was a qualitative assessment based on the regional -- the expected regional groundwater flow pattern. And basically we -- if you -- in a topographic-driven flow system where -- like at -- expected at Eagle, you have a relatively expensive uplands in the central part of the peninsula, and then you have a steep drop-off in elevation between the site and the discharge area, which is Lake Superior. So based on the expected regional flow patter, you would expect basically that it's -- the sites in the transition area where there's no vertical gradient or possibly there's a small -- it's in the recharge area. There's a small downward vertical gradient. So generally these -- this other piece of data is consistent with a negligible vertical gradient for the site.
Q I think there's a -- also a figure I wanted to show that's in your report -- the Appendix B-3 report, figure 10.4 on this point too that I wanted to ask you about. I think this graphically demonstrates this point, Mr. Wozniewicz. And could you explain what this figure is and what it shows?
MR. HAYNES: Excuse me. Just for the record, what page on Appendix B-3 are we talking about here?
MR. LEWIS: Figure 10.4.

MR. HAYNES: Thank you.

A So basically we took -- we looked at the vertical gradients from individual wells, but then we looked at the data collectively. You wouldn't expect the vertical gradient to vary much across the site. So we simply took the heads measured at the -- from the six monitoring locations and just did a linear regression. And basically this straight line is the best fit to the data based on that linear regression. And the dash lines are the 95 percent confidence intervals. So basically just taking the during any time and doing the best fit, the line is basically vertical, which is an indication there's -- would suggest there's negligible vertical gradient for the site.

Q And then I think we turn to the packer testing that you did in phase II, Mr. Wozniewicz?

A Yup. So we did -- in phase II borehole, we wanted to get some additional data for the upper bedrock. Again, from the preliminary model, we had a -- we said that the average of the hydraulic conductivity is 2 times 10 to minus 8 for the upper bedrock. So we did five additional tests in the upper bedrock. The average hydraulic conductivity of those five tests is 1 times 10 to minus 8 meters per second. So in comparison to the average previously, it's 2 times 10 to minus 8. So this additional data is consistent with the previous data and our conceptual model.

Q Meaning those two numbers are close?
A Close -- yeah, very close.
Q And so this is part of this iterative process that you described earlier?
A That's correct. So you collect some data. You develop a model. You collect some additional data, and you check your model, so that's very important for development of reliable models to allow checking of the model as you collect the data.
Q And I think next we'll turn to the additional water sampling that you did in phase II again.
A That's right. We attempted to do -- wanted to do pump tests in borehole 107 to get water samples, but the sustainable rate from those two zones was 0.16 gallons per minute, which is below what most submersible pumps -- below their lower limit. So we had to -- to get the water samples, we had to do a series of basically our slugs. Basically you displace the water, allow it slowly to recover and then do another slug to collect your water sample. So we had to do a series of those slug tests to get those -- to get water samples.
So we collected three water samples at various depths to understand the changes in water quality with depth. And the conclusions are that the dissimilarity between the water quality in the bedrock and the water quality in the overburden suggests there is restricted

vertical hydraulic communication. And that's consistent with the low hydraulic conductivity that we measured for the upper bedrock.

The second point is, in a bedrock with lower hydraulic conductivity, you'd expect that there is a higher resonance time and a correspondingly higher TDS. So if -- the decrease in hydraulic conductivity with depth is consistent with the increase in TDS with depth. And the final point is that the sample that we collected from that moderately conductive zone at the -- in the lower bedrock was 3,000 TDS, and it was much higher than the TDS of the overburden or the upper bedrock.

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.

Q And then I think you've got a description of your test design, then?

A So -- yes. The -- again following ASTM standards, we isolated the zone -- the local zone of highest hydraulic conductivity, which is moderate hydraulic conductivity for the pump test, and that was in borehole 84. We want to maximum the drawdown so, similar to the drawdown expected during mining, we monitored in the lower bedrock, upper bedrock and alluvium in all directions from the pumping well. And we ran the test long enough to basically look at hydraulic properties on the scale of the orebody. So the longer you run the test, the farther the radius of influence. So basically you're -- for the pump test, you're integrating the hydrogeologic conditions on the size of the orebody so that there's a scale influence.

Q And I think the next slide explains why that location was chosen?

A Again we -- yeah. So we were always looking for these conductive features, and in borehole 84 we got this clear -- this is from the flow logging data. We got this clear deflection in the logs to suggest that there was a -- there's a potential -- you always have to confirm it with packer test for a zone of measurably higher flow than the background. So we did our packer testing, and our packer testing also confirmed the flow logging that says that -- that showed that this zone was the highest localized zone of hydraulic conductivity, which, again, is moderate hydraulic conductivity. So that's how we selected the zone for the pumping test.

Q And I believe -- I wanted to review that, because Dr. Prucha had indicated he didn't know why we had tested this zone. But this explains the rationale, then?

A Yeah. And it's gone over in detail in the reports, the rationale why this particular zone was selected for pump testing.
Q And I think next we turn to the analysis of that data, Mr. Wozniewicz?
A Yeah. So the main result from this test was that we isolated the highest hydraulic conductivity zone that we found from packer testing from the pump test, and we pumped -- the sustainable rate, we pumped that at 1.6 gallons per minute and resulted in 196 meters of drawdown. That's a very significant drawdown. And it's consistent that -- so you have a low rate and a large drawdown, and that's consistent with low hydraulic conductivity for the bulk of the rock mass. Now, we did interpretation on the length of that conductive feature and, from -- in Willy's model we came up with a length of 145 meters for that conductive feature. Now, this -- if you look -- just look at the general trend of the drawdown and the pumping rate, the rapid decrease in pumping rate in drawdown indicates that this moderate conductivity feature is limited extent and, as a result, it drains relatively quickly. And so what you're relying on is drainage from the host rock, which is low hydraulic conductivity. So the feature is limited extent. We drain it. And because the host rock is such low hydraulic conductivity, you cannot respond fast enough to

keep up with the rate that you're pumping water out of it.
Q So is it -- in general could we conceptualize it as if we had the straw or a tube embedded within the rock and then we suck the water out of that tube?
A Yeah, or kind of a plane -- a flat planar feature. And it's limited in extent. It's not connecting to any other conductive features, so you're just draining -- if you use your analogy of the straw and -- the material on the outside of the straw is low hydraulic conductivity, and it can't respond fast enough to feed that straw, so you just drained that feature.
Q So does the high drawdown rate like you have here, 196 meters, does that indicate, then, the limited extent of this conductive feature?
A I think it's the low -- it's a combination of three things. It's the combination that it's the very low rate, the very high drawdown and the fact that the drawdown never stabilized. So if you have a system of connective features, you pump. The drawdown will stabilize. This drawdown was continuing to go down in almost a linear fashion, which, again, indicates it's limited of extent.
Q And again, is that consistent with the water quality data?
A Yeah. And the water quality data tells us something a little bit different. Again, it's this idea of data integration. Each data tells you a little bit something

different about the system. The high TDS of the water is consistent with relatively low hydraulic conductivity bedrock between that conductive feature and the up bedrock. So if these -- if this feature was well-connected to the upper bedrock, you wouldn't expect this high of TDS, or you'd expect an increase in trend with TDS as you're pumping or a decrease in trend in TDS while you're pumping.
Q And I think this next slide demonstrates more graphically this drawdown in this pumping well?
A That's right. So based -- you know, based on our interpretation of the packer test, we designed the pumping rate, assuming that the system was relatively well-connected. And we started up at a higher rate of --
Q Could you --
A Maybe I'll explain this diagram; sorry.
Q Yeah, let's do that too.
A So on the left-hand axis, you have drawdown from 0 to 250 meters, and the right-hand axis is time. So this pumping test was 7 days pumping and 7 days -- so we started pumping, and the water level drops in the borehole. At that point we turned off the pump and monitored the recovery. So if you have a low rate and the pumping level drops significantly, it's consistent with low hydraulic conductivity. That's the first point.
The second point is we started at this higher rate

but, because we were draining this conductive feature of a limited extent and the surrounding rock couldn't respond fast enough -- if we would have kept on pumping at that higher rate, we would have reached the -- basically the pump intake. So what we had to do is we kept on having to throughout the test decrease the rate, and then here we ended up at a rate of 6.1 liters per minute or 1.6 gallons per minute.

And this is -- so during that constant rate, you see a linear -- almost a linear drawdown response, which means it's not connecting to any other conductive features, and it's draining. And because the host rock is low hydraulic conductivity next to that feature, again, it can't respond fast enough, so you continue to drain that feature.

Q And is that basically what would be expected to happen if you cut through that feature -- cut an opening through that feature; that it would drain and then slow down when it runs out of water, so to speak?

A Yeah. For this particular feature, you would cut through it. It would drain, and then the rate -- you might get some water we call flush storage from the limited store activity, and then after that your -- the response is due to flow drainage from the bulk of the rock mass of low hydraulic conductivity.

Q And I think your next slide discusses what you call the three-dimensional response to pumping in that hole?

A Yeah. Here's our three-dimensional -- this is a plane view of the pumping test response. Basically these are traces of boreholes. This is the pumping test zone at 84, and these black points are monitoring points in the monitoring wells in the upper and lower bedrock. Again, here is the upper and lower bedrock, and out here is well 20, out towards the decline in the upper and lower bedrock. And then we also -- again, we were sensitive to the issue of vertical connectivity, so we also monitored throughout the program and during this pump test in alluvium, looking for potential hydraulic connection.

Q That's the so-called vertical connection that Dr. Prucha was suggesting?

A Yes. So this pump test, basically we pump. We measured about 196 meters of drawdown in the pumping well itself, and it was located in the lower bedrock, and it was located in the massive sulfides. Out to the west we also saw a fairly large drawdown of 83 meters. Again it was in the orebody, the sulfides -- the massive sulfides. And we also saw a good -- relatively high drawdown in the lower bedrock in the massive sulfide -- sulfides in well 77. So it indicates, in the lower bedrock between those three wells, that those -- that that moderately conductive features is well-connected, because you have such a -- a drawdown similar to the drawdown in the pumping well.

Out to the east towards the decline, we had a drawdown -- a much lower drawdown of .77 meters compared to 196 meters in the pumping well. And then in the upper bedrock we saw no drawdown, and that's -- that response is consistent with relatively low hydraulic conductivity rock between the pumping zone and the monitoring well. Now, vertically -- so horizontally in the lower bedrock in the sulfides in the three monitoring zones, we have relatively good connections.

Out to the east we had relatively small drawdown, relatively poor hydraulic connection, so we -- that's consistent with relatively low hydraulic connectivity material between the pumping zone and that monitoring zone out to the east. Vertically -- now, vertically we saw no response in the three wells installed in the overburden. We saw no responses in two of the monitoring zones located in the upper bedrock at distances greater than 230 meters. So we -- so basically that radius of influence is relatively small for the duration of the test, and it's also consistent with the relatively low hydraulic conductivity measured for the bulk of the rock mass.

We had one upper bedrock zone that had a very small response of, I believe. 0.39 or about 0.4 meters, and the -- and again, the relatively low drawdown in that upper zone is also consistent compared to 196 meters in the pumping well. It's consistent with low hydraulic conductivity material between the conductive feature and the upper bedrock. And it's also consistent with the water quality that we measured from the sample that was collected from that -- from the lower bedrock.

Q Meaning again you get this higher TDS with depth?

A That's correct.

Q And I think the next slide is -- I'm not sure this adds anything to what you just talked about but, if it does, please tell us what that is.

A Again, the blue is the mineable ore. These traces of the boreholes we used in our investigation, the red, are the -- are proposed mine workings. So I kind of tried to overlay the pumping test response on this isometric view, so those annotations are mine, but the figure comes from the report. So in the pumping well in the sulfides, we had a drawdown of about 196 meters. We also had a pretty good drawdown in the sulfides out to the west and relatively close to the orebodies out to the east.

The monitoring zone towards the decline showed a very small drawdown consistent with low hydraulic conductivity between the pumping zone and the monitoring zone. None of the overburdened wells responded. Two of the zones in the upper bedrock showed no response, and one zone in the upper bedrock showed a very small response compared to the pumping well. Again, collectively the data suggests poor hydraulic -- low hydraulic conductivity between the conductive feature and the upper bedrock.

Q And I think the next slide is your summary of conclusions from the pumping test, Mr. Wozniewicz?

A Again, the main point from the pumping test is that small rate and large drawdown for the most conductive feature we encountered in the boreholes during our investigation. It's consistent with low hydraulic conductivity with the bulk of the rock mass. And we did spend a lot of time -- we selected that zone based on the flow logging and packer testing results. And the monitored hydraulic conductivity zone that we did encounter isolated the pump test. It appears to be sub-horizontal, limited -- it appears to be constrained into the lower bedrock and local in extent. And the supporting data for that statement is that the high TDS in the well in this feature suggests that it's not well-connected to the upper transmission, which has much lower TDS.

We interpreted -- based on interpretation, we interpreted a line for that conductive feature to be 145 meters in length. 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. And overall the rapid drawdown indicates that this feature is of limited extent, that we were draining it during the pumping test and that the host rock couldn't respond fast enough to feed the water that was being pulled out of that conductive feature.
Q And next I think we turn to a few slides that describes how we went from this preliminary model to the next phase of the work?
A Yup. So again it's -- what we talked about, it's -- we used an interim process through the whole program to allow us to check the model. And we used -- so our first assumption about this conductive features in phase I, that these features were well-connected and relatively long extent, because we didn't have the test data to suggest the regional extent and connectivity of those features. So we were conservative, and we assumed that those features were long and well-connected. And so what we did is we took that preliminary model, and we simulated the pump test in Willy Zawadzki's model, so we pumped it at the same rates that were pumped during the test. So if that model -- that preliminary model was correct, you'd expect it to match the drawdown response.
Q Well, I'm sorry. The red line is the preliminary model?
A The red is the preliminary model. The blue is the measured data. So when we simulated that test with the preliminary

model, what you find is a much lower drawdown and a much different shape in the character of the drawdown. So basically a lower drawdown indicates higher -- you're overestimating the connectivity and hydraulic properties of those conductive features. And the fact that the drawdown is flat indicates what you would expect. Because if you have a system of pervasive conductive features that are well-connected, the drawdown stabilizes.
Q Again, that's what you assumed in the preliminary modeling --
A That's what we assumed in the preliminary model.
Q -- before you got the additional data?
A Before we got the additional data so --
Q And that's what the red line represents on this graph?
A That's what the red line -- so this is kind of where there's a handoff between Willy and myself. So what we had to do to better machine the pump test data is reduce the connectivity and reduce the length of the conductive features to better match the pump test data.
Q Which is the blue line on this figure?
A That's correct.
Q And that led then to the -- what you called a refinement of the conceptual model, and I think that's the next slide, if you'd review that, please.
A Yeah. So the bedrock model, based on the hydrogeologic

program, was that there's an upper bedrock to about 90 meters total vertical depth that has an average hydraulic conductivity of 2 times 10 to minus 8, which is considered low hydraulic conductivity. Below 90 meters the bedrock is considered -- the bulk of the bedrock outside the conductive features is considered also to have a low hydraulic conductivity of 5 times 10 to minus 10 meters per second. Now, the conductive features, based on interpretation data, are 145 meters in length. So we found -- we identified two potential conductive features in the packer testing, and then we did the pump testing that suggested those two features are connected hydraulically.
Q So there's really one?
A There's one. So we had one conductive feature. To be conservative, we added eleven conductive features into the model.
Q Eleven like that one?
A Eleven like the one that was encountered in borehole 84.
Q Even though the data did not show another ten of these?
A No, they -- that's correct. So to be conservative, we wanted to maximize the intersection between these conductive features and the mine work, so we orientated more south. So if these conductive -- because of the bulk of the mass -- of the rock mass' low hydraulic conductivity, if these conductive features don't intersect the major mine or

major -- the openings, they don't have a big impact on inflows, because the low hydraulic conductivity rock restricts inflow into the mine between the mine openings and those conductive features.
Q So you artificially made them go north/south for -- again to be conservative for the model?
A That's right; to maximize the intersection with the mine openings and to maximize their impact on inflows.
Q Whereas, what did the data actually indicate about the true orientation of the --
A The true orientation was more or less east/west. And then we also -- to be conservative, we also made these features verticals to enhance the hydraulic connection between the mine workings and the upper bedrock. Now, the pump test data and water quality data suggests that the zone isolated for pumping test is of limited extent and in poor hydraulic communication with the upper bedrock. And also, no moderate hydraulic conductivity zones were encountered in the upper bedrock in packer testing.
Q Which would indicate a lack of this vertical connection?
A That's in combination with the water quality sample from the zone that we isolated in borehole 84.
Q But nevertheless, you assumed one again to be conservative for the modeling?
A That's right.

Q And you assumed this vertical connection from where to where?
A We assumed the vertical connection from the base of the model, which goes well below the mine openings, to the contact between the upper and the lower bedrock.
Q And then I think we're on your last slide, which is a summary, Mr. Wozniewicz?
A Yeah. This is -- just provides a summary. We looked at the geology, and we designed -- the boreholes that we did are characterization work in to intersect potential conductive features. Boreholes were located in the area of the proposed major mine openings where the hydraulic properties have -- are most important for mine inflows. We developed the model in a logical progression that allows checking of the model as we collect the data, and it also helps us to guide additional data collection needs. We consider the model is self-consistent with -- we looked at the flow logging data, packer test data, pumping test data and water quality data.

MR. LEWIS: Your Honor, at this time I'd like to offer some of the report. First, in Intervenor Exhibit 7, which is Volume 2-A of the mine permit application, Appendix B-2.

Q And that's one of the reports you've been discussing, Mr. Wozniewicz?

A Could you say that again? Sorry.
Q Appendix B-2 to the mine permit application?
A Yes.
MR. LEWIS: And for reference also for counsel, that's in our Bates range 103859-104043. And the other report is in Intervenor Exhibit 7. And again for reference, that's Volume 2-A of the mine permit application, Appendix B-3 and, for counsel's reference, Bates range 104045-104408. I think we've taken care of that. And 382 -- Intervenor 382 is Mr. Wozniewicz's CV. That's been stipulated to, but I'd note that for the record.
JUDGE PATTERSON: That was 382?
MR. LEWIS: 382, your Honor. And then finally I would offer Mr. Wozniewicz's slides here as a demonstrative exhibit for the court's use, which has been marked as Intervenor Exhibit 634.
MR. REICHEL: No objection, your Honor.
MR. HAYNES: Your Honor, I don't have an objection to any of these with the understanding that Kennecott Exhibit 634, the slides today, are merely demonstrative and not substantive evidence.
JUDGE PATTERSON: Right.
MR. EGGAN: And I would maintain the objection that I had to this issue throughout.
JUDGE PATTERSON: Okay. I will note that, and

they'll be exhibits as offered.

(Intervenor's Exhibit 7, Appendix B-2 received)

(Intervenor's Exhibit 7, Appendix B-3 received)

(Intervenor's Exhibit 634 received)

MR. HAYNES: Mr. Wozniewicz, my name is Jeff Haynes. I represent the National Wildlife Federation and the Yellow Dog Watershed Preserve. I have a few questions for you on cross-examination.

CROSS-EXAMINATION

BY MR. HAYNES:

Q Before your work with the proposed Eagle Mine, had you ever been to the Upper Peninsula of Michigan before?

A No, I haven't.

Q And so before your work at Eagle you have had no practical experience with the rock formations and the hydraulic conductivity of rock formations in the Upper Peninsula of Michigan; true?

A No. I mean, I worked at other sites where the geology was similar.

Q But none in the U.P.?

A None in the U.P. specifically.

Q Thank you. And in reviewing your resume, you list several facilities that you've worked at. But the resume, at least from what I can tell, does not seem to suggest that you've worked in underground mines -- worked in a project that's

dealt with underground mines before; is that true?
A I've worked -- I've done a lot of testing -- some testing underground in underground mines --
Q I see.
A -- for -- yeah -- from the underground.
Q I'm sorry?
A From the underground.
Q I see. Your resume also suggests that you have no experience working in mines that are similar to the proposed Eagle Mine; that is, a nickel sulfide intrusion; true?
A I have not worked on a nickel sulfide type deposit before.
Q All right. Thank you. And your resume also suggests that you have not worked in a mine or proposed mine that is beneath a river like the proposed Eagle deposit flows -- or is below the Salmon Trout River; correct?
A Can you repeat the question, please?
Q Sure. I can rephrase it. That was probably five questions in one.
A Yeah.
Q You understand that the proposed Eagle Mine orebody is beneath the Salmon Trout River; correct?
A Yes; correct.
Q Your resume does not indicate, at least that I can tell, that you've worked in a mine or a proposed mine that is beneath a flowing river; true?

A I've worked in -- for a year and a half on a full-time basis on the secondment, the Diavik diamond mine, which is under a large body of water. And I was a year and a half secondment to the mine full time.
Q All right. And the Diavik diamond mine is now an open pit mine; correct?
A Open pit and underground. When I was there they were looking at feasibility for underground, but they have a proposed decline and they will be doing underground mining at the Diavik diamond mine.
Q Under the open pit?
A Under the open pit; that's correct.
Q Where there's a body of water; correct?
A Where there used to be a body of water.
Q In the open pit that was created by the mine?
A There used to be a body of water. The deposit was originally under a lake. And what they had to do was they had to build a dike around the deposit back to the shoreline and then pump out the water and then mine the open pit.
Q Oh, I see.
A So it's adjacent -- now it's adjacent to the lake, but used to be under a lake.
Q But certainly the Diavik diamond mine is not similar to the proposed Eagle Mine in the sense that there was a river flowing over the top of it; correct?

A It's much more extreme, because basically the Diavik diamond mine is in a bedrock and the bedrock connects directly under the lake. So there's no overburden, per se, so the mine is very close to -- the borders of the mine is very close to a large body of water, and the bedrock goes directly under the lake. So it's much more extreme in terms of potential for inflow.
Q I see. You're saying that there's no bedrock intrusion in this deposit for the Eagle deposit --
A No.
Q -- that's near -- let me finish -- that's near a surface body of water?
A There is a -- there is an intrusion, a kimberlite intrusion, which is where -- that hosts the -- that hosts the diamonds.
Q All right. Let's turn to the proposed Eagle Mine.
A Okay.
Q You understand that there is part of the intrusion appears at the surface near the Salmon Trout River; true? You understand that, don't you?
A Yes, I do.
Q Okay. So when you say that the Diavik mine is more extreme, and in fact we have intrusions in both situations -- right? --
A Yes.
Q -- that appear at the surface?

A Yes; that's correct. But there is -- yes.
Q All right. Thank you.
MR. HAYNES: With Mr. Lewis' permission, since we don't have an electronic version of the slides that Mr. Wozniewicz testified about, I'd ask that if we could go through the slides with his folks?
MR. LEWIS: Certainly.
MR. HAYNES: If we could go to slide six on Kennecott Exhibit 634? Thank you.
Q Mr. Wozniewicz, on slide six you testified about the various ways that you want to integrate the data, both from the geology and the flow logging and the water quality samples in order to reduce the uncertainty in the model; corr?
A Correct.
Q All right. And when you say you want to reduce the uncertainty of a model, what portions of the model are you trying to reduce the uncertainty of? Is it of the data that's the input, or something else in the model?
A The whole purpose is to develop a model that's consistent with all types of data. So if you have a model that's consistent with all types of data, then you have a model that you consider is reliable.
Q All right. Do you understand the standard methodology for conducting uncertainty analyses in mines?
A That would be for a question better answered by Willy

Zawadzki.
Q Oh, I see. So your testimony here about the integration helps constrain uncertainty is something that we really ought to ask Mr. Zawadzki about more than you?
A You can -- we helped to develop -- I helped to develop the conception model. And again, the idea of a conception model is to develop a model that's consistent with different types of data.
MR. HAYNES: Let's go to slide seven.
Q Mr. Wozniewicz, the book that you cite here, the Anderson and Woessner report from 1992, --
A Yeah.
Q -- you've listed five bullet points on slide seven from -- that you say were taken from this book; correct?
A No. We said in the text the general concept was taken from the book.
Q Oh, I see. You understand that there are ten steps in the model construction in the Anderson and Woessner book, don't you?
A Again, that would be better asked of -- Willy Zawadzki did the modeling.
Q I see. So you're not aware of the ten steps, are you?
A That's not my area of expertise. Mine is the data characterization conceptualization.
MR. HAYNES: Let's go to slide eight.

Q Mr. Wozniewicz, in slide eight you describe the steps in developing the model; correct?
A Correct.
Q All right. And I want to focus on about mid way down the slide on the right-hand side we have a box entitled "2005 Geotechnical Database." Do you see that?
A Yes, I do.
Q And the model was -- ed some of the data from that geotechnical database; correct?
A All the data that was used from the geotechnical base is in the report. It's in the Table 7.1 in one of the reports.
Q Okay. And the geotechnical database is the database at least for purposes of preparing the model, that's the database that has the 109 boreholes; correct?
A My understanding; correct.
Q And you understand, don't you, that our side of the room over here has never been provided the data from those 109 boreholes? You understand that, don't you?
A Correct.
Q And so if we were to try to determine -- let me back up. If we; that is, I and my experts; were to try to double-check your work or to check your work to see if it was accurate, we'd have to go in part to the geotechnical database; correct?
A No, that's not correct. The data that we use from the

database is in the report in Table 7.1 that we cross-check the hydraulic properties against.
Q Which report? Is it Appendix B-2?
A It's the -- it's in Appendix B-2. It's the -- excuse me.
(Witness reviews documents)
A It's basically on slide -- the table I'm talking about is on slide 23, and it's the Golder report it comes from is --
Q Table 7.1?
A Yes.
Q All right. And that's found on page 33 of Appendix B-2; is that right? Do you have that appendix in front of you?
A I have the report in front of me, so it's Table -- the report is bedrock Hydrogeological Modeling to Assess Inflow for the Proposed Eagle Project. And it's Table 7.1 Entitled Comparison of Structural Data with Hydrogeologic Data.
Q That's not in B-2, then. I just want to make sure we're on the right -- we're all on the same page here.
A Yeah.
Q Give me the name of the report again.
A Bedrock Hydrogeological Modeling to Assess Inflow to the Proposed Eagle Project.
Q And what's the date of the report?
A It's in 2006.
MR. HAYNES: Your Honor, I'm sorry. I have to take about a two-minute break here just so that I can locate

that report so I'm on the same page as the witness. Would you allow me?

JUDGE PATTERSON: Oh, yeah; sure. Go ahead.

(Off the record)

MR. HAYNES: Thank you, Your Honor. I appreciate it.

Q Mr. Wozniewicz, I just wanted to double-check that where Table 7.1 was in Appendix B-4.

MR. HAYNES: And just for the record, it's on the 33rd page of DEQ Exhibit 33.

Q But it's also on your slide 23, so could we go there, --
A Sure.
Q -- slide 23?
A Uh-huh (affirmative).
Q Now, Mr. Wozniewicz, for Table 7.1, you say this is the table that contains data that you derived from the geotechnical database; correct?
A That's correct.
Q So if my experts and I wanted to check to see whether the depths indicated on this table and the lengths of the structure and the type of structure were correct, we'd have to go to that database; correct?
A That's correct.
Q All right. And that's
A Knowing that -- yeah.

Q And you understand we don't have access to that database?
A And the structures weren't important.
Q But you understand we don't have access to the database?
A Yes.
Q Okay. And if we wanted to -- there are five holes noted on this table; correct?
A Correct.
Q 47, 54, 73, 83 and 84; correct?
A Yeah.
Q All right. And so if we wanted to check nearby holes to see if these structures continued throughout the geology in the area, we wouldn't be able to do that, would we, without looking at the database?
A The structures we found were not significant from a groundwater flow standpoint. But you're correct in what you just said.
Q All right. And even if we wanted to determine whether your statement is true that the structures here are not significant from a groundwater flow basis, we still wouldn't be able to do that without looking at the database, would we?
A That's false. You can look at our reports, you look where the conductive features are cored in the boreholes and you can cross-check it against the flow logging and the hydraulic conductivity estimates. And those are all in the

report.

Q I see. Would you agree with me, Mr. Wozniewicz, that if -- let me back up. Have you looked at the core photos from the various boreholes at the Eagle deposit?

A I looked at only core photos for the conductive features.

Q I see. For these holes?

A For in particular borehole 84 where we did the pump test on. That's the only core photos I looked at.

Q Let's take hole 84, Mr. Wozniewicz.

A Yeah.

Q Do you understand that the Petitioners in this case have had access to 11 holes that have core photos? Do you understand that?

A Yes.

Q There's eight that were in the geotechnical reports that identified as having major structures, and we obtained the core photos for those eight boreholes through a FOIA request to the Michigan Department of Natural Resources now a party to this case. Do you understand that?

A Yes, I do.

Q Okay. And you understand that Dr. Wilson Blake obtained photos from three cores, three holes -- three different holes, that are now exhibits in this proceeding? Do you understand that?

A Yes.

Q And hole 84 is not among those 11; right?
A Correct.
Q So if we were to try to double-check your analysis of the structures in hole 84 that you're testifying about today, we wouldn't be able to do that, would we?
A Yes, you would. The most important thing we used in the model is the hydraulic response. All the hydraulic test data, all the plots of the data are shown in the reports.
Q All right. But --
A So you would be able to check -- all the input into the model come from these reports, so you would be able to check the data that was input into the model by looking at these reports.
Q Okay. But if we were to try to determine if there were other structures identified in hole 84 that you didn't include in your model, we wouldn't be able to do that without the core photos; correct?
A No, that's not correct. We -- you can look at the hydraulic test results and see if there's low hydraulic conductivity that we found in above that feature, there could be a structure there, but it's not transmitting much water. So in terms of groundwater flow, it's inconsequential.
Q And for the test that you performed in hole 84 that were the packer tests -- right? --
A Yes.

Q -- and the slug tests --
A Yes.
Q -- all right -- and then the pump test; correct?
A Correct.
Q If we were to try to double-check where those tests actually occurred within the core -- within the hole -- okay -- and compare the distances that you state where those tests occurred and where they actually occurred or the structures that they occurred around, we wouldn't be able to do that without the core photos; correct?
A Can you please restate the question?
Q Sure. For hole 84, --
A Yes.
Q -- which is the one that you performed the pump test on -- right? --
A Yes.
Q -- you also performed the packer tests?
A Correct.
Q And describe again what the packer test does.
A The packer test is an in situ test where you isolate the zone in the borehole and you perform a test, whether it's slug test or pump test, to determine the hydraulic properties of that zone.
Q Okay. Of that portion of the hole?
A Correct.

Q You isolate the top and you -- one end, and you isolate the other end, and then you -- and then you either force water in or pump water out; correct?
A Well, first you do tests along the entire length of the borehole, and then you try to -- with particular emphasis on potential flow logging anomalies. But you want to confirm the results of the flow logging, so you do the small test or smaller interval tests along the entire length of the borehole. It's called borehole scanning to get a local scale properties next to the borehole along the entire length of the borehole.
Q And how did you determine, Mr. Wozniewicz, which portions of hole 84 to do the packer test on?
A Based on the results of the flow logging that was done before the packer test. So what we do is scan, so you basically -- it's all based on hydraulic response. So we --
Q Hydraulic response along the entire length of the borehole?
A Based from those individual sections.
Q I see.
A So what we did is --
Q So if there's -- I understand that. So if we wanted to double-check how you determined -- or whether or not your determinations from the hydraulic response were correct, we'd have to look at the core photos to see that?
A No; no. You look at the reports.

Q So you're saying that Table 7.1 here on --
A Yeah.
Q -- slide 23 was really irrelevant to your work?
A No, it wasn't irrelevant. We basically did a -- it was due diligence on our part. Basically we found the conductive features were associated with the two moderately hydraulic -- well, the one confirmed hydraulic conductivity feature was in the sulfides and wasn't associated with any structure. But as part of due diligence, we wanted to take those structures from the database and also check it against the packer test results. And it would basically show that those structures were relatively low hydraulic conductivity.
Q All right. And for Table 7.1, if we look at what appears to be the widest column, which is the temperature, fluid, conductivity, heat, pulse, --
A Yeah.
Q -- caliber local deflection, the results here are uniformly "no"; correct?
A That's correct.
Q Which means that there's no -- let's look at the second item here, the fluid conductivity. And the fluid conductivity is the measure of what? The TDS?
A It's a measure of the -- it's a measure -- it's a measure of the properties of the water from a water quality standpoint.
Q Okay. For instance, total dissolved solids?

A Correct.

Q And then so for all of these holes, including hole 84, which is at the bottom of Table 7.1, you show no fluid conductivity, or was it not tested?

A The bottom of 84?

Q Yes. What does the "no" mean here?

A It means -- the "no" means at that location where the structure is we didn't see a major deflection in the flow log and indicate that there's a flow logging anomaly. And then also on the far right is confirmation based on packer tests performed over that specific interval.

MR. HAYNES: All right. Let's go to slide nine, please.

Q Mr. Wozniewicz, slide nine deals with ASTM Standard D5717; is that correct?

A That's correct.

Q Are you aware that this ASTM standard has been withdrawn?

A Yes; yes, I am.

Q Okay. So the text here that you testified about really doesn't apply anymore; correct?

A The only thing I was trying to point out that our typical procedures that we do were -- are consistent with these -- that have been taken out, yes.

Q The procedures you used were consistent with an ASTM standard that has been withdrawn; right?

A The procedures we used --
Q Right?
A No; no, that's not correct. That's not correct. I'm saying that the procedures were used were based on experience and based on work on other sites. Now, after the fact when we looked -- when we looked at these ASTM standards, some of the salient points from these procedures were also consistent with the work flow that we used.
Q The salient points from an ASTM standard that's been withdrawn; correct?
A Exactly. But we --
Q Thank you. All right. Now, the next question --
A Our work flow was based on experience.
Q Just answer my question. That's all I need.
A Okay.
Q Thank you.
A Yeah.
Q Mr. Wozniewicz, you talked about slug tests.
A Yeah.
Q And I had you describe what a packer test is.
A Right.
Q And tell us what a slug test is.
A Okay. Slug tests there's -- in hydraulic testing, there's different types of testing that you do for different types of hydraulic conductivity. So a slug test is where you

instantaneously remove a slug of water from the well --
Q You suck it out?
A We suck it out or air lift it out.
Q Okay.
A And then based on the -- you measure the recovery. And then based on the recovery, you do a transient analysis to get hydraulic properties.
Q Slug tests are really a very small snapshot of the hydraulic conductivity around the borehole, aren't they?
A Slug tests are used in scanning purposes. So you use slug tests along the entire borehole length. And what you're trying to do is locate those conductive features to do longer duration pump tests on.
Q And they test a pretty small volume of water, don't they?
A They test a small volume of water. And they're appropriate tests for this range of -- given the hydraulic conductivity at the site.
MR. HAYNES: Let's go to slide 15, please.
Q Mr. Wozniewicz, do you have the Appendices B-1, B-2, B-3 and B-4 with you at the stand?
A Are those the Golder reports?
Q Yes.
A Yes, I have the Golder reports on the stand.
Q Okay. All right. Sorry. We have to --
A Yeah. No problem.

Q We have a different nomenclature here.
A Yeah.
Q Just I want to make sure you've got the same stuff I do so that we don't have to flip back with slides. Appendix B-1 is the North Jackson report. Do you have that?
A I don't have the North Jackson report.
Q Okay.
A I just have the Golder reports.
Q Appendix B-2 just so we're on the same page is the Golder bedrock hydrogeologic investigation dated April 2005. Do you have that?
A Yeah.
Q Okay. And that's Appendix B-2. Appendix B-3 is the Golder report entitled Phase Two Bedrock Hydrogeologic Investigation dated February 2006?
A Yes. I have that.
Q You have that?
A Yes.
Q Slide 15, the second of the main bullet points, you talk about main structures. Do you see that?
A Yes.
Q And it talks about the orebodies elongated in an east-west direction. We see that. And there are east-west dikes?
A Yes.
Q You've identified those. And you've also talked about a

northeast-southwest fault that intersects the orebody. You understand that the geologists at North Jackson -- the folks at North Jackson said that there were northwest-southeast trending faults in that area, don't you?
A That crosscut the orebody?
Q That did not crosscut the orebody, but they were nearby?
A I'm familiar with those potential faults, yeah.
Q Okay. You didn't consider those here on your main structures, did you?
A No. They weren't -- we considered them not important for inflows.
Q You did not consider them important for inflows?
A Yes.
Q How far away are they from the orebody?
A We did sensitivities and if there's a structure --
Q No. My question -- wait.
A Yeah.
Q My question is how far away are they from the orebody?
A At least I would say 100 meters.
Q Okay. And by the way, the model that Golder developed has what area -- what's the area for drill on?
A You'd have to ask Willy Zawadzki.
Q Oh, I see. Okay. So I should also ask him about these northwest-southeast trending faults that were within 100 meters of the orebody to see how they fit in the model or

not? I should ask him that?
A Correct; correct.
Q Okay. You understand, don't you, Mr. Wozniewicz, that one of those east-west trending faults goes right through the decline? You understand that, don't you?
A If you're talking about there's a potential -- in Klasner's report he had a geophysical anomaly. It wasn't a confirmed fault. If that's the one you're talking about, yes.
Q And it goes through the decline?
A It's a geophysical anomaly.
Q Right. And it goes through the decline; right?
A The geophysical anomaly.
Q The one reported by Klasner goes through the decline; correct?
A The geophysical anomaly he has going through the decline; that's correct.
Q And you didn't consider that important for your modeling, did you?
A We considered the hydraulic -- we put a borehole out on towards the decline for the test, and the results of the pump test is a relatively low hydraulic conductivity between the pumping zone and that zone towards the decline.
Q That's from hole 20; right?
A Yeah.
Q That's the one hole way out there on the east?

A We also considered the -- my understanding was there's 13 boreholes out there that there's no evidence of a fault to confirm the geophysical anomaly and that the geology from those in the host rock is similar to around the orebody.
Q Okay. and those are the boreholes in the geotechnical database; right?
A That's correct.
Q The 109 boreholes?
A That's correct.
Q So if I wanted to double-check your last statement about the geology of that area, I'd have to go look at the database; right?
A That's correct.
Q And you know I don't have -- I don't have access to the database; right?
A Yeah.
Q So there's no way that I can double-check your last statement, is there?
A No. But I'll indicate --
Q I have to take it on faith; right?
A No. But I'll indicate from our testing we don't have any -- there's relatively low hydraulic conductivity out towards the decline.
Q Based upon one hole?
A Based upon one hole; that's correct.

Q All right. Thank you.
A And based on historical data, the host rock is relatively low hydraulic conductivity. So there's that historical data too from the other mine sites in Marquette and technical report number three.
Q In the Marquette iron range; right?
A That's right.
Q The Marquette iron range, Mr. Wozniewicz, --
A Yeah.
Q -- iron appears in sedimentary rock, doesn't it?
A It's in the bedded iron formation; right.
Q In sedimentary rocks?
A That's correct.
Q Okay. Not in an intrusive like we have here; correct?
A I'm talking about the rocks bounding the orebody. I'm not talking about the intrusive or the orebody itself.
Q Okay. And you have one hole that's in the sedimentary rocks east of the orebody to check your view that there's low hydraulic conductivity in the area of the decline? One hole; correct?
A That's correct.
Q Not a pump test in that area; correct?
A That's correct.
Q There are no packer tests done there?
A That's correct.

Q No slug tests done there?
A That's correct.
Q In slide 15 in your main structures -- sorry. Let me back up. Do you understand the term "brecciated zone"?
A Yes.
Q What is a brecciated zone?
A It's a broken zone in the rock.
Q Okay. You understand that there are brecciated zones between the intrusive here and the sedimentary rock; correct?
A Correct.
Q I don't see in your slide 15 any mention of those brecciated zones as major structures.
A It's there. It's a contact between the units.
Q Oh, I see.
A It's a contact between the units.
Q Okay. And the contact between the units is brecciated; correct?
A In not all cases. In some cases.
Q And in order to double-check that we'd have to go to the geotechnical database; correct?
A You could look at our findings from the reports that there was -- and this is from our experience, the broken zones or the fault zones are in the core for our hydrogeologic boreholes show now -- show low hydraulic conductivity. So

there's no correlation between those broken zones and the boreholes in our hydrogeologic investigation and significant groundwater flow.
Q But to double-check to see whether you're actually testing the brecciated zone, we'd have to look at the core data; correct?
A Absolutely not. You look in the reports. You can see the test results and you can go where you can -- you can see where those -- where those contact zones are likely to occur and you can check the hydraulic conductivity of those zones.
Q Okay. But if we wanted to see if your tests actually tested the brecciated zone; that is, to look at the rock where you're testing it; we'd have to look at the core photos; correct?
A No. You look at the traces of the borehole, and the boreholes intercept the orebody and they go in and out of the orebody and they go through the contacts between the orebody and the host rock and the sulfides.
Q I understand that. But in order to determine -- and I understand you've done the hydraulic conductivity tests on selective boreholes. And you're saying that -- your testimony is that and you've concluded there's certain hydraulic conductivities of varying degrees along these various boreholes. I understand that.
A Okay.

Q But if we wanted to see -- if we wanted to double-check whether your hydraulic conductivity tests were shown for the brecciated zones between the orebody and the sediment and host rock, we'd have to look at the core photos, wouldn't we, --
A No.
Q -- to see where those sections are?
A No. You just look -- you look at the borehole, look at the borehole traces, and you can understand where those intersections are. And the second point is that the only zone of moderate conductivity was in the massive sulfides and sulfides. So that was the only zone we found a moderate hydraulic conductivity.
MR. HAYNES: Let's go to slide 16.
Q Mr. Wozniewicz, you testified that on slide 16 you've got the red lines are the traces of the boreholes; correct?
A That's correct.
Q That is, if you're looking down, the top of the borehole is the black square; correct?
A The black circle; that's correct.
Q Circle? Thank you.
A Yeah.
Q The black circle is the identification of the borehole?
A That's correct.
Q And then the borehole goes down away from that black circle;

correct?
A That's correct.
Q So what we show here is five of these boreholes, the one that -- the ones that go north and south, intercept the dikes shown on Exhibit 214; correct?
A Can you clarify that with a pointer please which one you're getting at?
Q Oh, sure; sure. I don't mean to confuse you. The north-south holes here --
A Yeah.
Q Let me see if I've got these right. 83, which is on the west side; right?
A Yeah; yeah.
Q And 64?
A Yeah.
Q Those two are turning north-south; correct?
A That's correct.
Q Oh, 54. Thank you. And then hole 47 going to the east intercepts one of the east-west dikes; correct?
A No, that's -- those lines are the bounding structure that hosts the peridotites and intrusive and other dikes, other smaller dikes. So within that -- within those two lines there may be multiple small dikes between those two lines. So those are the bounding structures.
Q Okay. The bounding structures of the orebody?

A That's right.
Q The brecciated zones?
A No. It's the contact -- host rock -- in other words, it's the contact with the host rock. So the host rock is to the north of those lines and the host rock is to the south of those lines.
Q I see.
A Inside those lines are the peridotite, the massive sulfides and dikes.
Q I see. And again, if we were to check that statement, we'd have to go look at core photos; right?
A Well, you know the dikes -- everything is orientated east-west. The main point is that the potential -- that things are oriented vertically and east-west and the boreholes are striking north-south and designed to intercept those potential conductive features.
Q Right; right. Those are the boreholes that you measured the draw down in; correct?
A Yes. Those are the boreholes for the hydrogeological investigation.
Q And just continuing, so we've sort of come full circle on this, because my last question was -- I probably should have asked it after I go through these. Hole 74, which is this long one, is a north-south hole; correct?
A That's correct.

Q And hole 107 appears to be a vertical hole?
A It's near vertical. I believe it's minus 85, but, yes.
Q Right. And then hole 73 -- is it 73?
A Yes.
Q Okay. That's a north-south hole?
A Yeah.
Q And hole 77 is a north-south hole; --
A Yeah.
Q -- right?
A Yes.
Q And then hole 84 is the one that goes east-west through the orebody; correct?
A Correct.
Q That's the one that the pump test was done on; right?
A That's correct.
Q You didn't do pump tests on the other five holes that we've just been -- seven holes that we just went over; right?
A We did pump test on all the holes we did flow log in, five of the six holes that were flow logging done.
Q No long-term pump test on any hole besides 84?
A All the rates were -- where all the rates were low, consistent with low hydraulic conductivity.
Q That wasn't my question. You did a long-term pump -- you did a seven-day pump test on hole 84; correct?
A That's correct.

Q You did not do seven-day pump tests on any of the other holes; correct?
A We did seven-day pump tests on the most conductive features. And the scale of that test, that influences about the scale of the orebody. That's correct.
Q That wasn't my question.
A Sorry.
Q You did a seven-day pump test in hole 84; correct?
A That's correct.
Q And you measured the drawdown in the other holes that we just went over; right?
A In some of those holes, yes.
Q Some of those holes. You didn't do a pump test in any of the other holes, did you?
A We did short duration pump tests in five of the six holes.
Q Okay. Short-term meaning how long? An hour?
A Meaning six -- five, six hours.
Q Okay. Not seven days?
A Not seven days, no.
Q So the only seven-day pump test that you did was in hole 84?
A That was the only borehole that intersected a moderately conductive feature zone.
Q That's not my question.
A And that was -- yes, that was the only test (sic) we did a pump test in.

Q Thank you. Who selected the holes that are on slide 16 for the hydraulic conductivity testing?
A I selected the holes based on -- and based on discussion with -- some discussion with Andrew Ware.
Q I see. And that was based upon the geologic logging; right?
A No. It was primarily based on the regional geologic setting, the main structural grain, which was east-west, the potential conductive zones, and also the potential for a fault, that northeast-southwest fault.
Q I see. By the way, hole 84 does not intercept the major structures around the orebody, does it?
A What do you mean by "major structures"?
Q Well, the -- how do you refer to it? The contact between the units. Hole 84 doesn't intercept the contact, does it?
A Hole 84 I believe started -- I have to look at the geology -- started outside of the orebody, so it would intercept at least one contact.
Q By the way, did any of the holes here intercept the crown pillar?
A There was -- the boreholes -- if we can go back to the isometric view?
Q You mean forward?
A Yeah, forward.
Q Slide 17?
A Yeah.

Q By the way, on slide 17, which is this sort of three-dimensional view; correct?
A Correct.
Q Hole 84 is the one that goes from the top left and trends down to the right, doesn't it? Is that hole 84?
A Can I approach the screen?
Q Sure.
A Yeah. Hole 84 is this one right here (indicating).
Q Wait; wait.
(Off the record interruption)
A Yeah. So borehole 84 -- so borehole 84 would have went through a contact zone, because here's the orebody here. It would have went through a contact zone here, here, here and here. This is the orebody itself.
Q Right. And the contact zone, one contact zone, is at the top of the orebody; correct?
A That's correct.
Q Not along the sides?
A That's correct.
Q But it -- okay. But hole 84, since it goes east and west, does not intercept the contact zones on the north side of the orebody nor on the south side of the orebody; correct?
A We have other boreholes intercept contacts in that area.
Q Wait; wait. That's not my question.
A Yeah.

Q Be careful to answer only the question I've asked you. Okay. Mr. Lewis may ask you follow-up questions, but I just want answers to the questions that I'm asking.
A Okay.
Q The question was, hole 84 does not intercept the contact zones on the north side of the orebody nor on the south side of the orebody; correct?
A Let me think about that for a second. Excuse me for a minute. I just want to find --
Q Take your time.
A -- the one figure.
(Witness reviews documents)
A No. Hole 84 wouldn't intersect the contact zone on the north side.
Q Thank you.
A That's correct.
Q Mr. Wozniewicz, the mine here is going to consist of the decline, which is the tunnel from the surface down toward the other tunnels; correct? That's one part of it?
A Correct.
Q And then there are other I think they're called tunnels that come into the orebody for the mining; correct? Those are shown in red on this figure, --
A That's correct.
Q -- slide 17?

A Yeah.
Q And on this figure we've got the blue portion, which is the orebody itself, --
A That's correct.
Q -- a representation of it? I understand that. The holes that you select -- well, let me back up. You would agree with me, wouldn't you, that there's a likelihood of inflow into the decline?
A I would agree that there -- based on the measurements I've taken that the inflows to the decline would be relatively small.
Q But there will be inflows; correct?
A There's always inflows, yeah.
Q And if there's always inflow, then there will be inflows also to the tunnels that are going to be the tunnels for the mine -- the orebody itself; right?
A Correct.
Q Some inflow; right?
A Correct.
Q For purposes of your modeling, the holes that you show here -- is it eight holes? Is that how many you have?
A Total of nine holes.
Q Thank you. Nine holes. None of those intercept the tunnels next to the orebody; correct?
A Those intersect the rock that the tunnels are -- will be

within the north side of the orebody.
Q How many holes? One or two?
A Let's see. This looks like borehole 73, 77, 107's in that area, looks like 47 is in that area, and 84 is in that area.
Q But 84 goes right to the orebody; correct?
A 84 --
Q So it doesn't go through any of the tunnels if it intersects the orebody?
A Yeah. But the holes are inclined, so they could start off on the north side in the rock where the same rock that the tunnels will be in.
Q And I may be repeating myself and, if I am, I apologize, Mr. Wozniewicz. But for the holes that you just identified that may intersect the rock that the tunnels may be going in, there were no long-term pump tests done on those holes; correct?
A The -- we tried to do -- no, that's not correct, because we did pumping tests in five of the six short duration pump tests.
Q My question was long-term pump tests. There were none done in the holes that intercept the tunnels?
A The properties suggested they didn't warrant a pump test.
Q There were none done in those tunnels --
A Yes; that's correct.
Q -- in those holes; right?

A That's correct.
Q Thank you.
A There was none -- there was short duration pump tests done on five of six holes.
Q My question was no long-term pump tests done; correct?
A How do you define long-term?
Q Well, like the one for hole 84, seven days.
A That's correct.
MR. HAYNES: All right. Let's go to slide 19.
Q Mr. Wozniewicz, you testified regarding slide 19 that on the third bullet item here, packer testing done -- packer testing in over 3,000 linear feet of borehole?
A Yeah.
Q You testified that that was for four holes. Which holes?
A Those were for -- if you'd give me a moment, I just want to double-check my memory.
Q Sure, of course. Yeah. This is not a memory test. If it's in the reports, let's hear it from the reports.
A Okay.
(Witness reviews documents)
A Packer tests were done on borehole 04EA47.
Q I'm sorry. Say that again.
A Borehole 47.
Q Thank you.
A Borehole 73, borehole 83, and borehole 84.

Q Then on the next bullet item you said that the flow logging was done in six of the holes. Can you tell us which six those were?
A Yeah. Flow logging was done in borehole 73. Sorry. I'll do them in sequential order, if I could start again for you.
Q That's fine.
A Borehole 47, borehole 54, borehole 73, borehole 77, borehole 83 and borehole 84.
Q All right. Thank you. Let's go to slide 20. Mr. Wozniewicz, for the second group of bullets here, the third bullet you talk about two boreholes having a sustainable rate of below the lower limit of the pump. Which holes are those?
A Those would be borehole 73, borehole 77.
Q Right. And which page of which appendix are you -- or which report are you referring to here?
A It's the Eagle project hydrogeological investigation 2005 report.
Q So this is Appendix B-2?
A Yeah. Sorry. I'll try to be more --
Q And which page?
A Page -- the results are summarized on page 13.
Q Thank you. And then for the next bullet item, when you talk about three boreholes having pumping rates between 0.5 and 1 gallons per minute, which boreholes?

A Those would be boreholes 47, 54 and 84.
Q And on what page of your report are you referring?
A Page 13.
Q Again; right?
A Yes, same page.
MR. HAYNES: Okay. Let's go to page -- excuse me -- slide 21.
Q The second bullet on slide 21, Mr. Wozniewicz, talks about 18 structures identified in core.
A Yeah; yes.
Q Are those 18 structures identified in any of your reports?
A They're all in Table 7.1.
MR. HAYNES: Let's go to slide 22.
Q Mr. Wozniewicz, you testified about the method by which you determined that there was an upper bedrock and a lower bedrock zone for purpose of hydraulic conductivity; correct?
A Correct.
Q And again, just so that I understand or so the record is clear on this slide, for the -- it looks like four boreholes in the upper right-hand portion of the slide?
A Yeah.
Q Those vertical lines there represent four of the boreholes; right?
A That's correct.
Q And which ones?

(Witness reviews documents)

A That data is summarized in Table 7.1, so it's borehole 47, 73, 83 and 84.

Q That's in Table 7.1, you say?

A Yes.

Q Well, let's go to the next slide. All right. In Table 7.1 the hydraulic conductivity for these holes here shows hydraulic conductivities of anywhere from eight of the minus eight to eight of the minus ten. Do you see that?

A That's correct.

Q And the hydraulic conductivities for if you go back a slide to slide 22 for the upper bedrock show hydraulic conductivities in eight to the minus seven to eight of the minus eight for the upper bedrock. Do you see that?

A They show one times ten to the minus eight to five times ten to the --

Q To the minus seven; right?

A That's correct.

Q I don't see any -- on Table 7.1, I see no results that show eight times ten to the -- or ten to the minus seven here.

A That's correct.

Q So is that on Table 7.2? I'm trying to figure out where the data came from.

A The data came from the report itself. So we went to the zone that had the conductive feature and got the hydraulic conductivity of that zone.

Q Okay. So on slide 22 when it says Table 7.1 to 7.2, actually Table 7.1 doesn't show any of these numbers for the upper bedrock, does it?

A These are probably the smaller zones within the upper bedrock that packer testing were performed in.

Q Okay. But that's not -- but what I'm trying to get at, Mr. Wozniewicz, is that the boreholes that are on slide 22 for the upper bedrock here don't appear to be located on Table 7.1, at least the results?

A Most of those zones -- a lot of those zones are greater than 90 meters depth, so those are in the lower bedrock.

Q Right. On Table 7.1; right?

A Right; right.

Q So again, I'm just trying to figure out where -- what data is summarized by slide 22.

A So 22 -- you go to Table 7.- -- it's all summarized in Tables 7.1 and 7.2.

Q Okay.

A So those are the four boreholes we tested, it's a summary of the hydraulic -- not all the test results, but the summary of the hydraulic properties, longer intervals, and that's the results.

Q Again, Mr. Wozniewicz, just so the record is clear, if on slide 22 moving right to left, --

A Yeah.
Q -- if we start with the boreholes represented by the first vertical line on the right --
A Okay. So if I go to Table 7.1, we've got a hydraulic conductivity of 2.12 times ten to the minus eight meters per second. So let me just --
Q Where is that?
A Just let me look at this for a second, please.
Q On Table 7.1?
A Yeah.
(Witness reviews document)
A Can I approach the -- so borehole 47 the hydraulic conductivity from that interval is two times ten to the minus eight meters per second. So --
Q You're looking at the -- again, moving from right to left, I just want to make sure the record is clear on this.
A From right to left, this is -- one, --
Q What's the first borehole?
A -- two, three, four, five. So that's -- one, two -- that's five times ten to the minus eight. So that's consistent with the result from borehole 83.
Q Okay. And then moving to the left from there, what's the next borehole?
A The next highest hydraulic conductivity is 2.12 times ten to the minus eight, so that would be borehole number 47. And

that would be this (indicating) borehole right here. That would be the results right here.
Q That's borehole 47?
A Yeah.
Q Well, if I look at Table 7.1, --
A Yeah.
Q -- for borehole the table says that it was not -- hydraulic conductivity was not measured.
A Table 47?
Q Hole 47.
A At that depth. It occurred at the top of the interval, so maybe it wasn't a test at the top of the interval.
Q Okay. So again, where would I find the data that substantiates the second line from the right for hole -- if that's hole 47? Because it does not appear to be in Table 7.1, and it does not appear to be in Table 7.2.
A What data specifically are you referring to?
Q Well, I'm just -- I followed you when you were talking about hole 83, which is the first line on the right.
A Yeah.
Q We go the next line to the left, which you say is hole 47, --
A Yeah.
Q -- and we look at hole 47 on Table 7.1, --
A Yeah.

Q -- and the hydraulic conductivity on that it says not measured. And that's at a depth of 14 meters; right?
A Right. That's right towards the top of the hole.
Q I understand that. But --
A So probably the packer test was performed -- usually has to be performed to get a good seat a little bit below the top of the bedrock.
Q I understand that. All I'm trying to do, Mr. Wozniewicz, is find out -- you have a chart here --
A Yeah.
Q -- that summarizes some data.
A Yes.
Q I'm trying to find out where the data is or are.
A The data is 7.1 and 7.2.
Q Okay. And if the second line from the right you say is hole 47 --
A That's correct.
Q -- is in Table 7.1 hole 47 has a single structure --
A Yeah.
Q -- of four-tenths of a meter long at 14.21 meters depth, --
A Right.
Q -- the line here on slide 22 that you say represents hole 47 appears to go from give or take ten meters to about 100 meters; right?
A It goes from 14.- -- hole 47 goes from 14 meters down to 268

meters.

Q Okay. I just want to make sure I understand what you're saying here. I'm looking at the second line from the right.

A Yeah.

Q This is the one that appears in --

A Yeah.

Q -- mostly in the upper bedrock; correct?

A Right.

Q That line goes from -- if you say it's 14 meters, that's fine.

A Table --

Q And then the line stops at about 100 meters; correct?

A That's correct.

Q And does it then move over to the lower bedrock?

A No. Those are different tests in the lower bedrock.

Q Okay. All right. So it goes -- the line shown on slide 22 for hole 47 goes from 14 to about 100 meters; right?

A That's correct.

Q Okay. And Table 7.1 and Table 7.2 we don't have any data that show the hydraulic conductivity. I'm just trying to figure out where you got the data from.

A We got the data for -- the structural data from the geotechnical database, and all the results came from the packer test results.

Q But the packer tests aren't reported in Table 7.1?

A For that one feature that occurred pretty close to where maybe the packer sat over that interval.
Q Okay. So if we wanted to double-check your statement that the hydraulic -- the average hydraulic conductivity for hole 47 is 2.0 times ten to the minus eight, which is what that line represents -- correct? --
A Yeah.
Q -- it's not in these slides, is it?
A It's in the reports.
Q Where in the report? But it's not in the tables; right?
A It's all in the reports. Where that -- where that number came from is summarized all in the reports.
Q All right. But not in Table 7.1 or 7.2?
A The table -- all this data is summarized in Table 7.1 and 7.2.
MR. HAYNES: Okay. Let's go to the next slide, slide 23.
Q Just so that we're all dealing on the same page here, Mr. Wozniewicz, for hole 47 there's a single line for hole 47; correct?
A That's correct.
Q All right. And it has a structure of four-tenths of a meter in length at depth 14.21 meters; correct?
A Correct.
Q It does not have any data in this table that goes down to

100 meters; correct?
A It has --
Q For hole 47; --
A Yeah.
Q -- right?
A Right.
Q Okay. You're saying that that's somewhere in the reports?
A It's in the reports.
MR. HAYNES: All right. Let's go back one slide to slide 22.
Q For the third lien from the right, still in the upper bedroom, what hole does that line represent?
A That hole represents -- it looks like on the chart it's 1.8 times ten to the minus eight meters per second, so that would be hole 73.
MR. HAYNES: All right. Let's go to the next slide, slide 23.
Q I'm looking at hole 73, Mr. Wozniewicz.
A Yes.
Q And for the portion of hole 73 that is in what you call the upper bedrock, --
A Yes.
Q -- which goes from about somewhere between ten and 20 meters down to about 80 meters, I don't see any data for that range for hole 73. Do you?

A From -- 'cause from zero to 120 meters?
Q Right. No; no. Well, from, say, give or take 20 meters, which -- if we go back one slide to slide 22 -- sorry to keep jumping around here. If we had two screens, we could do this more efficiently.
A Yeah.
Q The third line you say represents hole 73; correct?
A Yes.
Q And the top of the hole here is somewhere between ten and 20 meters; right?
A Packer intervals start at 15 meters.
Q 15?
A Yeah.
Q And then the packer -- and then the interval went down to about 70 meters -- about 80 meters; right?
A That's correct.
MR. HAYNES: Okay. Let's go to slide 23.
Q From 20 meters to 80 meters there is no data for hole 73 on Table 7.1, nor is there any data for hole 73 on Table 7.2; correct?
A There is no -- there is no conductive features.
Q No conductive features?
A Or sorry. There's no -- this is the output for all the structure data from the boreholes that we did a hydrogeologic investigation. So if there is no structures

in the upper part of the borehole, then there was -- there was none in -- none there.
Q So for the packer test, you're saying hole 73 we can't correlate the packer test here with anything in Table 7.1 -- right? -- for hole 73?
A No. What this does say is that the structures encountered in borehole 73 where there was done packer test over in the lower bedrock were low hydraulic conductivity.
Q In the lower bedrock?
A In the lower bedrock.
Q But the line that we're looking at in slide 22 is in the upper bedrock?
A That's correct.
Q So that's not reflected in Table 7.1?
A No. That means there's no structures in the database in the upper part of the bedrock that were encountered by that borehole.
Q Just so the record is clear, the data that support your conclusion are found in the reports, not in Table 7.1?
A Can you rephrase that question?
Q The data that supports your conclusion regarding hole 73 are found in the reports, not in Table 7.1?
A And which conclusion are you referring to?
Q Well, the conclusion -- thank you. The conclusion that the hydraulic conductivity for hole 73 is two times ten to the

minus eight.
A That's in the report; that's right.
Q Okay. Mr. Wozniewicz, if we can turn back to slide 22, the fourth line from the right represents which hole?
A The fourth line from the right represents hole 73.
Q I thought the third line from the right was 73. That's what we've just been talking about for the last 15 minutes.
A Say that again.
Q The fourth line from the right --
A Yeah. You're still in the upper bedrock; right?
Q Yeah, still in the upper bedrock.
A Sorry. I apologize. Is in the report it's 1.05 times ten to the minus eight meters squared per second, and that would be borehole 84. That's correct.
Q And give us the --
MR. HAYNES: All right. Your Honor, I notice that it's a little bit past noon. I can continue this for a long time, but maybe we should do it after lunch, I'm thinking.
JUDGE PATTERSON: Okay.
(Off the record)
MR. HAYNES: I'm ready, your Honor.
JUDGE PATTERSON: Okay.
Q Are you all mic'd up there, sir?
A Yes, I'm ready. Thank you.
Q All right. Good. Thank you. If we can go back to slide

22, --

A Yes.

Q -- I'd like to complete our inquiry into the various notations on this slide. Mr. Wozniewicz, if we now turn to the three boreholes that are depicted on the left-hand part of this slide that I think you used to characterize the average bedrock hydraulic conductivity, we're going to go from the left toward the center now. For the vertical line that's the first line on the left, which hole is that? Which hole does that line represent?

A Okay. I'm just going to check the report. So that would be table 7.2. And just for clarification, this table 7.1 here is not the table 7. It's a different table 7.1 that's shown on a subsequent slide.

Q Oh, really. So there's the basis for our confusion.

A Yes.

Q All right. And it's table 7.1 from which report?

A From the Golder -- the 2005 report, Eagle project bedrock hydrogeological investigation.

Q Just to follow up with that, sir, that's table 7.1 found on page 33 of the Golder report which is what we call Appendix B-2, --

A That's correct.

Q -- the hydrogeologic investigation?

A That's correct.

Q And then table 7.2 referenced in slide 22 is also found on page 33 of that same report; correct?
A Correct.
Q And those tables show the top and bottom of the boreholes that are represented by the two points at the end of each one of these lines on slide 22; correct?
A They show the top and bottom of the test interval.
Q Yeah; right; the test intervals.
A That's correct.
Q As shown on slide 22; correct?
A That's correct.
Q All right. That clears up some confusion. So again turning to slide 22, the left-hand borehole for the lower bedrock is represented by which borehole?
A That would be represented by borehole 73.
Q And then if we go to the next line to the right?
A That would be represented by borehole 47. The next line to the left? Are you starting from the --
Q I'm starting from the left.
A Okay. Sorry. So the first -- the lowest hydraulic conductivity starting on the far left is borehole 83.
Q That's 83?
A Yup.
Q Not 73?
A No.

Q Okay.
A The next lowest hydraulic conductivity which is the next one to the right is borehole 47.
Q Right. And then the next one is 73?
A The next one is 73.
Q So for this chart on slide 22, we have four holes that are represented; correct?
A So --
Q We've got hole 47.
A That's correct.
Q Hole 73?
A That's correct.
Q Hole 83 and hole 84?
A That's correct?
Q And you've divided three of those; holes 47, 73 and 83; into two sort of portions here; correct?
A That's correct.
Q And if we look at table 7.1 and 7.2 on page 33 of appendix B-2, these tables are summaries; correct?
A Correct.
Q And where is the data that support the summaries in these tables?
A These are --
Q Where would I find the backup data?
A The backup data would be tables 4.2, 4.3, 4.4 and 4.5.

Q In the appendices?
A In the same report.
Q Now, on slide 22, sir, there's a horizontal red line --
A Yes.
Q -- that you've drawn at 90 meters; correct?
A That's correct.
Q And that's your view of the hydraulic conductivities in the upper bedrock versus the lower bedrock; right?
A At a early stage in the project, preliminary stage in the project.
Q I see. And you moved that line later on?
A No, it wasn't moved based on additional data.
Q It was moved, or it wasn't moved?
A It was not moved, but we collected the --
Q So later on in the project the line stayed at 90 meters; right?
A That's right.
Q Total vertical depth; correct?
A Yeah, with additional data to support that 90 meter line.
Q I see. Okay. And that line which you say defines the upper bedrock from the lower bedrock is used for the model to predict groundwater inflows into the mine; correct?
A That's correct.
Q And the model, as I understand your testimony, is in an area

87 square kilometers?
A The total model area?
Q Yes.
A No, I didn't state that. I said you have to ask that to Willie Zawadzki.
Q I thought that was in one of your slides.
(Counsel reviews documents)
Q Bear with me, sir, because I remember you testifying about that, and I just want to make sure that I can find the reference.
(Counsel reviews documents)
Q All right. I'll have to come back to that. I don't want you waiting on the stand.
A Sure. Okay.
Q But do you understand that the model -- the size of the model area is 87 square kilometers?
A I don't know precisely but --
Q It's in that range.
A I don't -- it doesn't sound too unreasonable but I --
Q Is that something we have to ask Mr. Zawadzki?
A You have to ask Mr. Zawadzki; yeah.
Q Okay. That's fine. However, if we're dealing with that relative size of 87, 90, 80, that kind of size for the model area, you would agree with me, wouldn't you, that the wells

that were tested here around the orebody are in a fairly localized area compared to the size of the model?
A I'd say that the wells are in the area that's most important to groundwater inflows.
Q But relative to the size of the modeled area, it's a relatively localized area; correct?
A Yes; that's -- yes.
Q Okay. And so the 90 meter line here is supposed to represent the change between the upper bedrock and the lower bedrock over the entire modeled area; correct?
A That's correct.
Q And that's not actually true, is it?
A There is -- there is -- this is based on the local properties, and there is supporting evidence that has larger scale than the packer test to support that the hydraulic conductivity decreases with depth. Water quality data kind of has -- each information you collect has a different scale of influence. Water quality data tends -- when you collect at specific depths, tends to have a larger scale of influence. It represents more of the regional groundwater water system.
Q The water quality data?
A Yup.
Q Like the conductivity?
A The TDS.

Q Or TDS.
A So the decrease -- the significant increase in TDS measured at the site suggests that the hydraulic conductivity decreases with depth, and it's consistent with this result here.
Q Okay. All right. We'll get into that in a minute. When you -- can we go to the slide 24, please? Mr. Wozniewicz, for slide 24, you quoted from various reports prepared by the predecessor agencies to the DEQ concerning the iron range in the UP; right?
A Correct.
Q And the portions on slide 24 basically say that there's not much water that flows through the bedrock in the iron ranges; correct? Is that a fair characterization of what your point is here?
A The point here is that -- there's two points to this slide. One point is that the host rock surrounding the iron formation is relatively low hydraulic conductivity. And that was consistent with the results that we had with our investigation. The second point is that they said that the flow is -- that there's flow within the iron formation because of chert and also because the iron formation is considered a porous or it has high primary porosity.
Q Right. And the iron formation as it is within -- and chert is defined as what? I don't think you defined that in your

direct examination. Tell us what that is.
A It's a igneous rock, and it can be kind of glassy, fine grain igneous rock; glassy in texture.
Q Okay. And I think you testified there's no real chert around the Eagle deposit; correct?
A Within the elevations that they planned to mine, there's no -- to my understanding from personal communication with Andrew Ware, there's no chert in that area.
Q Okay. So the idea of comparing geology of the iron mines -- the iron range with the geology and the hydrogeology for the proposed Eagle Mine, those really are different kinds of things, aren't they? We have different geology, different kinds of fractures, different sedimentary rocks; correct?
A For the orebody, yes.
Q Okay. And by extension, the orebody and the contact zone; right? That's different than you would find in the iron mine range; correct?
A There's no documentation on the contact zone on the iron mine so I can't comment on that.
Q Oh, I see. So that would be difference; right?
A Possibly a difference.
Q Okay. Not taking into account the quotes that you pulled out of the reports here; correct?
A Can you rephrase that question? I don't understand.
Q Yeah. I mean that difference if you can't comment on it --

but you don't know whether there's a similar kind of intrusive -- well, there is no similar kind of intrusive zone for the iron mine range -- the iron range as there is here; right?

A Correct.

Q So we would have the same kind of contact zone -- correct? -- without the intrusive?

A Correct.

Q All right. And in these reports, the reports talk about various inflows into these mines, don't they?

A Yes.

Q All right. And you didn't focus on that in your slides here; right?

A No, because of the different types of mining techniques, the caving mine techniques and the significant subsidence had a big effect on inflow.

Q Okay. But if there's going to be inflow into the mine from the walls of the mine, it doesn't matter if they're caving or if they're doing stopes, does it, if the walls are coming in from the -- if the inflow is coming in from the walls?

A But if you have subsidence, what you're doing is creating --

Q No. I didn't ask about subsidence. I said about the caving method versus the stope method.

A If you're caving, you're creating vertical conduits to allow connection to the overburden to allow flow in the mine.

Q Right.
A So it could be quite a different circumstance.
Q And when you blast stopes, you're creating a vertical surface too, aren't you?
A I can't comment on that. That's not my area of expertise.
Q Okay. So you really can't comment on whether or not the caving method has any difference for the inflows into the iron mines?
A Well, the caving method I understand is much more aggressive than less significant subsidence. So I would say there is a big difference.
Q All right. But you would find the inflows into those mines relevant to a consideration of a modeling inflow into the proposed Eagle mine, wouldn't you?
A You have to consider the difference in geology, and you have to consider that there was caving and there was a lot of subsidence.
Q But relevant nonetheless?
A And you have to consider the potential reason for the differences.
Q But relevant nonetheless; correct?
A Not necessarily because --
Q So the inflows into the iron mines are a totally irrelevant factor for purposes of modeling the projected inflows into the Eagle Mine?

A No. I want to state that you need to consider the differences between the geology, differences between the mining. You need to consider the differences between the mine openings. You need to consider the differences in depth. So there's a lot of variables that you need to consider when you do the comparison.
Q Right. But the comparison would be an irrelevant comparison with those caveats?
A With all those caveats?
Q Yes.
A I would say very -- I would say no because the differences are so great between the two mine sites.

Q Now, I think I'm going to get in to a slide that's been renumbered so you'll have to bear with me. We were handed two extra slides this morning, and I think they threw off my numbering.
MR. LEWIS: Come after number 25, Mr. Haynes.
MR. HAYNES: Right. Thank you.
Q All right. Let's go to slide 31. Let's see if it's the right one. Yes. On slide 31, Mr. Wozniewicz, we've got five -- the first bullet point talks about five tests performed in the upper 90 meters in borehole 107. Do you see that?
A Yes.

Q This is the packer testing; correct?
A Yes.
Q Right?
A Yes.
Q The testing there confirm that there was a hydraulic connection between the upper -- what you characterize as the upper and the lower bedrock; correct?
A No.
Q No hydraulic connection?
A No. The tests there confirm the hydraulic properties near the borehole.
Q So these tests weren't aimed at determining the hydraulic connection between the upper and lower bedrocks; right?
A These test -- this particular test was aimed to do additional testing in the upper bed- -- additional testing in the upper bedrock to either confirm or refute the earlier measurements in Phase I for hydraulic conductivity of the upper bedrock.
Q Just to the upper bedrock? Yes?
A Yes.
Q Let's go to slide 33. Mr. Wozniewicz, the first bullet on slide 33 says, "pumping test interval encompasses conductive feature." This is the pump test for hole 84; correct?
A That's correct.
Q And the conductive feature you're talking about is the

northeast-southwest trending fault; correct?
A It's not a fault. It's a local moderately conductive zone we found in the sulfides.
Q Okay. It's a structure?
A It may -- there's no evidence that it's a structure. It could be a small -- it could be fractures.
Q I see. And the pump test for that conductive feature did not encompass any other conductive features in the area of the proposed mine; correct?
A That's correct. Based on interpretation of the test data.
Q Right. Now, the second bullet point on this slide says, "Maximum drawdown so similar to drawdown expected during mining." And the pump test for this hole was seven days; correct?
A Correct.
Q All right. The mine is expected to operate for ten years; correct?
A Correct.
Q So you're projecting a seven-day pump test over a ten-year operation of the mine; correct?
A The purpose of the pump test was to get a scale of influents over an area similar to the orebody, which is most sensitive to mine inflows; correct.
Q For ten years?
A Correct.

Q One pump test?
A There was five -- there was five short-duration pump tests, there's just one long-duration pump test, and then we attempted at least two or three other pump tests, but the hydraulic conductivity was too low for the lower limit of the pump; correct.
Q So one long-duration pump test?
A One long-duration pump test over the one moderate hydraulic conductivity zone that was encountered.
Q Right. The third bullet point here says, "Monitor in lower bedrock, upper bedrock and Alluvium in all directions from pumping zone." Do you see that?
A Yes.
Q Which wells were monitored -- let me back up. Alluvium is the unconsolidated material above the upper bedrock; correct?
A Correct.
Q Between surface and the upper bedrock?
A Correct.
Q When you say that there is monitoring in all directions in all three of these zones, can you point out the wells that tested the Alluvium north and south of hole 84?
A Excuse me just for a second.
Q That's fine.
A Okay. So the -- we have for the monitoring wells, the

monitoring wells in Alluvium are located to the 44 -- QAL 44, QAL 43 are located to the north, and monitoring well QAL023 (sic) is located to the west near the collar of 84.
Q I'm sorry. That's QAL203?
A Yup.
Q Located to the west?
A Yup.
Q But not north or south?
A No. So that statement is referring to the collective -- all the monitoring points collectively were located in different directions from the pumping well.
Q But not in all directions; correct?
A Collectively in all directions, yes.
Q All right. But my question was as to the Alluvium.
A The Alluvium ones were located to the north and to the west and the -- if you look at the map 43 is located -- 84 to be near the collar of the pumping well, and 43 was located elevation rise vertically in the area directly above the pumping zone.
Q You would agree with me, wouldn't you, that the access tunnels have to be de-watered?
A That's outside of my area.
Q Oh. Sir, when the long-duration pump test occurred for hole 84, --
A Correct.

Q -- what was the -- what was the draw in the pump during that pump test? How much was it pulling out?
A It started at -- I think it started at -- we started the test at 12 -- sorry. This is -- 12.2 liters per minute, which is roughly three gallons per minute.
Q And which slide are you looking at, 36?
A 34. 34.
Q Old 34?
A 34, yeah.
Q The one that's entitled, "Measured Drawdown in Pumping Well"?
A That's correct.
Q I think that's new 36.
A Okay. I apologize.
Q That's okay.
MR. HAYNES: Can we put 36 up, please?
MR. LEWIS: I didn't renumber those slides, Mr. Haynes.
MR. HAYNES: Oh, you didn't?
MR. LEWIS: Two slides I gave you were unnumbered, as I indicated on my note. So if you refer to the numbered slides they should still be the same number.
MR. HAYNES: That says "36."
MR. LEWIS: Unless my technician renumbered.
MR. HAYNES: Perhaps we're now on the same

numbered page.

MR. LEWIS: Perhaps we are.

MR. HAYNES: All right.

Q Mr. Wozniewicz, slide 36 -- you explained that the pump test in hole 84 started out at about three gallons a minute?

A That's correct.

Q Can you show us on this slide where that is?

A Right in this point here (indicating). So we started pumping down and it immediately showed a very sharp decline. So when we turned the pump on --

THE WITNESS: Can I approach the board, Judge?

JUDGE PATTERSON: Sure.

A So at this point we turned the pump on at three gallons per minute and it showed a very rapid drawdown. Okay?

Q All right. When you say "here," you're pointing to the left-hand vertical blue line?

A Yeah; that's right. This point.

Q You can use your fingers; that's okay.

A Right here (indicating).

Q I just want to make sure for the record that we're all looking at the same thing.

A Yeah, that's where we started the pump test at three gallons per minute.

Q Oh, that's the 12.2 liters per minute?

A That's right. It's about, yeah, roughly three gallons per

minute.
Q Okay. And then the rate -- the flow rate then was reduced down to 6.1 liters per minute, which is about a gallon and a half; correct?
A That's correct.
Q Per minute?
A Yup. And the reason was that we wanted to -- during the test we wanted to maintain a relatively constant rate during the test so we can look at -- the nature of the drawdown trend gives us an indication of the connectivity to other such features.
Q Okay. And what -- and the zone that you're pumping here is shown in the legend across the top; correct?
A That's correct.
Q It's about a 50-meter zone give or take?
A That's correct.
Q So the pump test did not occur -- or you didn't do a long-duration pump test over the entire length of the borehole; correct?
A No, only the most -- the highest zone of -- the highest hydraulic conductivity zone was isolated for the pump test, but we did packer tests above that zone in Phase I investigation.
Q Right, but no pump test?
A No pump test. And the results of the packer test suggested

that it wouldn't sustain a very high rate during pump --
very low -- below the --
Q And two gallons per minute you consider to be a high rate?
A What do you mean "consider a high rate"?
Q Well, you just said the packer test wouldn't suggest a high rate in a pump test.
A That's right.
Q Two gallons a minute is --
A Relatively speaking, yes.
Q -- is a high rate?
A For three gallons -- no. I'd say three gallons and one gallon is a very low rate, but when you have much lower hydraulic conductivity the rate will even decrease further and it'll be below the lower limit of most submersible pumps or pumping systems.
Q All right. Thank you. That's fine. You can sit down.
A Okay. Thank you.
MR. HAYNES: All right. For counsel's benefit I'm going to go to DEQ Exhibit 34, which is entitled -- I think the title of the exhibit is, "Figures For Appendices B-2 and B-2." Okay. And in that exhibit I'm on page five.
Q Mr. Wozniewicz, do you recognize this page five that's up -- that's on the screen?
A Can you give me the figure number on the Golder report, please?

Q Sure. It's Figure 3-1.
A Figure 3-1?
Q Right. And it's for borehole 47.
A Okay. Yes.
Q Do you have it in front of you?
A Yes.
Q Now, one of your slides on direct examination showed one of the figures that we're going to go through.
MR. HAYNES: And just for the record that was slide -- new slide 34, which has hole 84. We'll get to that in a minute.
Q But would hole 47 -- now, sir, this slide and the six or so after it show various measurements of various parameters; correct?
A Correct.
Q And they show -- it shows, for instance, the temperature of the water in the hole; correct?
A Correct.
Q That's the second group from the left?
A Correct.
Q And the first column from the left shows what?
A It's a caliper log. It shows the diameter of the borehole.
Q Okay. And then the third column from the left shows -- well, I guess -- let's back up. On the very left-hand side is a legend that shows the type of rock that the hole goes

through; correct?
A That's correct.
Q And that's explained in the -- on the far right; correct?
A Correct.
Q All right. Now, going back, the third column from the left shows two things: one in blue and one in black. What is the line shown in blue?
A Blue is fluid resistivity and black is fluid conductivity.
Q And the fluid resistivity is not something that you've testified to today; correct?
A That's correct. We didn't -- and we didn't emphasize that in the -- that measurement in the investigation.
Q Okay. And the fluid conductivity; that type of conductivity is different than hydraulic conductivity; correct?
A It's an indication of the fluid properties.
Q All right. So it's a chemical question; right?
A Water quality properties; that's correct.
Q Okay. And is a shorthand for the fluid conductivity the TDS?
A You have to make some -- the measurement is an indication for the TDS, but you have to make some -- include some variables to make that calculation.
Q Okay. And the TDS is total dissolved solids; right?
A Yup.
Q And so when you're measuring fluid conductivity what you're

measuring is in some instances at least the salinity of the water; correct?

A Well, in this case the reason we didn't emphasize any of the fluid conductivity, because we were getting mixing of the drilling water that was left in the borehole, maybe mixing of different zones. So we primarily used the fluid resistivity and conductivity for inflections to show where there's potential conductive features. So that was it.

Q Okay. But this column, the fluid conductivity is what you referred to in your testimony as the water quality testing that confirmed your earlier --

A No. No, we -- to get representative water quality samples you can't use this to get representative water quality because you've got the fluid in the borehole which may be left over from drilling and natural formation. What you have to do is isolate it in interval, you have to remove the water in interval and packer, you have to pump out sufficient volumes until the parameters stabilize until you consider you're getting representative samples from the formation to get a representative water quality sample.

Q All right. But you used the conductivity in your analysis, didn't you?

A We only used where we saw differences as potential indicators where there will be localized zones of moderate hydraulic conductivity.

Q So your answer to my question is "yes," you used the conductivity in your analysis?
A We used -- not the conductivity directly; we used inflections in conductivity and inflections with the other -- in conjunction the temperature and heat pulse meter to try to interpret where there may be zones of water hydraulic conductivity.
Q All right. But when you say "inflections," what you mean are changes in the direction of the line; correct?
A That's right. That's right.
Q So for hole 47, which we have here, for the conductivity -- the fluid conductivity line, if we go down to, oh, say the 75-meter depth there's an inflection in the line?
A Yup; yes. But there's no inflection in the temperature line, so I would say for -- you know, I would say we want to do the packer testing to confirm that but there's no major inflection in temperature, so it may or may not be a zone of moderate conductivity. And then perform the packer test to confirm or refute that.
Q Okay. But certainly if we go -- and the scale here, by the way, is from zero to 20,000 for the conductivity; correct?
A That's right.
Q So that's a pretty large difference, isn't it, when you're dealing with several orders of magnitude; right?
A Again, we just looked at it because the water quality is a

mixture of the water in the borehole from past drilling. We just used it for inflections, so we didn't look at the magnitude.
Q You said that, sir. My question is, from zero to 20,000 is several orders of magnitude; right?
A Yes.
Q Okay. So if you have a change here in the conductivity from, you know, somewhere -- and this is a log scale, is it? No, it's not a log scale. You know, we're going along from the surface down and we have the conductivity of about 2,000 and then we have a change further down the hole to about 10,000; that's a significant change, isn't it?
A Yes.
Q Okay. And then in this hole 47 the conductivity drops again to near zero; right?
A Yeah, and that's a common end effect you see. Because you're measuring at the bottom of the borehole you see a common distortion in the flow log anomaly.
Q Okay. And the borehole went down to how far; hole 47 went down how far?
A Let's see.
Q It looks like it went 250 -- 260 meters down; right?
A Total measured depth was 268 meters.
Q Okay. And when the conductivity starts inflecting back towards zero that's at the 200-and -- oh, -25-meter or so;

correct?
A Correct.
Q So you've got maybe 40 meters, 120 feet of borehole, which has a significantly different conductivity than the upper portions?
A The meaning is -- and we don't know what the meaning is. It could be from -- just from mixing of fluid left over from drilling that wasn't properly taken out. Again, we -- because you're getting mixing of different waters in the entire borehole and you're getting mixing of water left over from drilling we didn't emphasize the conductivity measurements; we emphasized the packer testing afterwards.
Q All right. You said that. I understand that. Let's go to the next page, page six of this exhibit. Page six deals with hole 54; correct?
A Correct.
Q And if we look at the conductivity line here, sir, --
A Yup.
Q -- there seems to be a fairly quick break there toward the bottom of the hole; correct?
A Correct.
Q And you didn't think that was significant?
A Again, we looked for deflections in the borehole. There wasn't a major deflection in the temperature. And then when we subsequently did the pump test we did the pump testing

for the flow log and the rate was relatively low to be consistent with low hydraulic conductivity bedrock.
Q All right. You didn't do a pump test in hole 54 at the bottom, did you?
A We did a pump test over the entire interval. We put the pump at 15 to 20 meters and we pumped flow from the entire interval.
Q For the entire hole?
A From the entire borehole.
Q Okay. And did the -- and that was the six-hour pump test?
A I don't know the exact number, but roughly on the order of several hours, my understanding is.
Q Did you evacuate the entire hole with the pump test?
A No, we pumped -- the idea of the pump test for flow logging is you want to maintain a constant rate, and so we pump tested at -- the maximum rate we could pump at with the pump depth of 20 meters was, I believe -- let me see -- .5 gallons per minute. So with the pump at 20 -- 15 to 20 meters the maximum rate we could get was around .5 gallons per minute from 268 meters of borehole.
Q Okay. Would you agree with me, sir, that for hole 54 where we have on the conductivity line sticking pretty close towards zero that that suggests that that's fresh water?
A No. The conductivity has no indication of the in situ representative water quality of the formation, because you

have fluid left over from the drilling, you've got mixing of fluid in the borehole, its entire open hole, so I wouldn't say that's representative of the formation. You have to get the representative formation from water quality samples collected through proper tests.
Q   Sir, you know what the substance called "Triddium" is, don't you?
A   Triddium?
Q   Triddium, yes.
A   Yes, I do.
Q   You've seen sample results for the chemical analyses for the boreholes at the proposed Eagle Mine that contain Triddium?
A   Yes, I did.
Q   Okay. You're aware that Triddium was found at some of the lower depths in the lower bedrock aquifer?
A   Very low concentrations; below .8 my understanding.
Q   Right. I also noticed, sir, in your résumé that you used a program at a mine in Arizona, a program prepared by Golder called "FracMan"?
A   Correct.
Q   All right. What is FracMan?
A   FracMan is a discrete fracture network model.
Q   That is used for what?
A   For representing flow in fractured rocks settings.
Q   And we have at the proposed Eagle Mine a fractured rock

setting, don't we?
A We have a fractured rock setting.
Q And you didn't use FracMan for this proposal, did you?
A No, for inflows -- for large-scale inflows we used a combination of the FracMan technique, which is the discrete fracture method and the porous media method. So because we have -- 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 then we kind of took the Fracman approach and put in -- because we had -- we found these moderate conductive zones that were considerably higher than the background, then we put them in discretely. So we had a combination of the discrete fracture network approach and the porous medium approach.
MR. HAYNES: Thank you, sir. That's all I have for now.
MR. EGGAN: I just had a few questions.
JUDGE PATTERSON: Okay.
MR. EGGAN: Sir, my name is Eric Eggan and I represent some of the petitioners in this matter also, particularly with respect to groundwater. Just a question or really just three or four questions, I'm sure.

CROSS-EXAMINATION

BY MR. EGGAN:
Q But did you do the characterization for the April 6th and

July 6th predictive models in the area of the TWIS?
A No. I didn't do any modeling and we were -- only did the bedrock part.
Q Okay. You did the -- you were focusing on the characterization that led to the bedrock models?
A For the -- yes; that's correct.
Q Okay. And the data you collected, it was critical that you collect accurate data?
A That's correct.
Q Because you want data going into those models, you want them to be as accurate as possible?
A Correct.
Q And it's also important to collect an adequate amount of data, isn't it? In other words, to have sufficient data to really make the model be realistic?
A That's right, and that's typically -- that's based on the conditions you encounter at the site, professional judgment and experience.
Q Okay. But there are also ASTM guidelines that -- or standards that require characterization and tell you how that characterization is done?
A That's correct.
MR. EGGAN: Okay. Sir, I don't have any other questions.
THE WITNESS: Thank you.

MR. EGGAN: That's it for me, your Honor. Thank you.

JUDGE PATTERSON: It's actually six.

MR. EGGAN: Was it six?

JUDGE PATTERSON: I was counting. You were close.

REDIRECT EXAMINATION

BY MR. LEWIS:

Q Mr. Wozniewicz, I wanted to ask you to the extent that -- perhaps muddied a little. This is a surface up here in the orebody -- again, not to scale or anything, but -- and we've talked about this intrusive that's close to this orebody?

A Yup.

Q And this (indicating) is -- I understand it is -- we've been referring to as peridotite in this?

A That's correct.

Q And this being the orebody, and then out here we have sedimentary?

A That's right.

Q And just to be clear, when I wanted to ask you about these test holes that you used, how many of those in fact penetrated those three layers and penetrated -- in other words, penetrated the sedimentary -- penetrated the contact between the sedimentary and the peridotite and also penetrated the contact between the orebody and the peridotite?

A So all the boreholes except the one out to the east contacted all three major units. So all boreholes contacted the host rock, the peridotite and the orebody, except for 20, which was outside the influence of the orebody.
Q And is that eight of nine?
A That's number 20, I believe.
Q But the total?
A The total? There's the total of nine boreholes, so eight, yeah.
MR. LEWIS: Thank you. That's all I have.
MR. REICHEL: May I have just a moment, your Honor?
JUDGE PATTERSON: Uh-huh (affirmative).
MR. REICHEL: I have no questions. Thank you, sir.
MR. HAYNES: Nothing further.
MR. EGGAN: Nothing further, Judge.
JUDGE PATTERSON: You're done. Thank you very much.
THE WITNESS: Thank you, sir.
(Witness excused)
JUDGE PATTERSON: Take a quick break?
MR. LEWIS: That's fine, your Honor.
(Off the record)
JUDGE PATTERSON: Whenever you're ready.

MR. LEWIS: The intervenor calls Mr. Willy Zawadzki.

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

MR. ZAWADZKI: Yes, I do.

WILLY ZAWADZKI

having been called by the Intervenor, testified as follows:

DIRECT EXAMINATION

BY MR. LEWIS:

Q Even though I tell people that your name is spelled just like it sounds, would you please state and spell your full name for the record?
A My name is Willy Zawadzki. It's Z-a-w-a-d-z-k-I.
Q And Willy is W-I-l-l-y?
A That's correct; W-I-l-l-y.
Q Mr. Zawadzki, you're also a hydrogeologist with Golder?
A That's correct.
Q And you're the person that Mr. Wozniewicz referred to earlier that did the modeling part of this hydrogeology work?
A Yes, I am.
Q And I think you're originally from Poland; is that right?
A Yup. I was born and grew up in Krakow, Poland.
Q And you did some of your initial engineering hydrogeology work there?

A Yes. I started the hydrogeology engineering program in the University of Mining and Metallurgy in Krakow, Poland, then I transferred to the University of British Columbia where I completed BSC degree in geology and immediately after I did graduate degree, MSC degree in hydrogeology at the same university.
Q And your degrees are in, you said, both geology and hydrogeology?
A Yes.
Q And you have certain professional affiliations as well?
A Yes. I am a professional geologist with the Association of Geoscientists and Engineers of British Columbia. I'm also a certified groundwater professional with the National Association of Hydrogeologists in the U.S. I'm a member of the International Mine Water Association and the International Association of Hydrogeologists.
Q And would you take us through your career since you obtained your master's degree? What have you done professionally in this field?
A Upon graduation I started with Vancouver office of Golder Associates in 1996 and I've been with that office ever since. I started as a junior hydrogeologist and gradually became senior hydrogeologist. In 2003 I was made an associate, which is the equivalent of being a junior partner in the company. And in terms of the work that I've done, I

have a bit of experience in hydrogeological aspects of contaminated sites, primarily in the design of hydraulic containment systems to prevent discharge of contaminants into the environment. I did some work in aquifer protection and water supply, but more than 50 percent of my work relates to mining hydrogeology. And I work on various projects throughout the world practically on any -- on all the continents. And most of these projects -- or I should say all of these projects require some sort of a modeling in support of these studies.

Q Have you also been a lecturer at the university?

A It's true. In the year 2000 I was asked to teach a third-year undergraduate course in hydrogeology at the Department of Earth and Ocean Sciences at UBC and since then I did it in 2001, 2007 and I will be teaching this fall. It's a third- and fourth-year groundwater course.

Q Groundwater hydrology?

A The third-year course is groundwater hydrology, which is an introductory course, the physical hydrogeology, and the fourth-year course is contaminant hydrogeology.

Q And that's at the University of British Columbia?

A That's right, in Vancouver in Canada.

Q And you also have a number of publications listed in your CV; is that right?

A Yes, I have several publications, most of them peer reviewed. Some of them refer to hydrogeology contaminated sites that I mentioned earlier; some of them refer to -- relate to some basic research that I did as part of my master thesis and then later on in collaboration with people at UBC and that had to do with scaling properties and data work of hydraulic conductivity measurements primarily based on slag tests or single well response tests and pumping tests. And I have several papers that relate to mining hydrogeology.

MR. LEWIS: Your Honor, for the record, Mr. Zawadzki's CV is Intervenor Exhibit 398.

JUDGE PATTERSON: And, again, for the record that's been stipulated to.

MR. HAYNES: Yeah; that's correct.

MR. EGGAN: Yes.

MR. REICHEL: That's correct.

Q Mr. Zawadzki, you've prepared some slides also to assist in explaining your testimony and I'd like to ask you: have you had experience in these hydrogeology studies in connection with excavations under and near water bodies?

A Yes. I would say that most of the projects that I have been involved with were under water bodies that were larger than the ones that we are considering for the project, for the Eagle project.

Q Can you give us a few examples of that?

A One project that I was involved with -- maybe you can bring up the first slide.

MR. LEWIS: Let's look at slide number 1, please.

A It's a project that I've been involved since 2001. It's located in Vancouver, British Columbia on the north shore and it involves construction of two 7.2-kilometer long tunnels that were -- just one second here -- that were started right here (indicating), which is a dam and the manmade reservoir water called Capilano Lake right there. And the tunnels will cross under the residential area here under Grouse Mountain and the ski resort up above Grouse Mountain. And there is a residential area on the other side of -- east side of the mountain, and finally next to the Lynn Creek.

In cross section again, this is where the Cleveland Dam is located and the Capilano Reservoir. We have a major river right here, it's Capilano River. That's the shaft. Tunnels will cross to the other side of the mountain, come up through the -- water will come up through the shaft right here. That's Lynn Creek. And also nearby the eastern terminus of the town we have a lake called Rice Lake which is right about there. And we did hydrogeological characterization for this project, and in support for this project I developed a suite of free flow models which were used to predict inflows through these towns during

construction and after water, so after the towns are pressurized. And also we looked at the interactions between the overburden and bedrock.
Q So similar on a larger scale to what you've done for the Eagle project?
A Yes. That's a larger scale project; it's 7.2-kilometer long tunnels, twin tunnels.
Q And if we could turn to the next slide, I think you included some representative examples of mining projects in bedrock with which you've had experience?
A That's correct. This is a list of major projects that I was involved that relate to mining in bedrock, and specifically projects in which we use TFlow to make predictions of groundwater inflows or poor pressures behind pit slopes and things like that.
Q And TFlow is the modeling that you used for the Eagle project as well?
A That's right. That's the numerical code that was selected for the development of the -- what's called "bedrock groundwater model." And I grouped them into three subgroups, so we have some underground mines that I worked on, which some of them are located in the Northwest Territories, in Turkey, Mexico and British Columbia and Australia. Then I have a list of open pit mines where we used TFlow. So, again, Northwest Territories, China, in

Kazakstan and Peru and in Indonesia. And finally three tunneling projects in Aberdeen in British Columbia, another project in British Columbia, and then a mining project in Peru.

Q Next I'd like to turn -- we've got a slide that has I think two of the Golder reports. I talked with Mr. Wozniewicz about some of the other Golder reports, but these two we've listed for you. And could you describe briefly what these two reports discuss and what the purpose of them is?

A They discuss -- the first report summarizes the hydrogeological investigations that were conducted at the Eagle site and then discusses the preliminary and revised bedrock groundwater model. And my responsibility within that report was the development in conjunction with Mr. Wozniewicz of the conceptual bedrock hydrogeologic model and then numerical groundwater model which was developed using TFlow. So that's the first report.

And the second report, which is dated April 2008, here we conducted some additional predictions of mine inflow based on the permitted mine plan, and we also incorporated some new analyses that Dr. Carter discussed, and we also conducted sensitivity analyses on the predicted inflow.

MR. LEWIS: And for the record, the first report Mr. Wozniewicz referred to is in Intervenor Exhibit 7; it's also referred to as Appendix B-4 to the mine permit application. That's Bates range 104410-104473. And the second report is identified as Intervenor Exhibit 399.

Q I'd like to turn next then, Mr. Zawadzki, to a discussion of the initial bedrock hydrogeological modeling you did, if we could go to slide 4, please?

A That's right. So I have to step back somehow in chronology that Mr. Wozniewicz discussed and take us back to the preliminary site investigations after which the preliminary bedrock model was developed. And that preliminary bedrock model was based on the preliminary conceptual model that we developed with Mr. Wozniewicz, which was developed at the end of Phase I field investigations that were done in 2004. That conceptual model consisted of three hydrostratigraphic units: the upper bedrock, which based on field testing we inferred to extend down to 90 meters below ground surface and with hydraulic conductivity of 2 times 10 to the minus 8 meters per second, so a relatively low hydraulic conductivity. And the lower bedrock unit, which we inferred to extend below 90-meter depth with even lower hydraulic conductivity of 5 times 10 to the minus 10 meters per second.

And finally a third hydrostratigraphic unit is water conducted features, which we encountered in one, possibly two boreholes at the site. To be conservative in this conceptual model we included a suite of these

conductive features -- we assumed that they are vertical -- to maximize the connection between the upper bedrock and lower bedrock. We made them relatively long. At that time we didn't know what the length of these features could be so we made them one to two kilometers long. And we had them oriented both in a north-south and east-west direction at horizontal spacing of 120 meters going east to west and 225 meters going north to south. So --
Q   And you had 11 of the north-south features and five of the east-west features?
A   Yes. So although at that time the field data indicated the presence of one, possibly two feet or anomalies in flow logging, we decided to incorporate 16 of these features in the model.
Q   And if we go to the next slide, I think that is a description of how you incorporated the mining plan into the model?
A   That's right. That mining plan was provided to us by Kennecott and it called for ten-year-long mining. So during the first two years that's just the construction of the decline down to 143 meter elevation, and then between year one and three mining would progress upwards from an elevation of 143 meters to 263 meters, and then between years four and eight mining would continue from elevation of 263 meters to 303 meter elevation. I want to make a point

here that this preliminary model included mining up to the elevation of 383 meters; whereas, the permitted topmost mine level is 327.5, I believe.
Q Is what?
A 327, the meter elevation. So in the preliminary model we were assuming that mining would progress to higher elevation than is in the permit.
Q And is that one of the revisions you made later in the latest report, Exhibit 399?
A That's correct. That was the purpose of -- one of the purposes of the April 2008 memorandum.
Q And if we could go to the next slide, I think you've got some further description here about what you call the "Preliminary Bedrock Numerical Model"?
A So a normal step in the modeling study is after the conceptional model is developed one has to decide what is the most appropriate tool to implement that model numerically or mathematically. And there are several modeling codes that could be used. We decided to use FEFLOW, because FEFLOW has certain characteristics that allow us to incorporate the conceptual model as good as we can for the project. So the main characteristic that FEFLOW has is the capability of incorporating discrete water conductive features.

In FEFLOW this is done using to the planer discrete elements that can be oriented at arbitrary angles and they can be of arbitrary length. And it was important because this is what we encountered in the lower bedrock. We suspected the presence of one, possibly two water conductive features. And our conceptual model on which we decided to base this model called for 16 of these features. At the same time FEFLOW can simulate what's called equivan (pronouncing) *2:35:23 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.

Finally FEFLOW can simulate mining quite accurately because it allows for fairly complex boundary conditions that can quite accurately simulate the progress of mining throughout the mine life. So they were the reasons why FEFLOW was selected for the study.

Q And then can you describe the extent of the model you created here?

A The model is relatively large; it covers an area of 87 kilometers square and it's about ten kilometers by eight kilometers. Vertically it extends from the top of bedrock down to the elevation of minus 250 meters which takes it 400 meters below the lowermost mine level. This is important because we made sure that the dimensions of the model are such that the drawdown that could be created by mining would never intersect the outer boundaries of the modeling. In other words, the model is conservative because there is no influence of the outside boundaries from model predictions.

In terms of boundary conditions and any groundwater model that requires boundary conditions, they are linked to the outside world, we used specified head boundary along the top of the upper bedrock to simulate leakage from the overburden. Now, I want to add that that type of boundary assumes unlimited leakage from the overburden into the rock. In other words, it's like putting a lake on top of the upper bedrock, so it's a very conservative boundary from the perspective of predicting the inflows.

Everywhere along the perimeter of the model and at the model bottom we assumed low flow conditions. And, again, these boundaries are set far away from where the mining was simulated, so there's no influence on these boundaries on model predictions. And finally, we used specified head boundaries to simulate progress of mining and these boundaries were assigned everywhere along the decline, accesses, ramps and stopes and they were set to atmospheric pressure. In other words, they allowed unlimited -- unrestricted inflow of groundwater into the mine workings. So another conservative assumption that was used.

Q I think your next slide illustrates how the model is actually put together, or it's a illustration of that?
A That's right. That's a graphical representation of the model, so here (indicating) on the lower left side, this is the plan view, that's the scale four kilometers. And the green line here shows the extent of the model. This little -- it doesn't show very well, but that line here indicates the decline, and this is the location of the ore body. The triangles that you see here; this is the finite element mesh that the model is using to soil groundwater flow equation. It's one of the mathematical methods of solving the flow problem. On the right-hand side we see an oblique view of the finite element mesh. So again, this is the model top and the base of the model mesh is the elevation of minus 250 meters, so well below the bottom of the proposed mine workings.
Q And why does the figure in the lower left appear darker in the center around the mine itself?
A This shows that the finite element mesh used for modeling was refined in the vicinity of the mine workings. And that's a standard modeling technique where we want to have relatively high resolution, spacial resolution in the sizes of finite elements near the area of interest -- in that case mine workings -- to provide accurate predictions. And as you move away from -- as you move away from this location

you can go to courser elements, because it's not really that important to have very accurate predictions at greater distances. The reason for that is that during mining we -- in bedrock you would expect fairly high hydraulic gradients in the vicinity of the workings and these gradients would be very weak or none at great distances from the mine.

Q How many of those little triangles in that mesh are there?

A There is approximately 180,000 finite elements in that model.

Q And what do each of those represent or what do they mean?

A Well, what the model does or -- that applies also to MODFLOW type models which would be an alternative for FEFLOW. The models break the model domain -- in our case it's just bedrock -- into smaller area, volumes. And then at each of these elements it looks at the water balance or how much water is coming in, how much water is coming out, and it also checks the water balance over the entire model domain, so for all these elements. And the water balance just by conservation of mass has to come out to zero, and based on that solution the model calculates hydraulic heads -- well, let's call them water levels, but hydraulic heads at each of these little dots, each of the intersections of finite elements. And using these hydraulic heads one can then predict groundwater velocities, hydraulic gradients and in our case inflow to the mine workings.

Q And if we turn to the next slide, I think this -- could you describe how this relates to this initial modeling?
A So I mentioned that any model required boundary conditions, but we also need what's called "initial conditions," which is a starting point for any transient simulation. And in this preliminary model we assume that groundwater is at hydrostatic conditions in the model. In other words, there's no flow -- significant flow in bedrock. And this is consistent with our observations with respect to the vertical hydraulic gradient which is close to nil. And with respect to the horizontal gradient this was not necessary to incorporate in this model. And the reason for that is that the hydraulic stress that will be imposed by mining on the bedrock is much harder -- much, much, much higher than any lateral groundwater flow that might be occurring under natural conditions.
For example, near the mine workings we will be expecting about 200-meter pressure drop due to mine dewatering in deep bedrock; whereas, even if there were some horizontal flow in bedrock we would be expecting changes on the order of a meter or maybe two meters over project area. So it's not necessary from the perspective of predicting mine inflows to incorporate any small premining horizontal groundwater flow in bedrock.
Q And if we continue then, Mr. Zawadzki?

A So at the end of Phase I field investigations we had the results of flow logging, we had the results of Parker testing and we constructed our preliminary conceptual model. We didn't note any transient data to which this preliminary model could be calibrated, so at that stage we did not conduct any model calibration; however, we did so at the conclusion of Phase II field investigations. So based on the preliminary model we simulated progress of mining and we estimated that the mine inflow could reach about 180 USgpm after three years of mining, and then that that inflow would gradually decrease. So that was the conclusion from the preliminary modeling study.

Q And then you made recommendations at that point?

A That's right. At that time -- this was -- these actually are recommendations after Phase II field investigations, where we conducted the additional testing in one of the boreholes in the upper bedrock, and we also conducted transient pumping test in borehole 84 that Mr. Wozniewicz was talking about. We made some recommendations for revision of the numerical model. We concluded that there was no need to adjust hydraulic conductivity of the upper bedrock, and we capped it at 2 times 10 to the minus 8 meters per second. And we also concluded that we have to calibrate the model to the results obtained during the pumping testing in borehole 84, which indicated that the

water-conductive feature that we tested is likely shorter and poorly connected to any other feature that might exist. So these were the recommendations for the revision of the model, which were also reported in the February 2006 report.
Q So the 185 gpm, that was the preliminary model before you had the testing that Mr. Wozniewicz referred to earlier?
A Yes.
Q And then it was based on that in part that you concluded you should revise the predictive model?
A Sorry. Could you rephrase that?
Q It was based on that additional testing that you decided you should revise that preliminary modeling?
A Yes; yes, that additional testing guided us in terms of ablating or revising the numerical model.
Q And when you say that -- you refer to calibrating to the hole 84 pump testing, are you talking about making the model match that in effect? Is that what you mean?
A Yes.
Q And if we look at the next slide, then, I believe this is your discussion about revisions then to the numerical model, Mr. Zawadzki?
A That's correct. The first thing -- now we are moving into the revised groundwater model, and the first thing that we did as part of the study, we took our preliminary model and simulated the pumping test that was conducted in borehole

84, and we wanted to compare what would be the response in the model with the response that was observed in the field. So on this graph, what you see on the left axis, we have drawdown expressed in meters, and it's increasing with that. On the top axis, we have time in hours. The blue line, then -- I believe you saw that diagram earlier on today when Mr. Wozniewicz was discussing the test.

The line here represents drawdown that was measured during the pumping test in the borehole 84. And the red line is the drawdown predicted by the preliminary model after that test was simulated in the model. So it's a model-generated drawdown. And as you can see, during the pumping test, that, at the end we had drawdown of over 190 meters; whereas, the preliminary model, that drawdown is about a factor of 5 less. The other important characteristic to note here is that, in the preliminary model, the drawdown stabilized, and it remained constant, indicating that -- and that's understandable.

We -- in the preliminary model, we have a network of well-connected features, so that network responded, and the drawdown stabilized; whereas, during the field test, the drawdown continued to increase. It never stabilized, indicating that that feature that we were testing at the site was relatively short and poorly conducted. So we knew that we would have to make adjustments to the model to bring it closer to reality. At the same time, this shows that our preliminary model, with whatever limited data we had after Phase I to the investigations, was on the conservative side, because overall it predicted lesser drawdown than was measured during the test and, if you turn it around, it would predict greater inflows to the proposed mine.

Q And then, if we turn to the next slide, I think that's an additional description of what you've just been talking about and your additional -- and your calibration of this model?

A That's correct. So as I mentioned, the first thing that we did, we too, the preliminary model, simulated the test and realized that there's quite a discrepancy between model-predicted drawdown and observed drawdown. So now, during model calibration, we started making adjustments to the model to calibrate it to the pumping test. And what we did, we removed the connections between water-conductive features in lower bedrock. We eliminated all the features that were running east/west, and we started looking at the length of the remaining water-conductive features in lower bedrock, and we gradually reduced their length.

So the graph here on the left showed the result of model calibration. Again, this is drawdown expressed in meters, and the blue line here is the measured drawdown during the pumping test; whereas, the red line is drawdown predicted by the calibrated model. So as you can see, that drawdown matches quite well what was observed in the field. That's good calibration result. On the right diagram, what you see is the progress of calibration. On the left we have radio transmisivity inferred from the pumping test results, and the top here is the time.

The blue dots here represent transmisivity inferred from the pumping test. The magenta line here represents the transmisivity inferred from the simulated drawdown using the preliminary model. And as you can see, these two lines diverge, and this is consistent, because the transmisivity later on in the test is increasing, which suggests that we are encountering more and more well-connected features, which was part of our preliminary model.

As we started reducing the length of these features and this line -- let me just check the length here. The yellow is -- we have now features only 320 meters long. The light blue line we have features 175 meters long. And finally, when we brought these features to 145-meter length, we achieved good match between what was observed in the field and what the model predicted, and we considered that model calibrated to the pumping test. So that's the calibration that we conducted.

Q Dr. Prucha indicated in his testimony that you all have not

calibrated your model. Do you know why he would say that?
A I believe that we calibrated the modeling transient mode to the pumping test in borehole 84.
Q Would you continue your discussion of this revised modeling on the next slide then, Mr. Wozniewicz?
A So this is a summary of the adjustments that were made to the preliminary model, which now brings us to the revised model. We have reduced the length of water-conductive features to 145 meters and eliminated the connections between these features. We also reduced slightly the transmisivity that was assigned to water-conductive features to 1 times 10 to the minus 6 meters squared per second.
Q And are you using that term now synonymously with hydraulic conductivity, or is it a different term?
A Transmisivity is defined as the product of thickness of the unit in hydraulic conductivity. In -- when dealing with fractured rock, it is very often more convenient to use the term "transmisivity," because very often one does not know what the thickness of the water-conductive feature is, so, yes.
Q I see here in transmisivity you're using the units meters squared per second?
A Yes.
Q And in the hydraulic conductivity we were talking about earlier, the units were simply meters per second?

A Meters per second, yes. And overall both describe transmissive properties of porous media or in this case water-conductive features. So these were revisions that we made to the model, and then we ran two cases to predict mine inflow, a Base Case, which was based on the calibration to the test in borehole 84. And again, we had the network of poorly connected 145-meter-long features. And that base -- in our opinion, that Base Case provides most likely inflows that could be encountered during mining. And we also ran what we called an Upper Bound Case. In this case we used the preliminary model, which included the network of well-connected features, and this scenario provided a reasonable upper bound of the inflows that could be encountered during mining.
Q So you incorporate some of the features of the preliminary model for the Upper Bound Case?
A Basically it is the preliminary model.
Q Okay. And in reference to Dr. Prucha's testimony again, as you may have read, Mr. Zawadzki, and in terms of what Mr. Wozniewicz talked about in terms of the -- what you were able to pump out of this -- the highest conductive feature you encountered, I think he said it was 1.6 gallons per minute?
A Yes; that's correct.
Q How does that relate -- how does your actual findings here,

based on this testing, relate to Dr. Prucha's suggestion that there could be an inflow rate as high as 3,000 gallons a minute?

A Well, the best I think would be to compare it to the -- to our pumping test and the calibration progress. So our calibrated model for the drawdown of 195, I believe, meters that corresponds to a pumping rate of about 1.6 USgpm. Our preliminary model under-predicted drawdown by about a factor of 5. Well, these things are nearly linear, so you can turn them around. So in our preliminary model, to simultaneous drawdown equal to 195 meters, one would have to pump by a factor of about 5 more, so that would make it 10 gallons a minute.

Well, that's not what we saw during the pumping test, and then that's why we calibrated to that test. If you were to make additional modifications to that Upper Bound Case model, which includes a network of well-connected features, let's say make them longer, increase their hydraulic conductivity -- and that's the changes that I believe Dr. Prucha made in the model -- well, that pumping grade during the test would be on the order of hundreds of gallons a minute, and this is not -- something that we did not see in the field, so I don't think that adjustments and pumping rates predicted by the modified model are reasonable.

Q Now, on the next slide, I think you've got a discussion of additional modifications you made to the Base Case and Upper Bound Case?

A That's correct. We made two more modifications in our revised bedrock model. One had to do with the boundary condition that was used to represent inflow from the overburden. As I mentioned in the preliminary model, we specified the boundary to simulate inflow from the overburden, and that's a very conservative way of simulating that inflow. Again, it's essentially like putting a large water body on top of the model. We wanted to more reasonably simulate that leakage in the revised model, so we replaced that boundary with what's called 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. At the end, as I will discuss later -- and it's documented in our April 2008 memo -- the assignment of the topmost boundaries is not -- the model predictions are not that sensitive. It really doesn't matter. So that was one of the modifications. And the other modification was we incorporated rock dilation of facts in that model, which are potential changes in hydraulic conductivity that might be related to stresses that could develop around the mine workings. And we did that --

Q Now --
A Sorry?
Q Go ahead.
A We did that based on our experience at other mine sites. We assumed that hydraulic conductivity could increase by a factor of 3 with a 50-meter radius around all the underground openings.
Q Is that a conservative assumption?
A Based on work that Dr. Carter presented, I believe that this was a reasonable assumption; although, in our revised predictions, we incorporated these changes in a more rigorous way or I would say a very conservative way.
Q At this time you made this assumption, this was before Dr. Carter had done his initial analysis on stress-induced permeability changes?
A Yes.
Q And then, just jumping ahead a little bit, in your latest reporting, you incorporated Dr. Carter's analysis?
A Yes, we did.
Q And then would you continue then with your revised inflow predictions?
A Yes. So now we have our revised model that's calibrated to the -- in transient mode to the pumping test, and we incorporated those minor changes to the uppermost boundary condition and to -- and then we accounted for potential

changes in permeability to dilation. And again we ran predictions for our Base Case and Upper Bound Case. And in the Base Case we found that the mine inflow at its peak would reach about 75 gallons per minute, and in the Upper Bound Case, it would be 215 gallons per minute.

Q And then you have your recommendations there as well, Mr. Zawadzki?

A Yes. At the conclusion of the modeling study in 2006, we made recommendations, which are standard recommendations for any mine that I work on. One is to rigorously monitor mine inflows and also monitor hydraulic heads in the wells surround the mine. And then, if we were to see some discrepancies between model predictions and what was observed, we made a recommendation that one should go back to the model, use the model to guide any mitigation efforts that might be required to reduce inflows from the ones predicted by the model.

Q Such as grouting?

A Such as grouting. There are other options.

Q And I know you and I looked at the mine permit the other evening, and you're aware that there is a condition in the permit requiring Kennecott to do additional characterization once underground, including characterization of the hydraulic characteristics of the rock?

A Yes. I believe -- are you -- can you rephrase the question?

Q Yes. You're aware that there's a condition in the permit requiring that Kennecott once underground do additional drilling and characterization of the hydraulic properties of the mine?

A I am aware of the requirement for monitoring the mine inflows with different thresholds triggering different actions.

MR. LEWIS: Just for the court's reference again, your Honor, it was previously marked DEQ or Respondent Exhibit 117. It is the mining permit. It's been offered and being admitted into evidence. And Section E-8, again, just to take us back a little, states that:

"As each level is developed, starting with the lowest level, the Permittee shall collect in situ stress data and standard geologic, geotechnical and hydrologic data to evaluate rock stability for the overlying level or levels. Supplemental diamond drilling shall be carried out if necessary to fill in any data gaps, and a 3-D physical model shall be developed and maintained to accurately assess ground and hydrologic conditions."

Q Now, I think, Mr. Zawadzki, you're referring to the monitoring sections of that permit.

MR. LEWIS: And those again, for the court's reference, are in Section L, Paragraphs 9 and 10.

Q And that's where you probably recall, Mr. Zawadzki, the permit requires that the applicant take certain actions if the mine inflows exceed certain levels?
A Thresholds, yes.
Q Now I think we're ready to turn to the latest revised modeling that you did, as you indicated earlier, based on the final permitted crown pillar thickness and the additional analysis of the potential for stress-induced permeability changes by Trevor Carter, and I think that's what this slide is talking about, 14?
A Yes. So what we did, we took the -- our revised model, which was calibrated to the pumping test in borehole 84, and again we ran the Base Case prediction and Upper Bound prediction so network of short -- relatively short poorly connected fractures and then a network of well-connected fractures. And in that model we made two modifications before running the predictions. One had to do with the permitted mine level, which is at 327.5 meter. So what we did in the model, we removed all the boundary conditions that represent mine levels between 353 and 383 elevations. The other modifications that we made in the model, we incorporated stress-induced permeability changes that Dr. Carter talks about. And my understanding is that that assessment was done and, from the worst-case-scenario perspective, was very conservative. And we actually took

that very conservative assessment to the next level. What we did in the model, we increased the dimensions of all the mine levels by 30 meters into the walls, --

Q Laterally?

A Laterally -- which essentially neglects any resistance to flow that rock mass more fractured -- potentially fractured due to changes in stress would provide.

Q Essentially infinite permeability?

A It's essentially infinite permeability within the 30-meter zone around the mine workings, so that's -- you cannot be more conservative in incorporating these changes. And we also increased the hydraulic conductivity within the 10-meter zone above the mine workings by three orders of magnitude. So we incorporated these changes in a very conservative way in the model.

Q Now, as I recall Dr. Carter's testimony about his analysis, he actually predicted a clamping effect in the crown pillar above the mine. Did you take that into account in this new analysis?

A No, we did not.

Q And was that conservative also not to consider that?

A Yes, it is conservative because, if one were to reduce hydraulic conductivity above the -- in the model above the workings, that would provide some reduction in mine inflow. We did not include it in the model

MR. LEWIS: And for the court's reference again, Dr. Carter's report has been entered as Intervenor Exhibit 592.

Q And this next slide, I think, is a graphical representation of your Base Case and Upper Bound Case, Mr. Zawadzki?

A That's correct. First I want to mention the predicted inflows. So in the Base Case scenario, the revised model that incorporated now permitted mine level and incorporated more rigorous representation of potential changes in hydraulic conductivity due to stress, we predicted 60 gallons per minute peak inflow -- annual inflow I should mention -- peak annual inflow, and in the Upper Bound Case, 210 gallons per minute. Now, the --

Q And again, you've got gallons per minute on the right axis?

A Yes. The graph below shows the changes in mine inflow over time. On the right axis it's USgpm. And as you can see, during the first three years of mining, in the Upper Bound Case, the inflow increases and then essentially remains the same. Smaller increase is predicted for the Base Case, and later on in my line the inflow would essentially remain at that relatively constant rate.

Q Now, you've got some spikes there on the Upper Bound line, could you explain what those mean?

A These spikes are essentially an artifact of modeling, and they're also related to a conservative way how the mine is simulated in the model. What we do in the model, we divide the mine plan into one-year increments, and then we assume that, at the beginning of each year, the entire area to be mined is incorporated. In other words, if one level is to be mined in year three, we just open it up right at the beginning of that year in the model. What this does, it introduces huge stress in the model, which would not happen in reality.

In reality mining progress is gradually, so there is never a situation where the entire level, or two levels for that matter, are open. What this does, it puts the large stress, which leads to larger-than-real releases of water from storage. Sometimes this is referred to -- at least in tunneling, as inrushes, and this is what you see in these peaks. What we do, we use this entire curve to calculate average annual inflow, and this is the dot right here. In other words, that big inflow will never occur in reality.

Q As you said, an artifact of the model?

A It's just an artifact of -- conservative way of modeling mine workings.

Q Now, in addition to the calibration that you did earlier and discussed earlier, I think you indicated you also did a sensitivity analysis that's reflect in your latest report, Exhibit 399. And could you explain what that is, please?

A Yes. We run sensitivity analyses. That's one of the standard techniques that is used in groundwater modeling that allows one to assess how sensitive model predictions are to the uncertainty in the modeling parameters. So that's the -- that's what sensitivity analysis does. What we did, we run six sensitivity scenarios, and we looked at ranges of parameters or model assumptions, and then we looked at how that affects inflow.

So the first two we looked at the hydraulic conductivity of the upper bedrock and hydraulic conductivity of the lower bedrock, and then these two sensitivity analyses, we went back to the data, and we looked at the highest and lowest hydraulic conductivity that was measured in upper or lower bedrock, and we varied that parameter based -- over that range. So these are these factors that you see. So for example, for the hydraulic conductivity of the upper bedrock, we increased it by a factor of 5 from the Base Case value, and we decreased it by a factor of 10 from the Base Case value, which spans the entire range of what was measured in the upper bedrock.

For the hydraulic conductivity of the conductive features, while -- we are already testing one of the most transmissive features of the site, so that number that we are using -- the value of hydraulic conductivity that we are using for this feature is conservative. Nevertheless, we varied the properties assigned to this feature by a factor of plus minus 5 from the calibrated value. We also looked at the number and conductivity of the conductive features. While -- especially from the results of our pumping tests, it seems that there's only one water-conductive feature at the site.

So what we did in our Base Case, it's fairly conservative. We have eleven of these features in the model. So in sensitivity we removed ten of these features and just retained one for the Lower Bound. And then for the Upper Bound Case for that sensitivity simulation, we assume a network of well-connected features like in our Upper Bound scenario for mine inflow predictions. We also looked at the orientation of water-conductive features. But again, in the model conservatively, we assumed that these features are oriented north to south to maximize the intersections with the mine workings.

We don't quite know how these features are oriented. They might as well be oriented east to west, so we changed the orientation to east to west. And finally, we looked at how sensitive the model is to the boundary conditions both at the top of the model -- and that's the boundary that represents leakage from the overburden -- but also along the perimeter of the model, and we changed both these boundary conditions to specify that. In other words, we put a large body of water in the top of the model, and then we surrounded the model with a large body of water. So these are the six sensitivity simulations that we considered.

Q Now, in point number 4 there just a moment, you've already got eleven of these features in the Base Case model?

A Yes; that's correct.

Q By the testing you've only really identified one?

A Yes.

Q And then you actually -- for the sensitivity analysis, you increased the eleven number even further?

A For the Upper Bound for that sensitivity simulation, we had 16 features that were over a kilometer long that were all connected.

Q And I think this next slide illustrates the results of the sensitivity testing and puts it in relationship to your Upper Bound and Base Case numbers, Mr. Zawadzki?

A Yes.

Q And could you explain what this shows, please?

A This diagram presents the results of sensitivity analyses. And what I did here, I sorted the individual sensitivity runs from the ones that caused the greatest impact on model predictions towards the ones that had lesser or least impact on predictions. On the left axis, we have inflow, so right here it's 60 USgpm, which is our Base Case, and this is our

Upper Bound Case at 210 USgpm. And what we found from the sensitivity analyses is that the model is most sensitive to the hydraulic conductivity of the upper bedrock to the number and conductivity of water-conductive features and to the hydraulic conductivity of water-conductive features.

For the parameter that's most sensitive, when we varied it over the range of values that were measured in the field, we got an inflow ranging from 15 gallons per minute all the way up to 150 gallons a minute; for the number and the conductivity of permeable features, from 40 to 110 gallons per minute. What is important to note here, that even -- none of these sensitivity simulations get anywhere close to the -- to our Upper Bound Case, which indicates that we used good professional judgment for selecting the features for our Upper Bound model. As I indicated before, it provides reasonable Upper Bound predictions of mine inflow, and our Base Case model provides most likely inflow predictions.

Q And I think on the next slide you've got a discussion about you did another assessment, assuming there was a large conductive feature somewhere near the mine workings. And would you describe what you did here, please?

A Yes. What we wanted to find out is what would be the impact of significant water-conductive features that would not intersect the mine workings, and from our testing we believed that there's no feature of the plan intersecting the workings, but that could be located in close proximity to the workings. So we took our revised model, Base Case model, and we incorporated the feature that was 3 kilometers long, that was 100 meters wide and had the hydraulic conductivity of 1 times 10 to the minus 5 meters per second which, in my experience, would be a significant water-conductive feature. And we place that feature 100 meters away from the mine workings, and then we run the mining simulation.

And what we found out, that, even if such feature were present in the vicinity of the mine workings, the inflows would practically not change. The reason for that is that our testing indicates that the matrix in the lower bedrock is of low hydraulic conductivity, and it will provide sufficient buffer, so any recharge from such feature would not significantly influence inflows to the mine workings. So that's the conclusion from the additional simulation.

Q   And then I think on the next slide you did some additional sensitivity analysis. I think it was in response to some of the things that Dr. Prucha had to say. And would you explain what you did here, please?

A   What we did here, we did two additional model simulations. In the first one we took our Base Case model, which includes eleven water-conductive features, and we extended these features from the contact between the lower and upper bedrock all the way up to the contact between the upper bedrock and the overburden.

Q Which is one of Mr. Prucha's theories that there could be a vertical conductive feature all the way to the overburden, as I recall?

A That's correct. And I believe that this is one of the modifications that were made in the model that he used. And again, we ran the mining scenario in the model, and the model predicted that the inflow will be increased to about 75 gallons per minute, which is 25 percent more from the Base Case model of 60 gallons per minute, which is not very significant. We also looked at the assumption that we made with respect to the contact between the upper bedrock and lower bedrock, and we -- in this additional model simulation, what we did, we lowered that contact by 30 meters, so from 90-meters' depth to 120-meters' depth.

Q So increasing the thickness of the upper bedrock?

A That's essentially what we did. We increased the thickness of the upper bedrock. What this does is it puts the uppermost permeative mine level within the upper bedrock, which is more permeable. It's low hydraulic conductivity, but it's higher than the lower bedrock. Again we ran the mining simulation, and we got inflow that was approximately

30 percent greater than the Base Case inflow. Again, it's a minor variation. It's not a catastrophic change in predicted inflow.

Q And on the next slide I believe you have a summary of your latest analysis?

A So this is just a summary of what we found after running these additional simulations. So we found from the sensitivity analyses that, by varying the model input parameters based on the uncertainty that was estimated from field testing, the inflow could range from 15 gallons a minute to 150 gallons a minute on our Base Case inflow, which is the most likely inflow that would be encountered during mining as 60 gallons a minute, and that -- we also found out that, even for -- that our Upper Bound Case, which is 210 gallons per minute, is well above anything that we encountered while running sensitivity simulations, and that includes those additional simulations. That included a 3-kilometer-long feature and extending water-conductive features to the overburden. So that's the summary of the memo.

And then I wanted to talk about some conservative assumptions that were incorporated in the model. So first of all, our Base Case model is based on averages of hydraulic parameters that were measured in the field. It's calibrated to the -- in transient modes to a long-duration pumping test, and also, the whole conceptual model is based on data from boreholes that we're targeting potential features, potential contacts. So it's -- overall it's a good data set. Nevertheless, in that model we incorporated a list of conservative assumptions, and that's on the next slide.

So first of all, in our testing, we -- particularly from our pumping test, we know that we have only one water-conductive feature of moderate hydraulic conductivity. In the model we included eleven of these features, so ten more than what was measured at the site. If we were to just incorporate one feature in the model, tomorrow that Base Case model would predict lower inflows than what is reported.

The second assumption was that the water-conductive features in the Base Case model were oriented north/south. That assumption was made to maximize the amount of intersections between the features and the mine openings. If we were to orient these water-conductive features at different angle -- let's say east/west -- there would be less intersections, and the Base Case model would predict lower inflows than what is reported. Finally, we assumed that the water-conductive features are vertical. In other words, they provide the shortest connection between shallower rock and the mine workings. These features could be -- we don't know the true orientation. They could be horizontal. If they were horizontal, again, lower inflows would be predicted.

And finally, we did not incorporate potential changes in hydraulic conductivity due to potential clamping of rock in the crown pillar that Dr. Carter talked about, although we did incorporate in a very conservative way increases in the hydraulic conductivity along the sides of the mine workings. There is two more assumptions that we made in the model that make the Base Case model conservative. One of them is assumption made with regards to backfilling.

In the model no backfilling is simulated. We at the end of mining have the entire mine open, and the water is allowed -- groundwater is allowed to inflow to all levels within the mine. In reality, I understand backfilling will be conducted as no one level will be open at any one time. And backfill obviously has finite hydraulic conductivity, and it will reduce mine inflows. So that's one assumption. And the other assumption that we made, we assumed that no mitigation whatsoever would be conducted during mining, although, overall, the measured hydraulic conductivity at the site is low to very, very low; that one water-conductive feature that we encountered, well, it could be grouted. So in our Base Case model, we have eleven of these. They all could be grouted, and that would result in lower inflows than what the model predicted.

Q Finally, I wanted you to identify, on Intervenor Exhibit 73 -- I looked at that with you last night, I believe, Mr. Zawadzki. Do you recall that? It's a CV that was provided to the Petitioners in our exhibits. And on that CV there's what's called Eagle 97 Base Case Version 01.1FEM. Is that the FEFLOW data set?

A That's correct. That's the FEFLOW model that was discussed in our April 2008 memorandum. That particular file refers to the Base Case model.

Q And have you reviewed that exhibit?

A Yes.

Q And does it accurately reflect that data in that model?

A Yes.

MR. LEWIS: And I want to identify the two records, reports I talked with you about, the first one being the Intervenor Exhibit 7, which has been referenced as Appendix B-4 to the mine permit application, Bates range 104410-104473, and the second being the more-recent report, which is Intervenor Exhibit 399 and offer those into evidence at this time.

MR. REICHEL: No objection, your Honor. And for the record, I would note that Appendix B-4 -- I think was noted earlier -- is also identified as Respondent's Exhibit

Number 33.

MR. EGGAN: What number was that, Mr. Reichel?

MR. REICHEL: 33.

MR. EGGAN: 33.

MR. HAYNES: No objection, your Honor.

MR. EGGAN: No objection, your Honor.

JUDGE PATTERSON: All right. There being no objection, they'll be entered.

(Intervenor's Exhibit 7, B-4 received)

(Intervenor's Exhibit 399 received)

MR. LEWIS: And that concludes my direct examination, your Honor.

MR. REICHEL: Your Honor, I have no questions at this time, but I reserve the right to ask questions based upon cross-examination.

MR. HAYNES: Your Honor, could we have a short break?

JUDGE PATTERSON: Sure.

MR. HAYNES: Thank you.

(Off the record)

MR. LEWIS: Your Honor, I was reminded to offer for the court's use Mr. Zawadzki's slides that have been labeled as Intervenor Exhibit 633 as a demonstrative exhibit.

MR. HAYNES: I was hoping that counsel we overlook that so I wouldn't have to put my non-objection on the record that sounds like Mr. Eggan's objection that, with the understanding that it's a demonstrative exhibit and not substantive evidence, I don't have an objection.

JUDGE PATTERSON: All right.

MR. EGGAN: That sounds like my objection, but it isn't quite all of it. I would object to the use of that document, because it really isn't evidence. But I understand that you've ruled on this issue, and I don't have anything more to add.

JUDGE PATTERSON: All right.

MR. REICHEL: No objection.

(Intervenor's Exhibit 633 received)

JUDGE PATTERSON: Mr. Haynes?

MR. HAYNES: Yes. Thank you, your Honor. Mr. Zawadzki, my name is Jeff Haynes. I represent the National Wildlife Federation and the Yellow Dog Watershed Preserve.

CROSS-EXAMINATION

BY MR. HAYNES:

Q If we could turn to your slides --

MR. HAYNES: Kennecott Exhibit 633 and slide 1, please.

Q You have that in front of you; right?

A Yeah. Are you referring to the slides that --

Q Yes, the -- this package that we were handed yesterday.

A Yes; yes.
Q Mr. Zawadzki, you're based in Vancouver; correct?
A That's correct.
Q Have you ever been to the Upper Peninsula of Michigan?
A I've been to Marquette, so the answer is "yes."
Q And you visited -- what? -- the Kennecott offices in Marquette?
A Yes.
Q Did you visit the mine site?
A No.
Q What was your purpose of going to the Kennecott office in Marquette?
A We were reviewing -- with Mr. Wozniewicz we were reviewing some of the data that later on was used for the development of the hydrogeologic model.
Q Of the models?
A That's right.
Q Which data?
A Honestly, I cannot recollect. It has been awhile.
Q Was it geotechnical data, or was it groundwater -- water hydraulic data?
A I believe it was groundwater data, but honestly, I cannot recall.
Q That's the only time you've been to the Upper Peninsula?
A Yes.

Q You never modeled any other proposed mine sites in the Upper Peninsula?
A No.
Q You've never been in a mine in the Upper Peninsula?
A I don't think that there are any operating mines in the Upper Peninsula.
Q But you've never been in any, have you?
A No, because there aren't any.
Q The answer to my question is "no"?
A "No."
Q Thank you. Slide 1 of Exhibit -- of Kennecott Exhibit 633 shows a cross-section and then an aerial view of the -- is this a proposed tunnel or an actual tunnel?
A The tunnels are currently under construction.
Q They're under construction. Okay.
A So they are halfway through right now.
Q Right. In -- near Vancouver; correct?
A Yes.
Q And the tunnel here -- you said this is a larger scale than the Eagle Project, as I recall your testimony; right?
A Yes.
Q Okay. It's a larger scale only in the sense that we have a 7.2-kilometer tunnel that's much longer than the Eagle orebody; correct?
A That's correct. There actually are two tunnels.

Q Two tunnels. All right. But it's larger only in that sense, isn't it? I mean, you have a horizontal tunnel going through rock and other things here, but what you don't have is an orebody that's sitting underneath a river -- correct? -- for these tunnels?
A Yes, there's no orebody.
Q Right. And you're not dealing with an orebody that's in an intrusive, sandwiched in between dikes; correct?
A Yes.
Q That's correct?
A Correct.
MR. HAYNES: If we could go to slide number 6, please?
Q Mr. Zawadzki, on slide 6 you describe some of the attributes of the model -- correct? -- generally?
A Yes.
Q And one of them is the extent of the model, and you say that the approximate horizontal extent of the model is 87 kilometers squared --
A That's correct.
Q -- or about -- I think you said 10 kilometers by 8 kilometers; right?
A About right, yeah.
Q Give or take. And if my conversion is right to those of us who think still in miles instead of kilometers because we

live south of the border, that's about 6 miles by about 5 miles, give or take; right?
A Yes, about right.
Q Okay. So the area that you're modeling here is about 30 square miles, 6 by 5; right?
A About right, yeah.
Q Just for reference, do you know what the size of a township is in Michigan?
A No.
Q 36 square miles. All right? That's just for reference. So your model is predicting the drawdown over this 87-kilometer-squared area; right?
A The model predicts drawdown at great depth. The extent of the drawdown come closer to the contact between the upper bedrock and overburden is much less.
Q But the model that you've constructed here deals with this 10-kilometer-by-8-kilometer area; correct?
A Yes. And the reason for modeling such a large area is to make sure that the -- whatever little influence that the boundary conditions could have, the outer boundary conditions could have on predictions are removed. That model, for the purposes of predicting mine inflow, could have been made much smaller.
Q All right. But it also could have been made larger?
A Well, yes.

Q I mean, at some point you reach an asentote,*3:47:25 don't you, --
A Yes.
Q -- of influence of the drawdown on the regional area -- on the region; correct?
A That's correct.
Q And so you've drawn the asentote* 3:47:37 somewhere 5 kilometers either way of your center point; correct?
A Yes.
Q 10 by 8 kilometers. Now, on slide 8 -- you say here on slide 8, which is in Appendix B-4, page 11, that there is some horizontal flow -- I'm looking about two-thirds of the way down in this paragraph that you have on slide 8.
A Uh-huh (affirmative).
Q "Some horizontal flow of groundwater in bedrock likely occurs under conditions"; right? I mean, there's some flow in this -- in the modeled area; correct?
A That's correct.
Q Horizontally through the bedrock?
A Yes.
Q Let me just pose a hypothetical to you. If hypothetically we had a natural-occurring cavity where the mine is going to occur; that is, when it's mined out; if that were simply natural -- it was a cavern that occurred naturally -- there would be some flow from the water going into that cavern

naturally -- correct? -- if there's a horizontal flow?
A If there is some horizontal flow.
Q Which you say there is?
A There might be. Then, yes.
Q So your model has to take into account, doesn't it, this natural flow once the mine is developed?
A No, it does not. And the reason for that is that, whatever horizontal flow might exist under natural conditions, it's very weak compared to the stress that the mine dewatering will put on groundwater system in bedrock.
Q Right. I understand that's what you say here and what your -- what slide number 8 says.
A Uh-huh (affirmative).
Q It's very weak. But it's not zero?
A No, but it will be very small compared to inflows related to dewatering.
Q Okay. But not zero and, therefore, should be taken in account in the model, shouldn't it?
A In my professional opinion, it will not matter.
Q Others might disagree, don't you think?
A I would be surprised if somebody were asked to develop a model to predict mine inflows that would dispute that. There are different objectives when you develop the model so, for some other purposes, it might be the case but not from the perspective of predicting inflows.

Q Now, I know that Mr. Wozniewicz -- is that how -- is that a correct pronunciation of it -- pronunciation of his name, Wozniewicz (pronouncing)? Is that close enough?
A I believe so.
Q Okay. Describe the pump test -- the long-duration pump test, which was seven days; right?
A Yes.
Q And your model is based upon that one -- well, the only long-duration pump test that the model uses is that one; correct?
A The model is based on integration of all the data that we collected at the site.
Q Right. But that wasn't my question. The only long-duration pump test that the model uses is the one in hole 84; correct?
A The model was calibrated to the long-duration pumping test but, in terms of how the model was developed, it was developed based on all the data that were collected.
Q I understand that. Let's go back to my question. I'll back up for just a moment so that you and I can get to the same end point here.
A Uh-huh (affirmative).
Q The model is based on the packer tests; correct?
A Some of the parameters in the model are based on packer tests.

Q Some are based on the slug tests, yes?
A Well, in our case it's equivalent. It's like the packer test. We --
Q Oh, I see. And the model is also based on the short-term pump tests, which were the ones that took place over several hours; correct?
A Couple of hours.
Q Right?
A Correct.
Q And then the model is also based upon a single long-duration pump test that took place over seven days in hole 84; right?
A Yes. And the pump tests measured large-scale hydraulic properties over a considerable distance.
Q Right. There were no other long-duration pump tests used in the mode; correct?
A Well, duration is relative.
Q Well, I understand that, sir. But we're -- Mr. Wozniewicz testified at length about the single pump test -- long-duration pump test that occurred in hole 84. You're aware of that, aren't you?
A We are referring to pumping as in hole 84 and defined as long duration, yes.
Q Right. That was the longest-duration pump test that occurred for this model calculation; correct?
A Correct.

Q There wasn't one that was any longer than that; right?
A Correct.
Q There was no seven-day or multi-day pump test that occurred in any of the other eight holes that were used for purposes of developing this model; correct?
A Yes. There was no other seven-day pumping test.
Q No other pump test of a couple of hours; right?
A Correct.
MR. HAYNES: Let's go to slide 12.
Q Mr. Zawadzki, on slide 12 we have two bullets that are in the white portion of the slide. One refers to the Base Case, and one refers to the Upper Bound Case. Do you see those?
A Yes.
Q And in the one that -- the bullet dealing with the Upper Bound Case you talk about, "A relatively long, well-connected water-conductive" -- excuse me -- "relatively long well-connected water-connective features." Which features were those? What was --
A These are 16 water-conductive features that are incorporated in the Upper -- which initially we incorporated in our preliminary model, and then they were incorporated in the Upper Bound model.
Q And can you name those 16 features?
A They -- can you rephrase the -- I -- they do not have names.

Q Are they structures? Are they dikes? Are they faults? Are they broken zones, sheared zones?
A We don't know. We -- all we know is that, from the hydrogeologic perspective, these zones are acting as conductors to flow. It can be a single fracture. It can be a fractured rock zone. It can be another structure.
Q That is, you inferred the features from the hydraulic testing; correct?
A Correct.
Q You didn't determine whether the hydraulic -- the inferences that you drew from the hydraulic testing actually corresponded to features in the cores, in the holes themselves; right?
A I don't know if I can answer that question. That work want conducted by Mr. Wozniewicz.
Q So you don't know whether those features were ever actually in a sense calibrated to reality, from your inferences?
A My understanding is that we tested all potential features in the boreholes that -- in 18 boreholes. We -- sorry. I -- let me rephrase; that in the boreholes that were included in hydrogeologic investigations, we look for flow anomalies, and we tested the most significant anomaly. So other features -- structural features that were encountering these boreholes from groundwater perspective are not significant.
Q Okay. But I'm talking about the 16 conductive features that

you talk about on this slide. You said that you inferred those features from the hydraulic testing; right?
A No. We from hydraulic testing inferred existence of one water-conductive feature. To make the model conservative, our preliminary model we included 16 features in the model. They do not correspond to anything that we measured. Only one feature was encountered.
Q Oh, I see.
A So we included them to make the model conservative.
Q So the 16 are just made up, then? They don't correspond to reality?
A Well, it's possible but extremely unlikely that network like that exists. Again, we encountered only one feature. But at the preliminary stage in the preliminary model, we didn't have the pumping test data so assumed -- we assumed this network of well-connected 16 features.
Q Could have used 15?
A We could have used 15.
Q Could have used 10?
A Well, we carefully selected the number of features to make sure that our preliminary model is conservative. The number of these features were selected so we maximize the amount of intersections with the proposed mine workings and these features. 15 probably wouldn't be sufficient. We wanted these features to intersect both north/south and east/west

to intersect the mine -- the proposed mine workings.
Q Right. And is one of those features in your preliminary model that you're talking about here extending the features from the lower bedrock to the overburden?
A The preliminary model assumed that these features terminated the contact between the lower bedrock and upper bedrock so --
Q So these features only dealt with the lower bedrock?
A Yes.
(Counsel reviews notes)
MR. HAYNES: If we could go to slide 13, please?
Q Mr. Zawadzki, slide 13 talks about -- this is -- slide 13 is, again, dealing with your preliminary model; correct?
A Just one moment.
(Witness reviews documents)
A Slide 13 refers to revised model.
Q The revised preliminary model?
A Well, there was a preliminary model that was done before we conducted pumping test in borehole 84, and then the revised model.
Q After the pumping test?
A After the pumping test on --
Q I see.
A This is the model that's discussed on slide 13.
Q Yeah. Okay. That's fine. Does the revised model -- strike

that. The first solid bullet which talks about boundary conditions representing overburden modified to allow better coupling, you see that?

A Yes.

Q Does the boundary condition here include the fact that the intrusive intersects the surface?

A The uppermost boundary condition was assigned a head-dependent boundary, and that boundary uses a term called conductants. And the conductants was derived from the properties of the overburden units that overly. So --

Q Let me back up, because we may not be understanding one another right now. You know, don't you, that the intrusive goes up to the surface near the Salmon Trout River?

A Yes.

Q You're aware of that, aren't you?

A I'm aware of the outcrop.

Q Right. Well, not only the outcrop, but near the Salmon Trout. And there's two places where the intrusive hits the surface; one is at Eagle Rock east of the orebody and one is near the Salmon Trout River. You're aware of that, aren't you?

A Yes.

Q Okay. I'm talking about the latter, which is where the intrusive comes to the surface near the Salmon Trout River. Was that fact taken into account in your revised model when

you modified the overburden regime?
A Yes. I believe it would be properly handled by the head dependent boundary. But moreover, as we found out later during our sensitivity analyses, we in fact could specify that boundary at these locations, which is like putting not a river but a lake on top of the model. And in terms of predicting inflows, it does not matter.
Q It doesn't matter that there's a lake sitting over -- sitting over the intrusive?
A It does not matter, considering the hydraulic properties that we measured at the site.
Q And you understand that the intrusive has -- the contact zone between the intrusive and the sedimentary rock is fairly broken rock? You understand that, don't you?
A I don't know what you mean by -- I don't quite understand what you mean by "broken rock."
Q Well, it's not bedrock. I mean, it's not the -- it's not the peridotite intrusive, it's not the sedimentary rock. It's the contact zone has rock that's been broken by the fact that we have this intrusive thrusting up through the sedimentary rock. You understand that, don't you?
A The fact that the rock is broken does not imply that it's very transmissive. It could be, it could not be.
Q But certainly for modeling purposes you would assume that it is transmissive, wouldn't you, if you want to model --

A Well, I would assume parameters that are based on testing. And we completed fairly extensive testing in the vicinity of the orebody. And there's no evidence for any of these features to be that conductive and extending to the ground surface.
Q All right. Mr. Wozniewicz testified that there were nine holes that were selected for hydraulic modeling purposes; right?
A Correct.
Q One of those holes was number 20 over near the Eagle Rock -- right? --
A Yes.
Q -- or in that area? So we only have eight holes around the orebody; right?
A Yes.
Q Do you know that there are about a hundred -- at least when the model was prepared in 2006, there were at least 109 boreholes out there; right?
A Yes.
Q So Mr. Wozniewicz apparently selected eight of those near the orebody to use for hydraulic modeling; right?
A Yes.
Q Instead of all -- instead of using all 109; right?
A It would not be necessary to do testing in all these boreholes.

Q All right. So basically they were selected eight out of 109, which is less than 10 percent of the holes that were available for purposes of this modeling; right?
A Yes. And that's a --
Q "Yes" is fine. That's all I need. And none of those holes intersected the contact between the orebody -- or the intrusive and the sedimentary rock near the Salmon Trout River, did they, at that surface elevation?
A I cannot comment on that. But my understanding is that we intersected all the contacts between individual rock units.
Q You're saying that of the 109 boreholes, the eight that were selected constitute all of the contacts between the orebody and the host rock?
A What I indicate is that we tested all contacts between the -- I mean, not all contacts -- all types of contacts, so between the host rock, the peridotite, the sulfides. Not all locations were these contacts were encountered. That's not necessary.
Q And in your view irrelevant; correct?
A No. You need to collect sufficient amount of data so you have confidence in your conceptual model and then your numerical model.
Q Right. And help me with this for just a moment. If you had eight boreholes that you say contact the relevant -- contact all of the types of -- excuse me -- intersect the types of

contacts between the orebody and the other rock; right? That's what you testified to? What if you had nine boreholes that all -- and the ninth one also intersected a contact? Wouldn't that assist in calibrating your model?
A Again, in my experience the density of boreholes that was used for testing was actually greater than some of the projects that I've been involved in the past. Boreholes used for hydrogeologic testing.
Q So the ninth borehole that I'm hypothesizing here would have done no -- would have made no difference in your model?
A Most likely not.
Q That is, additional data would not have assisted you? Is that what you're saying?
A For the purpose of predicting inflows, I don't think that it would be significant. I don't know, but -- I don't know for sure, but --
(Counsel reviews notes)
Q Mr. Zawadzki, have you reviewed the reports that Dr. Sainsbury prepared on behalf of the Department of Environmental Quality?
A Not in great detail.
Q You've reviewed them, though?
A It was a very -- I mean, I would not call it a review; more a --
Q You read them?

A Not in detail, no. I did not read complete reports for sure.
Q Are you aware that Dr. Sainsbury disagrees with your view that the permeability around the stopes would increase more than the 30 meters that you suggested?
A I am not aware of that. I cannot comment.
Q All right. That's fine.
A But what I can say is that --
Q That's all my questions for that topic.
MR. HAYNES: If we could turn to slide 16, please?
Q Mr. Zawadzki, slide 16 and 17 deal with your sensitivity analysis; correct?
A Yes.
Q And you're aware that ASTM has promulgated the standard for conducted sensitivity analyses for groundwater flow model applications?
A I'm aware of general standards for groundwater modeling. I'm not sure if I'm aware of that particular document.
Q You're aware of a document -- well, I'll name it for you. It's called the Standard Guide for Conducting a Sensitivity Analysis for a Groundwater Flow Model Application number D5611 from 2002 promulgated by ASTM? Are you aware of that standard?
A I believe at some point I might have seen the document. But it would be awhile ago and I don't recall the details.

Q So you don't know whether your sensitivity analysis was performed according to that standard, do you?
A Our sensitivity analysis was performed to industry standards.
Q That wasn't my question. Do you know whether or not your sensitivity analysis was performed according to the ASTM standard for sensitivity analyses for predicting groundwater flows?
A I don't know.
Q Okay. A sensitivity analysis is different than an uncertainty analysis, is it not?
A Well, it's one and the other could be related.
Q But they're not the same? They're not equivalent; correct?
A Not necessarily.
Q They might be equivalent?
A Results of sensitivity analysis could be used to assess uncertainty.
Q That wasn't my question. Are you familiar with what is called an uncertainty analysis?
A Can you clarify or --
Q Well, if you aren't, you aren't. That's fine. I just, you know -- this isn't a trick question. It's a phrase that I've heard modelers use. It's called uncertainty analysis.
A Well, we always assess uncertainty in predictions. So I guess I am, but I don't quite know what you are referring

to.
Q All right. That's fine. And when I -- so would you say that your sensitivity analysis is equivalent to an uncertainty analysis?
A The results of sensitivity analysis we conducted were used to establish the uncertainty -- potential uncertainty of our predictions. This is we use the results of sensitivity analysis and professional judgment to arrive at our upper bound case for predictions.
MR. HAYNES: If we could turn to slide -- no. Let's stay on slide 16.
Q Your sensitivity analysis, Mr. Zawadzki, varied certain factors. Is that an accurate sort of overview of what you did for your sensitivity analysis?
A We varied hydraulic conductivity and then we made some adjustments with respect to assumptions in the model.
Q Within a certain range; correct?
A Correct.
Q All right. But one of the things that you did not vary here was the assumption that water conductive features do not extend from the lower bedrock to the surface; right? You didn't change that assumption?
A Can you rephrase the question?
Q Sure; sure. Let's look at item number three here. That's what I'm pointing to, the hydraulic conductivity of the

conductive features. One of the bounds -- strike that. One of the assumptions that you used here is that we have -- is that you have a lower bedrock -- right? -- and an upper bedrock, and the unconsolidated material over that; correct?
A Correct.
Q All right. And you assumed that there's no hydraulic connection between the surface and the lower bedrock; right?
A The water conductive features are entirely within the lower bedrock. And we did not encounter any anomalies in the upper bedrock, so there's no evidence for these features.
Q There's no evidence. So for purposes of your modeling, you assumed for the model that there's no hydraulic feature extending from the lower bedrock to the surface; correct?
A When we look at slide 16, that's correct. However, this was addressed on slide -- I'll just flip here -- on slide 19.
Q All right. We'll get to that. All right.
MR. HAYNES: Let's go to slide 18.
Q Mr. Zawadzki, in slide 18, one of your adjustments to the model in Kennecott Exhibit 399, which was your additional predictions from April 2008, was this feature -- this three kilometer long feature located 100 meters away from the mine and unconnected -- and it was unconnected in the mine; correct?
A Yes.
Q All right. For purposes of simulating possibilities here,

which is a model simulates possibilities, doesn't it, and that's what you're trying to do is check various assumptions to see if they make sense?
A Yes. That's the -- one of the purposes of sensitivity analyses.
Q Right. Wouldn't it make sense -- sir, if you're going to assume a water conductive feature that is 100 meters away from the mine and not connected, wouldn't it make sense to turn that feature 90 degrees and connect it to the mine?
A You would not, because our testing does not indicate presence of such feature within the area that would be mined.
Q And you're testing didn't indicate the presence of this three kilometer long feature 100 meters away from the mine; right?
A That's correct. Our upper bound case assumed 16 features, although only one was encountered. So this is how this was handled in our upper bound case and in our sensitivity analysis. It's on -- this is outside of what could be reasonable to have such highly transmissive feature passing right through our monitoring network that was used for testing. If that were the case, we -- first of all, you'd measure much higher hydraulic conductivity, the TDS versus depth profile would be different. The conditions just would be different than what we observed. So it's outside of

what's reasonable to assume in sensitivity analysis.
Q Well, but what's reasonable isn't necessarily what you have to look at in terms of what you're going to be modeling, is it? Shouldn't you be looking at worst case scenarios not reasonable scenarios?
A But that would be unreasonable worst case scenario. It would be extremely unlikely to have a feature like that.
Q Unlikely, but not impossible; right?
A Well, whenever you deal with the subsurface there's always some uncertainty. But this is outside of what in most studies that I was involved in considered. It would not be standard practice.
Q Well, then why would you assume that a three kilometer long feature that is vertical and located 100 meters away from the underground mine is a reasonable upper bound scenario?
A We are not claiming that this is a reasonable upper bound scenario. This is -- the intent of that model simulation was to show that if such feature were present the mine inflows would not be effected. It was not -- the purpose was not to create some sort of an upper bound scenario or anything like that.
Q And so you're dealing with "what ifs" here; correct?
A Outside of the area that was tested, of course. Conditions could be different. But because the hydraulic conductivity of bedrock in the vicinity of the proposed mine is low, mine

inflows would be primarily controlled by the properties close to the mine, not by the properties of any feature, if they exist at greater distance.
Q Hydraulic conductivity of the bedrock is low. I understand that. But what about the other features around the orebody that are not part of the bedrock that are the fracture zones, the shear zones, the gouge zones and so on? Those aren't -- those don't have low conductivity, do they?
A This is all part of bedrock. And structures, as Mr. Wozniewicz indicated, they are faults; first could act both as conduits but could act a barriers. It all depends on infilling on the characteristics of these zones. There is no correlation between -- or strong correlation between structure and water conductive features. And definitely there is none or nearly none at the site.
MR. HAYNES: All right. Let's go to slide 19.
Q Slide 19 in the first bullet talks about extending the conductive features to the top of the upper bedrock; right?
A Yes.
Q As we know, there are, at least for purposes of our discussion today, three zones that you've identified; the lower bedrock, the upper bedrock, and the unconsolidated material; right?
A yes.
Q Okay. So when you say that the conductive feature is

extended to the top of the bedrock -- upper bedrock, are you saying there that the conductive feature extends -- would that capture all the water in the unconsolidated material?
A These features have only moderate hydraulic conductivity. They are not -- they would not act as big conduits to flow. And it would also depend on the characteristics of the lower most hydrostragraphic unit in the overburden. So, for example, if we had low permeability till, it would essentially blanket any leakage that could occur from the overburden into these features. But most importantly we do not have --
Q Excuse me. But the till here is not -- it's not low hydraulic conductivity till, is it? It's not low permeability till; right?
A This was just an example. I cannot comment on the surficial hydrostratography. This was just an example. But what I wanted to say is that we do not have any evidence that these features do extend from lower bedrock through the upper bedrock.
Q But for considering your sensitivity analysis or a worst case scenario, if you wanted to extend your sensitivity analysis, you would have to extend the features into the overburden; correct?
A To provide conservative estimates of mine inflow, we are allowing infinite leakage from the overburden into bedrock.

It's again like having a water body up top of the model. So in that respect, yes, there's these features would conduct water. Although, as you can see from this model simulation, where the feature were extended to the top of the model, the change is not that significant. It's only 25 percent greater inflow that in the base case.

Q Again, based upon the assumptions that you put into the model; right?

A Yes. And I believe that these assumptions are conservative.

Q Well, on the second bullet, sir, where you extend the -- you lower the contact between the upper and lower bedrock from 90 meters total vertical depth to 120 meters, you've just -- you've lowered that contact zone 30 meters; correct?

A Yes.

Q And if you lowered it further, that would increase the mine inflow, wouldn't it? It would tend to?

A I have not ran the simulation --

Q Oh, you haven't? I see.

A -- with that contact lower at a greater depth.

Q But certainly lowering the contact would be a reasonable kind of variation of the model, wouldn't it?

A I don't think that lowering to greater depth than what we did would be reasonable. Our data that Mr. Wozniewicz discussed indicates that that transition between the upper bedrock and lower bedrock occurs at about 90 meter depth.

So we already are going 30 meters below that contact.
Q All right. 90 feet below?
A In meters.
Q Yeah. 30 meters, 90 or 100 feet, I mean, for those of us that think in feet versus meters.
A Oh, yeah. Sorry.
Q Sorry. But if you wanted to further test the model to predict mine inflows, wouldn't you lower that contact even more than just 30 meters? I mean, we're dealing with a mine here that has a height of about 200 meters; right?
A I guess it is slightly under 200 meters.
Q 180, I think is --
A 180, I believe.
Q Yeah; right. 180 meters, about 600 feet top to bottom of the mine?
A Yes.
Q So if you're lowering this contact by 30 meters, that's maybe a 5 percent difference considering the height of -- or the depth of the mine; right?
A I understand. But that adjustment is not done based on the depth of mining. It's based on our testing. And we are already outside of the depth that's reasonable based on what we saw during packer testing and our pumping test.
MR. HAYNES: Let's go to slide 20.
Q Mr. Zawadzki, on the second portion of slide 20, which

starts, "Overall, the base case model," do you see that?
A Yes.
Q The second sentence says, "Boreholes used for hydraulic testing targeted potential conductive features such as contact zones, dikes, fractures and faults." Do you see that?
A Yes.
Q And that refers to what you testified earlier, which is that you targeted types of features, not all the features -- correct? -- from the eight boreholes that intersected the orebody?
A My understanding was that you were referring to all the contacts or features in 109 boreholes. These would consider all the intersects.
Q All the types?
A All the types? Yes.
Q But not all of the features?
A No.
Q All right.
A We tested all the features that were identified in the boreholes included in groundwater investigation.
Q Right. And the eight boreholes that intersected -- I'm putting number 20 to the side now. Okay? That ninth one way over there by Eagle Rock, but the eight boreholes that were used for the hydraulic testing that intersected the

orebody -- right? -- you tested the types of features not all of the features in all of the boreholes that were available to you, all 109; right?
A I don't know if I can comment on that. This is a question that Mr. Wozniewicz I believe addressed. And all I can say is that especially in our pumping test he looked at the properties and overall behavior of water conductive feature that was encountered.
Q Of the types of features; right? But you didn't test all of the intersections of all of the features of the orebody that were in the entire data set of the 109 boreholes?
A Well, we conducted testing in boreholes that were selected for groundwater investigation.
Q I understand that. I agree with you, sir. What I'm trying to see is whether or not you tested all of the features in all of the boreholes. And the answer clearly is "no," isn't it, of the 109 boreholes?
A Well, we did not conduct testing in all the geotechnical --
Q All right.

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

MR. EGGAN: Mr. Zawadzki, my name is Eric Eggan, and I have a few questions for you.

CROSS-EXAMINATION

BY MR. EGGAN:

Q Initially, as I understand it, you've prepared three models; a preliminary model and then two additional models thereafter?
A Well, we prepared the preliminary model and then we revised the model. And within that model, we had two scenarios; the base case scenario and upper bound scenario.
Q Can we agree that was it three or was it one? I'm not trying to stump you. I just want to know. Was it one or was it three?
A I would rather refer to it as one model that in logical -- there was a logical progression as the data was being collected that was developed. I don't know we have -- I would not refer to them as three models.
Q Okay.
A I would rather refer to one model.
Q And fair enough. Let's look at it this way: Of the modeling that you did, the model type that you used was a transient model?
A Yes.
Q And you used the transient modeling approach throughout the preliminary and then the supplementals that you did to that model?
A Yes.
Q Okay. And I assume that you used transient rather than a steady state approach because you trust transient modeling

more than steady state?
A Steady state models can be as reliable as transient models. Here it was more that the transient model was required to simulate the progression of mining over time.
Q Okay.
A And also we had transient data sets to which we calibrated. But I would not agree with the statement that steady state model are in some way inferior. All the models are developed with different purposes, and there are situations where a steady state model is an excellent tool.
Q In this instance, you trust your transient model for this particular mine in this application?
A Yes.
Q Okay. Likewise, you utilized a FEFLOW code to simulate the groundwater flow, didn't you?
A Yes.
Q And, again, I assume that that is because you trust FEFLOW over some other kind of code for this particular application?
A There are many codes that are very reliable and verified and tested. But we selected FEFLOW because it was the most appropriate modeling code to use at this project.
Q That's really what I was going for. Because of the circumstances in this particular project, FEFLOW was the code that you adopted and the one that you think is the most

reliable for this project?
A For the purposes of modeling groundwater flow in bedrock, yes.
Q Okay. Now, your 2005 initial whether you call it a -- the first model or your 2005 modeling effort, that was not calibrated; am I right?
A No, it was not calibrated.
Q But your 2006 and then your 2008 supplements, updates, new models, whatever we want to call them, those were calibrated?
A Yes. They were calibrated to the pumping test in borehole 84.
Q Well, that would have been my next question. The 2006 and 2008 supplements, those were calibrated to a single pump test; am I right?
A Yes. They were calibrated to the response in the pumping well and in the monitoring piesometers.
Q Yes. Again, the calibration was to the single pump test that you and Mr. Haynes talked about and you and Mr. Lewis talked about?
A Well, the model was based on all kind of testing that we conducted. But the calibration was conducted to the pumping test.
Q To that single pump test?
A Yes.

Q I'm just focusing right now on just that small little part, the calibration, --
A Yes.
Q -- which is important?
A Yes, it is.
Q Okay. But in this instance, it was calibrated to that single pump test that you talked about?
A Yes.
Q Okay. Now, there was another model of the groundwater flow in bedrock in this project; am I right?
A I'm aware of the surficial model.
Q I'm thinking of the Fletcher Driscoll modeling that was done in 2005.
A I don't know the details of that modeling, although we provided inflow predictions from the FEFLOW model for that study.
Q I understand. But all I'm asking about is there was another modeling effort done by Fletcher Driscoll, and that was done in 2005?
A Yes, although I do not know the details of the study.
Q Okay. Are you aware, sir, that that was a steady state model?
A No.
Q Are you aware that the code they used was not FEFLOW, but was MODFLOW?

A MODFLOW is perfectly well suited for simulation of --
Q Sir, that isn't what I asked. Are you aware that the code that was used was not FEFLOW, which you've indicated you thought was best for this project, but was MODFLOW?
A I indicated that --
Q Are you aware, sir?
MR. LEWIS: Objection to form, if Counsel wants to be argumentative. There's a problem with the form of the question. That's not what Mr. Zawadzki testified to earlier.
MR. EGGAN: Well, he didn't testify at all about the Fletcher Driscoll modeling.
MR. LEWIS: No. But what he said was it was an appropriate model for the bedrock modeling they did. He did not say it was necessarily the appropriate model for groundwater modeling, in fact. And you're suggesting that he said that, and you're mischaracterizing the testimony.
Q Sir, are you aware that the Fletcher Driscoll modeling that was done in 2005, whether you liked it, didn't like it, thought it was a good modeling effort or not, are you aware that Fletcher Driscoll utilized MODFLOW rather than FEFLOW? Are you aware of that?
A Yes.
Q Okay. Now, I guess I'm just going to ask. Did your modeling consider the mine dewatering effect on the A and D

aquifers?
A No. The -- no.
Q It did not? Okay.
A It did not include these aquifers. It indirectly included potential leakage from the overburden from the unconsolidated sediments.
Q Okay.
A It does not explicitly simulate any of the hydrostratographic units in the overburden.
Q Just so that I understand, then, what we have with respect to mine dewatering in the bedrock, we have your modeling efforts which include the -- it must have been 2006, the initial preliminary, or was that 2005?
A I believe it was 2005 when we did the preliminary model and then in 2006 we calibrated that model and produced a revised model.
Q Okay. And then in 2008. So we have your efforts in 2005, 2006 and 2008; correct?
A Yes.
Q Okay. And we have another company, Fletcher Driscoll, doing this MODFLOW study of the bedrock in 2005 also; correct? So we have two companies doing multiple efforts at modeling at this location?
A Again, I cannot comment on the other study. Our modeling effort was directed towards bedrock and predicting mine

inflows. So that was the focus of our study.
Q Do you know whether the Fletcher Driscoll MODFLOW model in 2005 was calibrated?
A I don't know.
Q You don't know?
A No.
Q Would it have been helpful to you to have considered modeling done by others as you put together your modeling scenarios here?
A For the purposes of modeling mine inflow and then groundwater flow in bedrock, we had sufficient data for model development and calibration.
Q So you didn't think it would be helpful one way or another to know what Fletcher Driscoll came up with?
A I don't think that they came up with anything that was relevant to groundwater flow in bedrock.
Q You don't know that the -- let me say it a different way. Do you know whether or not the Fletcher Driscoll model was intended to model the upper and lower bedrock zones?
A I know that -- sorry. Can you rephrase the question?
Q Sure. Do you know whether or not the Fletcher Driscoll model was intended to model the upper and lower bedrock zones?
A My understanding is that that model focused on the surficial groundwater flow and that it incorporated inflow predictions

from the bedrock model.

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

MR. LEWIS: I have nothing further, Your Honor.

MR. REICHEL: May I have a moment, Your Honor?

(Counsel reviews notes)

MR. REICHEL: Sir, my name is Robert Reichel. I represent the DEQ. I just want to follow-up on a few items raised on cross-examination.

CROSS-EXAMINATION

BY MR. REICHEL:

Q At one point I believe Mr. Haynes was asking you about whether or not you reviewed some comments made in a document prepared by David Sainsbury under a contract or a subcontract to the DEQ. Do you recall being asked about that?

A Yes.

Q I believe your testimony was that you had not -- in substance, you had not extensively reviewed that document; is that a fair statement?

A That's correct.

Q But I believe Mr. Haynes was starting to ask you something about whether or not you -- about the extent or increase in permeability around mine openings and the aerial extent of that. And I believe you wanted to respond further to Mr.

Haynes' question but didn't have an opportunity to do so. Do you recall that? Let me go back to that. I believe he specifically asked you something about to the effect that there was potential increase in permeability around the stopes of -- in the area greater than 30 meters or something like that. My notes may not be precise. And but if you have nothing else to add on that, that's fine. But I believe in response to that question you started to offer some further explanation and didn't have an opportunity to so. I simply wanted to give you the opportunity to complete your response to that.

A What I wanted to indicate, that in our April 2008 study, in our memo, we incorporated the effects of stress induced permeability changes that Dr. Carter presented in a very conservative way and that assumed that the changes in hydraulic conductivity related to stress would extend to considerable distance from the mine workings 30 meters. And in our model, we made very conservative assumptions; in other words, we extended the mine workings laterally in all directions by 30 meters. So in that respect, we in a very conservative fashion incorporated these changes in the model. And also what we found out was that the -- after these changes were incorporated, the changes in mine inflow were not that significant. They were on the order of maybe 10 to 15 percent from what the inflow was without these changes incorporated in the model.

Q Sir, you were also asked, I think, by both Mr. Haynes and Mr. Eggan on cross-examination about the fact that the work that you did in terms of calibrating the modeling effort that you performed referred to or was based upon one pump test -- there was one pump test of a seven-day duration. Do you recall that, or what was referred to as a long-term pump test?

A Yes.

Q Let me ask you this: Based upon your work on this project and your professional experience, does the fact that the modeling effort that you performed was calibrated to that pump test as opposed to some other hypothetical or additional pump test that might have been performed, does that alter the conclusions that you've drawn with respect to the range of mine inflow predictions that you've reached? In other words, does the fact that the model is calibrated to that pump test lead you -- does that alter your professional judgment as to whether or not the predictions that are incorporated in your model analyses about the rate of mine inflow are invalid? Does that effect the validity of that?

Q No. We used the results of the pumping test to calibrate the model and then we provided revised predictions of inflow. And in fact what we found out was that our preliminary model would likely over predict -- likely over predicts mine inflow. We provided a number of 180 gallons per minute. After calibration, our base case inflow was 60 gallons per minute. So the results of the test indicated that we were conservative in our initial model and that likely inflows would be less than what would be used -- what was based on the assumptions in our preliminary model. So what we've learned is that in reality after conducting the pumping test the inflows to the mine would be less than what we originally predicted.

Q You were also asked by Mr. Eggan on cross-examination about the use of -- or what type of model you used on -- he used the phrase "this project," emphasizing the fact that you used the FEFLOW model as opposed to some other steady state model. Do you recall that question?

A Yes.

Q Now, when you testified that you believed the use of FEFLOW modeling was appropriate for this project for the work that you did, when you talked about this project, just so the record is clear, what project are you talking about? Is that characterizing the geology in general or is that making specific predictions about rates of -- potential rates of inflow into the mine?

MR. EGGAN: Your Honor, could we break these questions down into one question? That's like a paragraph of questions. And I'd kind of like to know the answer to one of those questions.

MR. REICHEL: I'm simply trying to establish background. But in the interest of moving forward, I'll restate the question.

Q Okay. When you testified that it was your opinion that the use of the FEFLOW model was appropriate for this project, could you explain again so the record is clear precisely what this project is in the sense that you used it? What objective were you trying to accomplish?

A Our objective was to provide reliable predictions of inflow to the mine from bedrock. So our -- the entire study was focused bedrock. So the comment that I meant with respect to applicability of FEFLOW was in relation to modeling groundwater flow in bedrock and bedrock alone.

MR. REICHEL: I have nothing further. Thank you, sir.

MR. HAYNES: Nothing further, Your Honor.

MR. EGGAN: Nothing further, Judge.

MR. LEWIS: Nothing further.

JUDGE PATTERSON: Thank you, sir. Call it a day?

MR. LEWIS: May as well. May as well.

(Proceedings adjourned at 4:52 p.m.)

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