A1. Testimony of Robert Prucha (referenced in Chapter 2). Excerpt from Hearing Transcript, Vol. 8, 9, and 40, *Petitions of the Keweenaw Bay Indian Community, et al. on Permits Issued to Kennecott Eagle Minerals Company* (Michigan Department of Environmental Quality, May 7, May 8, and July 16, 2008). (electronic only)

STATE OF MICHIGAN

STATE OFFICE OF ADMINISTRATIVE HEARINGS AND RULES

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

HEARING - VOLUME NO. VIII

BEFORE RICHARD A. PATTERSON, ADMINISTRATIVE LAW JUDGE

Constitution Hall, 525 West Allegan, Lansing, Michigan

Wednesday, May 7, 2008, 8:30 a.m.

APPEARANCES:

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

the elders.

MS. HALLEY: Thank you. No further questions.

JUDGE PATTERSON: Thank you, sir.

MS. HALLEY: Thank you.

MR. HAYNES: Your Honor, before we call our next witness, I'm afraid we have to take that dreaded technology break.

JUDGE PATTERSON: Okay. All right. How long do you need?

MR. HAYNES: Five to ten minutes.

(Off the record)

MR. HAYNES: Petitioners call Robert Prucha to the stand.

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

DR. PRUCHA: I do.

ROBERT H. PRUCHA, PH.D.

having been called by the Petitioner and sworn:

DIRECT EXAMINATION

BY MR. HAYNES:

Q Would you say your name for the record and spell your last name, please?

A Robert H. Prucha. It's P-r-u-c-h-a.

JUDGE PATTERSON: I'm sorry. Can you do that again?

THE WITNESS: It's P-r-u-c-h-a.

JUDGE PATTERSON: Okay. Thank you.

THE WITNESS: Uh-huh (affirmative).

Q Dr. Prucha, could you tell us briefly what your educational background is?

A I have a background in geology, hydrogeology and engineering -- water resources engineering.

Q And did you obtain a bachelor's degree?

A I did.

Q In what subject?

A Geology.

Q And where did you get your bachelor's degree from?

A At UC Berkeley.

Q For those of us out here in the Midwest --

A In California.

Q Thank you. And, Dr. Prucha, did you receive a master's degree from an educational institution?

A I did.

Q From where and in what?

A University of California at Berkeley, and that was in the mining hydrology --

Q And what was your --

A I'm sorry -- engineering hydrology.

Q And what was your master's thesis or the subject of the

master's thesis?
A Geothermal reservoir engineering.
Q And did you obtain a Ph.D.?
A I did.
Q From where and when?
A University of Colorado at Boulder in 2002 in civil engineering water resources.
Q And what was your Ph.D. thesis?
A It was on looking at integrated hydrologic models and developing conceptual and numerical frameworks for large-basin systems and in semiarid areas.
Q Dr. Prucha, where do you live?
A In the Boulder, Colorado, area.
Q Do you have any professional registrations?
A I do. I'm a professional engineer in the State of Colorado and in California.
Q Could you give us briefly your work experience post master's degree?
A I worked at several companies, some large -- a large engineering firm, a smaller engineering firm for a number of years.
Q And generally what have your duties been in your work?
A Mainly to develop hydrologic models, water-flow systems.
Q And what is your present employment?
A I co-own a small business called Integrated Hydro Systems,

and we are involved in developing to a large extent models or reviewing models that have been developed for surface water systems, groundwater systems, the integrated coupling of those systems.

Q Have you published any papers dealing with hydrologic modeling?

A I have; integrated modeling to a large extent where you couple groundwater systems and surface water systems.

Q And are those papers listed in your resume?

A They are.

MR. HAYNES: For the record, Dr. Prucha's resume is Petitioner's Exhibit 120, and it has been admitted by stipulation.

Q Dr. Prucha, in your experience and education, have you become familiar with geologic terms?

A Yes.

Q And for instance, geologic terms such as "dikes"?

A Yes.

Q "Faults"?

A Yes.

Q A geologic term such as "unconsolidated material"?

A Yes.

Q By the way, is that a relatively recent phrase that's used to describe another -- is there another way to describe unconsolidated material? What did it used to be called?

A It's what I normally refer to as unconsolidated material or deposits that are not consolidated. They're not in hard rock.
Q So unconsolidated material would be not bedrock?
A That's right.
Q In your field of hydrology and water resources engineering, are there other geologic terms that would be used that are relevant to your testimony today?
A You may hear terms like "quaternary deposits" or "alluvial deposits."
Q And what do you mean by "quaternary deposits"?
A Those are really Ice Age -- post Ice Age deposits, and I think they can be synonymous with the unconsolidated deposits or materials.
Q And what about alluvial deposits?
A Alluvial deposits are deposits that were deposited in a moving water system.
Q So how would you distinguish from a geologic standpoint quaternary deposits from alluvial deposits?
A "Quaternary deposits" just refers to an age or a date, and they're pretty much the same material.
Q I see. Now, do you have experience reviewing hydrogeology reports of other consultants?
A I do.
Q Do you have experience writing such reports?

A Yes.
Q And has that been true throughout your career?
A Yes.
Q Do you have experience reviewing characterizations of bedrock aquifers?
A Yes.
Q And has that been true throughout your professional career?
A I would say not exclusively. I probably spent more time looking at unconsolidated deposits. But in almost every system I've looked at, bedrock becomes an important factor in looking at the whole hydrology of the system.
Q I see. And do you have experience preparing reports dealing with characterizing groundwater flow?
A Yes.
Q And would those reports characterizing groundwater flow deal with groundwater flow in the unconsolidated materials as well as bedrock?
A Yes.
Q Do you have experience designing conceptual groundwater flow models?
A Yes.
Q And for Judge Patterson's benefit and perhaps for ours too, can you give a brief description of what you mean by "conceptual groundwater flow model"?
A It's a term that's used to describe where you think water

comes into a system; the basic structure of the system; the aquifers where water flows through; the aquatards where water doesn't flow through so easily; where water exits the system. So it's really a pretty comprehensive description of where you think the water's going throughout the system and what the stresses are or influences -- factors that influence its movement through the system.

Q And, Dr. Prucha, these models are predictive systems, are they not?

A That's right.

Q Do you have experience calibrating groundwater flow models?

A Yes.

Q And what do you mean by "calibrating groundwater flow models"?

A It's the process where you develop a conceptual understanding of the system, and you construct a mathematical model of the flow going through the system. And the process of calibration is your efforts to try and reproduce what you see in the field, either flows or groundwater levels, within a specified degree of tolerance.

Q When you say "a specified degree of tolerance," what do you mean by that?

A Well, that's where you say -- when you develop a model and you try and reproduce a water level at a given point within the system or flow, the model's only a representation of the

true system. There are simplifications. But effectively, that means that you will have some difference between what you simulate and what you observe. And the calibration attempts to reduce or minimize that difference between your observed and estimated or simulated level at that point.
Q Dr. Prucha, in your experience, do you have experience validating groundwater flow models?
A I do.
Q And what do you mean by "validating groundwater flow models"?
A We typically use it in a context of having developed a calibrated flow model. And typically you use it in the context of -- when you calibrate a model, you have another set of system observations, a distinct set, and you try to reproduce that set so it's -- the first model that you calibrate is one set of conditions. The second would be another set of conditions. Maybe the rainfall changes. And you go through the same process of calibration, where you compare the simulated or estimated model-derived value with what you observe. And again, if you can show that your model correctly -- you know or reproduces the system flow within this tolerance in both conditions, it provides considerably more credibility in the model that you've developed; that it reproduces the system.
Q I see. In your work, Dr. Prucha, do you have experience

using models to predict groundwater flows?
A Yes.
Q Is that the purpose of such models or a purpose?
A It's a purpose, yes.
Q And in your work, Dr. Prucha, do you have experience performing uncertainty analyses?
A Yes.
Q And what, for our benefit, is an uncertainty analysis?
A After you develop this series of models that you believe represents the system within this tolerance that you've specified, because the model is a -- it's a simplification of the actual system, you acknowledge that there will be some error in that calibration. And the uncertainty analysis is an attempt to add effectively a plus or minus at the end of a predicted value. So I estimate the flow out at this river of "X" amount, and you would add a plus or minus saying, "I believe that it's uncertain within a certain range." So there are a series of steps that you usually go through in conducting an uncertainty analysis, and it's really a required step these days to qualify your response. Because in modeling it's possible to develop a model that's not very-well calibrated, and you can generate a significant amount of uncertainty that could be greater than your objective.
Q For purposes of your testimony today, Dr. Prucha, did you

review various groundwater models prepared by Kennecott and its consultants?
A I did.
Q Dr. Prucha, we've had put on the screen a figure from Kennecott Exhibit 7.
MR. HAYNES: This is the -- for the record, the environmental impact assessment Appendix B-3.
JUDGE PATTERSON: B?
MR. HAYNES: B; "B" as in "boy," 3, Figure 8.1.
Q Dr. Prucha, have you reviewed this figure?
A Yes.
Q And is this figure related to the hydrology of the -- excuse me -- the groundwater modeling that was performed for the proposed Eagle Mine?
A Yes.
Q Dr. Prucha, can you tell us what the various -- what your understanding is of the various figures that are shown on this Figure 8.1?
A Okay. My understanding is that this is a map that describes the locations of where they conducted a bedrock well test, where they pumped the groundwater from the bedrock. And in this upper left corner here shows a line going down here with a black zone, and it says, "This is well 084." It's a pumping test interval. They pumped the water from this (indicating) zone in the lower bedrock, and they observed

the response in surrounding wells that are labeled at various locations here.

Q And just for the record, what are the labels of the other wells?

A To the left or west of the pump zone is well 84. And by the way, this is a well that has an -- it was drilled at an angle. So it started at the ground surface here and went to the east. To the west of that pump zone is well 074, and it actually starts at the surface to the south and goes up to the north. They have a shallow well, 023, to the far left -- upper left corner; have another well here, 107, that's between 84 and, say, 23, and another well, 077, that starts to the north and drops down into the lower bedrock to the south. And they have a well to the far right called YDO2-20. The text below each just indicates the amount of the drawdown at the -- during the test reported when they pumped this particular well.

Q When they pumped well 84?

A Right, when they pumped well 84.

Q And just for the record, for instance, what was the drawdown, based upon this figure, for well 074?

A I believe that says "83 feet" or "meters" -- "83 meters."

Q Okay. Can you explain for us what you mean by "drawdown"?

A When you pump a well -- and by the way, this particular well was pumped from a particular zone that was packed off over a small zone where there was a fracture noted that produced flow through it. But drawdown effectively is, when you pump this well, the water surrounding it with time starts to drop from its original elevation, and that propagates out from the pump zone with time. So at the location where the pump was actually sitting in this well, the drawdown is the greatest. The water level drops the most. And for this well it was nearly 200 meters that they dropped that; couple of football field lengths. It's a pretty significant drop.

And out at wells at a distance here, they dropped -- this dropped 83 meters. So it's saying, in effect, that the pumping at this lower -- from this lower zone here (indicating) is influencing the water level at this well 074.

Q Is the purpose of the pump test, then, to try to determine how the water behaves underground when there is water drawn out from underground?

A Yes.

Q Dr. Prucha, I've now put up on the screen from Petitioner's Exhibit 63, this is slide 14. Dr. Prucha, is this a figure that you prepared?

A I did.

Q And what was your purpose in preparing this figure?

A My intent was to take the figure that had been provided in the report and simply try to locate it over the orebody and

with reference to the Salmon Trout River to tunneling in the area and to noted faults.
Q All right. For this figure we see a blue line that starts on the bottom sort of center and then trends up and to the left, and I see a label that says "Salmon Trout River." Is that your representation for your analysis here of where the Salmon Trout River is?
A That's right. This comes from the DEQ website for -- this is just another geographical information shape file, so it's a file that had this map, and I simply brought it into this program.
Q So you transposed an electronic map onto this figure?
A That's right.
Q Okay. And then the -- there seems to be an -- I guess it's orange-colored or magenta-colored figure to the north of the Salmon Trout River. What does that represent?
A This (indicating) line?
Q Right; yes.
A The red boundary is the approximate location of the orebody --
Q And where did you get --
A -- as I took off --
Q I'm sorry. Where did you get the orebody figure from?
A I traced that from a map that I'd gotten from a report and brought that in. That wasn't provided.

Q And then we have a purple line that seems to go in various directions. What's that represent?
A This is an approximate line that represents the tunnel. And again I got that off of a map. The intent wasn't to draw it super accurately but to get the approximate location and reference it to the pump test wells.
Q I see. And horizontally going through about the center of the figure, we see a light blue sort of dashed line. What does that represent?
A This is a line that represents a dike that a geologist in the late 70's identified.
Q And by "a dike" -- what do you mean by "a dike"?
A It's an obtrusive body of material that's different than the surrounding country rock that is extending up vertically relative to that country rock and --
Q And you've identified, it appears, on this figure that dike as the Klasner Dike?
A That's right, --
Q Is that your --
A -- as he defined it.
Q I'm sorry?
A As he defined it.
Q All right. Now, we also have a sort of a yellow line that's on the right-hand side of the figure that trends sort of northwest to southeast. What is that?

A This is actually the left side of a zone that the same author, Klasner, in the late 70's defined as a fault zone. And again, this was taken from his report by georeferencing his material and lining it up with information that we had at the local site here.
Q And we also see a red arrow in the upper right portion of the figure that you seem to have labeled "Klasner Fault Zone." What is that?
A Right. This orange line represents the westernmost boundary of the fault zone. And so if you proceeded maybe 500 meters to the east, it would represent the other side of this zone that he had mapped as a fault zone.
Q Now, you may have already testified to this, but what was your purpose in preparing this slide?
A The primary purpose was -- when I read through these reports initially, I had a lot of trouble trying to determine where these wells were located with respect to the orebody. One of my primary interests was to determine whether they had characterized hydraulic -- through hydraulic testing the entire area where they plan to mine, tunnel; whether they had crossed mapped faults through the area.
Q Now, in your experience, Dr. Prucha, is it important for modelers to take account of things like dikes and faults?
A Absolutely. They can be controlling features for the hydrology, especially in bedrock systems.

Q When you say "controlling features," what do you mean?
A Controlling the groundwater flow through those systems in the bedrock. The bedrock has been -- the matrix material, not the material that's faulted, appears to be relatively low permeability or has a low ability to transmit water through it.
Q Let me see if I can -- if I understand what you mean. Are you saying that bedrock normally doesn't allow water to flow through it very fast?
A Not very readily, not compared to the unconsolidated deposits that would --
Q Above the bedrock?
A Which are maybe sands. It much more readily allows water to flow through it; a greater volume.
Q And so, then, are you contrasting the dikes and faults with the bedrock, then, in terms of the flow capacity?
A That's right. They're associated with the bedrock. And when you think of the bedrock system -- when I read through the report, I think the conclusion is that there's not much flow through the bedrock system. And yet these large faults are -- can be significant conductors of water through the system -- through the bedrock system, and they can translate water from the bedrock system into the over- -- the unconsolidated material.
Q And explain that process for us; that is, how these faults

and dikes would transmit water more readily than the bedrock. Why is that?
A Because they're effectively open --
MR. LEWIS: Just a minute; just a minute. Just an objection as to form, your Honor. The witness has testified that they can be, and this question is now posed as if they are. So I have an objection to the form and the foundation.
MR. HAYNES: Well, I'll rephrase it.
JUDGE PATTERSON: All right.
Q Dr. Prucha, how would you describe the process by which faults and dikes can transmit water more readily than bedrock?
A There are continuous features that -- in the case of Klasner mappings, these are on the order of kilometers -- several kilometers or miles, and they're open. They have a certain width, and the -- they allow water to flow through readily along those lineaments.
Q Describe a lineament for us.
A It's a straight -- I mean, generally these features tend to be more linear than not linear.
Q Than curved or at right angles?
A That's right; that's right.
Q Dr. Prucha, I've had put up on the screen again from Kennecott Exhibit 7 the environmental impact assessment Appendix B-4, Figure 9.5. And is this a figure, Dr. Prucha,

that you've reviewed?
A Yes.
Q And what was your purpose in looking at this figure?
A This is a predicted drawdown at the end of mining for what's been referred to in the report as an upper bound case, where they --
Q And explain for us what you understand an upper bound case to mean as a -- from a modeling standpoint.
A Well, in modeling you try to define the range that could possibly result from your interpretation of -- conceptualization of the system flow. When I reviewed a lot of the available information, it suggests that there are faults that run through the area that are extensive. And I was looking to see in this result here (indicating) whether the model that had been developed produces a drawdown -- simulated drawdown in the bedrock that is reasonable.
Q And, Dr. Prucha, when you reviewed this exhibit, did you try to calculate the area that is shown by this figure in terms of the drawdown post mining?
A The area impacted?
Q Yes.
A I did not actually calculate the area for this particular drawdown.
Q Do you have an estimate?
A It's at least a mile in diameter.

Q So from the center of the figure out to the outermost concentric circle here, we have a mile in diameter?

A A mile in diameter, right, at least.

Q Now, is that modeling dimension something that you would expect to see from the models that you saw in the reports that you reviewed?

A I was surprised that it wasn't more -- that it was so concentric or circular. It didn't seem to indicate just by design that the faults had a pronounced effect going north, south and east, west like they imposed on this particular model.

Q And for modeling an area that has a mile in diameter, would you expect to see six wells used or more than six wells or less than six wells?

MR. LEWIS: Objection; foundation.

MR. HAYNES: Your Honor, I think I've laid a foundation that the witness can testify about how models are constructed.

JUDGE PATTERSON: I agree. I'll overrule the objection.

A I would expect over this area that you would have not only more wells but not all located in one location.

Q And what do you mean by that?

A Well, relative to the size of the drawdown area here (indicating), all of the wells in the bedrock are located in the very smallest central drawdown area that you can't even really see at this scale. It's almost a dot at this scale. So in effect, they haven't characterized the bedrock system over this entire area; just this small area largely within the orebody.

Q Just so the record is clear, Dr. Prucha, you're saying that, for purposes of this predicted drawdown figure, Figure 8.5 -- excuse me -- 9.5, the wells are located within the center circle, and there are no wells located, for purposes of this drawdown prediction, in any of the other concentric circles noted on this figure?

A Not that I noted in the reports.

Q Dr. Prucha, I've put up on the screen from Kennecott Exhibit 7 the environmental impact assessment Appendix B, as in "boy," 1, Figure 4. And is this a figure that you have reviewed?

A Yes.

Q And what does this figure show you in terms of the geology of the area around the proposed mine?

A Well, first of all, the proposed mine is located in this area, and it --

Q You're pointing with a laser to the center?

A In the central part of the figure. And the Salmon Trout extends just below that and off to the west going to the north. And what I saw from this figure was a number of faults -- fault lines that go from southeast to northwest, pretty much paralleling each other. And in some cases they're offsetting dikes that are effectively for the most part running east/west. Another thing that struck me about this figure was the length of these.

Q Of these what?

A Of these dikes and the faults; that the lengths of these are -- and here's the scale here. This is 1 kilometer, this scale down in the lower left. And these -- there are one, two, three, four dikes shown on here that are running east/west, and these are several kilometers -- several miles long. And I believe that other information I've looked at it's actually these extend on for even longer than that.

Q And why is that significant for purposes of groundwater modeling? Let me rephrase the question. Is that significant for purposes of groundwater modeling?

A It is.

Q And in what way?

A Well, I believe that these dikes can be low-permeability material compared to the surrounding country rock. In terms of the implications for modeling and so forth, these weren't considered in the model, and they would certainly have an impact on any estimate or prediction put forth by those models from the drawdown in this particular area.

Q Dr. Prucha, if you had been asked to prepare a groundwater model for this mining application, would you have put these dikes and faults into the groundwater model?

A Absolutely.

Q Would that have been best practices?

A Yes.

Q I'm sorry, Dr. Prucha. The faults and dikes, are those areas of low permeability or high permeability?

A Well, the dikes are generally considered to be areas of low permeability except for the information that I've reviewed from Marcia Bjornerud and Stan Vitton that indicates that there are brecciated zones around either side, the contact of these with the surrounding country rock.

Q And excuse me. What do you mean by "brecciated zones"? And could you spell that for the record so the court reporter --

A B-r-e-c-c-i-a-t-e-d.

Q And what are brecciated zones?

A My understanding is that they're the zone between the intrusive that was hot. And it cooled and created fractures in the country rock that was colder, and it created the fractured rock that's permeable, and that permeability allows water to freely move through that zone. So you can imagine that these might be impermeable to flow in a north-south direction. The dikes that are located east/west may be impermeable or prevent significant flow going from north to south. But along them on these brecciated zones at a large scale like this, you can imagine them preferentially routing water along them. Then add that into conjunction with the noted faults through the area -- and I note that some of these actually align with rivers, which I think is another important point that was sort of overlooked.

Q And how is it important to note that faults are generally aligned with rivers?

A Well, in a lot of systems I've looked at, this is generally the case, where over time the rivers tend to align themselves with these large structural features, because water moves through these faults preferentially, and they establish a connection with the surface water because they tend to drain water out through the rivers.

MR. HAYNES: I apologize, your Honor. We have to wait for the electrons to move right.

Q Now, Dr. Prucha, for purposes of your testimony, did you prepare the figure that we have up on the board, which is slide 13 of Petitioner's Exhibit 63?

A Yes.

Q And what were your source materials in preparing this slide?

A Again, the information that is shown on the map. I have a topography shown with the various colors underlying the whole box here (indicating).

Q And what do the colors represent generally?

A Elevations generally are higher in red zones and lower in

darker colors off to the north.
Q And what else have you shown on this figure?
A I've also shown the Salmon Trout River. It's roughly in the center of the diagram and goes up towards the north.
Q And does the diagram show the orebody?
A It does; a little red zone here (indicating) just above the Salmon Trout River, and then it shows Eagle Rock off to the right of that in the center area.
Q And what do the green lines represent -- the green horizontal lines?
A The green lines are the dikes that we saw in the former exhibit.
Q And what about the -- I think those are red sort of northwest-southeast-trending lines.
A These are the faults, the darker, almost brownish color heading off to the northwest.
Q And we also have a series of lighter blue lines that look like they tend mostly east and west. What are those?
A These were dikes as mapped by Klasner in 1979.
Q I see. And on this figure we have at the top -- it appears to be a reference to "Rossell and Coombs 2005." What is that?
A They were the authors of the geology report that I reviewed.
Q And what was your purpose in preparing this slide?
A Well, I'd also note that Klasner also mapped the orange

lines here as well, and these were faults in the area. And one of my primary interests was to see how two different groups were mapping the faults and dikes in the area.
Q Did you find the mapping between the two authors consistent generally or inconsistent generally?
A More consistent than inconsistent, but I did find differences.
Q Now, Dr. Prucha, have you reviewed Marcia Bjornerud's report that was submitted as part of the comments for the application in October of 2007?
MR. HAYNES: And for the record, that is Petitioner's Exhibit 3, Appendix A already admitted.
A Yes.
Q Dr. Prucha? "Yes"?
A Yes.
Q And what portion of that report, if any, was significant to you for your analysis here?
A Probably the most significant part was the brecciated zone along the dikes and the fact that these could be very significant water conductors or routes that groundwater can preferentially flow through.
Q Now, Dr. Prucha, we've had put on the screen from Kennecott Exhibit 11 the environmental impact assessment -- excuse me -- Appendix B, as in "boy," 8, Figure 21. And what was your -- you've looked at this exhibit, did you not?

A Yes.

Q And what was your purpose in looking at this Figure 21, which is the conceptual hydrologic -- excuse me -- hydrogeologic cross-section B to B prime?

A The point of this was to see whether the authors of the report had considered whether the intrusive that was mapped at the orebody was actually located underneath the Salmon Trout River and --

Q And what does this figure show you in that regard?

A This shows me that they are considering that at this -- in this particular conceptual diagram, that the actual dike that's shown with sort of the left part of the diagram that's sort of a vertical structure -- and it's elevated with respect to the surrounding country rock -- has intruded and sits below and is in contact with the Salmon Trout River and likely the wetland area.

Q Dr. Prucha, you've been talking about country rock. I don't see on this figure the phrase "country rock." Is there a designation of rock or soil types on this figure that would translate to country rock?

A It would be what they're referring to as the bedrock metasedimentary rock. And it's -- the writing doesn't show it well on this plot, but it underlies the unconsolidated material, and it appears on the left and the right of this (indicating) near-vertical dike or what they would refer to as igneous intrusive.

Q Does the phrase "metasedimentary" have a particular meaning in geology, just for the record?

A It's of sedimentary origin, and it has been consolidated into a rock as opposed to unconsolidated.

Q I see. And is there a significance about this figure for modeling purposes?

A A big significance.

Q And what is that?

A Well, in terms of producing a model, you'd want to be able to show that the bedrock system is intruding to the ground surface. And although this (indicating) figure doesn't come out in the area that's black here, it actually shows stratification of different layers in the unconsolidated material. But probably the most important thing about this drawing is the fact that, if -- I mean, there are brecciated zones in the contact of this intrusive. This would offer a direct conduit between lower bedrock areas where they're going to be dewatering the mine and surface water, in addition to the shallow aquifer system shown in black on this picture.

Q Now, I notice on this figure that there are some appear to be designations along the top -- along the surface. What are those designations?

A Well, in the original diagram, they refer to "boreholes" or -- that are, you know, actually wells that have been drilled through the dark area here, which is really the unconsolidated material. So there are wells at each one of these points.

MR. HAYNES: Your Honor, I apologize for the opaqueness of the exhibit, but I think that Mr. Eggan will be able to clear this up later with a color version. So I apologize.

MR. EGGAN: We can do that if you wish, if it would help to have the color version.

MR. HAYNES: It would help, yes.

MR. EGGAN: Okay. Do you want it now?

MR. HAYNES: Yes.

MR. EGGAN: MDEQ 010814. Okay. It's a different one. Let me give you a different one. I think it's MDEQ 0110820.

THE WITNESS: That's it.

MR. EGGAN: That's it in color.

Q All right. Dr. Prucha, Mr. Eggan has graciously put up on the screen the same Figure 21 in color. And with that help, can you explain for us what the different colors are in the legend for the different kinds of rock?

A Sure. The brown and the blue really are what are defined as sands. And the only difference there is that the blue is where groundwater has saturated the pores and exists there

above that. It's referred to as a vadose zone, so it's still sand, but there's not groundwater actually in that zone.
Q And just for the record, "vadose" is spelled how?
A V-a-d-o-s-e.
Q Thank you.
A The purple zone is referred to here as a fine sand silt and clay, and the red is considered a lean clay.
Q And what is a lean clay?
A Effectively a clay that has low permeability with respect to sand. So hydrologically it's going to provide less flow through it than sand.
Q I see. And the metasedimentary bedrock is in what color?
A Is gray, and it's shown below all of the unconsolidated soils in different colors.
Q All right. And then back to my question previously about the designations that appear to be on the surface here. What are those?
A These are simply well names, and associated with each well is a borehole that was drilled to install the well, and they record the geology as they go down.
Q And the representation here on this figure as you understand it shows the boreholes relating to the depth of the boreholes; is that a fair statement?
A I'm not sure --

Q Well, let me rephrase it. That was rather awkward. For these well designations does the figure show the depth of the well approximately?

A Relative to the ground surface shown here at the top it does, yes.

Q Dr. Prucha, for groundwater modeling is it important for purposes of groundwater modeling to test the groundwater flow system?

A To perform hydraulic tests on the system, it's imperative to develop that understanding before jumping into modeling.

Q And how do you test the groundwater flow system?

A Well, typically you will go out, and one of the most important bits of information is to measure the groundwater surface. So this line right here (indicating) that defines the blue-brown contact is a critical surface. That really is probably the most important bit of information about the groundwater system that you need to understand. And when you go to test the system -- and by testing, the whole purpose of that is to define the hydraulic properties of each of the wells, the material that's screened across each of the wells.

Q And just for Judge Patterson's benefit, what do you mean by "screening across the wells"? What does that mean?

A Well, each one of these wells it will have at the bottom -- as though you stuck a straw into the ground, it has a zone

where it's perforated and allows water from the surrounding aquifer to come into the well. And the rate at which it comes in gives you a lot of information about the hydraulic properties of that aquifer material.
Q And does the testing of the groundwater flow system depend on the number of wells used?
A Yes.
Q And does it depend on the spacing, the geographic spacing of those wells?
A Yes.
Q And does the spacing and number of wells relate to the appropriate coverage for the groundwater model?
A Yes. It's important to have the correct spacing.
Q That is, the coverage of the area that's modeled?
A Did they include the correct spacing for the modeled area?
Q Well, that was going to be my next question. Was for this model, Dr. Prucha, in your view, the appropriate spacing used for the wells?
A I don't believe so, no; no.
Q Why not?
A They're located in -- if I were asked to go down and perform the test of the shallow aquifer system here, I would locate them primarily in the areas where I anticipate the greatest mine dewatering impacts to occur. And I don't see that that was done here.

Q Dr. Prucha, we've gone back to slide 13. In relation to the question of the appropriate spacing of groundwater wells and considering the geologic structures that you've already testified to, for purposes of testing a groundwater model for the area around the proposed mine, where would you have expected wells to have been placed?

A All along the area from East Eagle over the tunnel entrance on the north side of the orebody through the orebody over that entire area plus any area that you would expect to be impacted around that. And given that this is largely underneath the Salmon Trout River, I would have expected wells on both sides and located -- you know, a number of wells in that area.

Q And in view of the geologic properties shown on this slide 13, Dr. Prucha, what would you expect in terms, not only in number but also the placement of the wells?

A Well, with reference to this plot here, I would have expected wells to be placed along noted -- near noted dikes, the brecciated zones above those, to see if there is contact and how much flow would occur there. I would expect them to have been placed near mapped faults -- fault zone areas.

Q And in your review of the groundwater models prepared by Kennecott and its consultants did you observe any such well located along those geologic structures?

A These are the features that I would expect to be major water

conductive features 'cause they were mapped, and they're very long. They run for miles. And I didn't observe that.
Q And would you consider that best practices for groundwater modeling?
A No.
Q Dr. Prucha, we've had put back up on the screen slide 14 from Petitioner's Exhibit 63. For the six wells that were placed and noted on your slide here, slide number 14, would you expect a groundwater model to be able to model the flow in the area shown on this slide as covered by these six wells?
A No.
Q Why not?
A Well, I don't believe that putting six wells in this area right here (indicating) covers even the area that they plan to dewater, let alone the area where faults have been mapped in the area or possible connection of this brecciated zone along the intrusive, the light blue line here in the center of the page just above the Salmon Trout River.
Q What do you understand from your reading of the reports, Dr. Prucha, to be the area that is planned to be dewatered?
MR. LEWIS: Objection to the form of the question, your Honor.
MR. HAYNES: I'm not sure what the objection is.
MR. LEWIS: I'm not clear if there's -- I don't

know what "plan to dewater" means. I've got no recollection of anybody talking about a plan to dewater. It may simply be that if I could get a little more explanation of what we're talking about, it would be fine.

MR. HAYNES: I'll do that, your Honor.

JUDGE PATTERSON: Okay.

Q Dr. Prucha, you mentioned the phrase "plan to dewater." What do you understand by that?

A The scheme to actually dewater the tunnels so that they can actually carry on the mining.

Q So did the documents you reviewed talk in any sense about dewatering the tunnels as the tunnel is built?

A Well, not specifically about every tunnel, but they do have a dewatering plan.

Q I see. And so back to my question, Dr. Prucha, what would you expect these six wells to be able to show in terms of -- in terms of the area that's going to be dewatered for this mine?

A Well, I think at most you can say something about only the area that they extend. And they don't extend up into the access tunnel to the north all the way over to East Eagle Rock.

Q And would you have expected that modeling to -- or that characterization to occur for this proposal?

A Absolutely.

Q That would have been best -- or would that have been best practices?
A Yes.
Q And based upon the six wells that you have observed in the modeling proposed by Kennecott, would you expect those six wells to be able to be the basis for a model for the one mile in diameter area that you described before?
A No.
Q Why not?
A It's too small of an area. And also the design of this test presumes that they have, in fact, intercepted a larger water conductive zone like the brecciated zone or, say, the fault zone over here (indicating) that Klasner had defined in orange.
Q When you say "the design of the test," what do you mean?
A The placement of the wells, the depth that they're pumping from, the fractures that they pump from and as it relates to the location of those, and they don't seem to acknowledge that these large-scale mapped water conductive features exist or potentially impact their test.
Q Now, Dr. Prucha, we've had put on the screen, from Kennecott Exhibit 7 the Environmental Impact Assessment Appendix B-4, page 16. Dr. Prucha, this is section 7.1 and 7.3 of Appendix B-4. And what is the significance of the discussion in this section for the purposes of groundwater

modeling?

A Well, as far as I can tell, the pump test on well 084 was pumped from a zone about 257 to 260 meters down. And this is the basis for that. And I wasn't very clear why that zone was chosen as the only zone to really pump test and then calibrate an entire bedrock model to.

Q I see. So is it your understanding that only one zone of this well that extends for almost 300 meters was tested here?

A In this particular case, yes, for this pump test that we referred to on that former diagram.

Q And were there other pump tests performed as part of the modeling besides this one?

A Not to my knowledge, that went into actually calibrating their bedrock model.

Q And in your view, based upon your experience, is the well 084 representative of the orebody?

A I would say of the orebody, it's through the orebody, so I would question whether it's fully representative of the entire orebody. It's one well.

Q Would you have expected for best practices to have seen more wells through the orebody and more pump tests through those wells?

A I would have expected to see more outside in the tunnel area, any area they plan to dewater.

Q And did you see those?
A No.
Q Now, Dr. Prucha, we've had put up on the screen, Kennecott Exhibit 7, Environmental Impact Assessment, Appendix B-1, Figure 18, which is labeled "Surface Monitoring Locations." Have you reviewed this figure?
A Yes.
Q And what, for purposes of your testimony, is the significance, if any, of this figure?
A Well, where they are collecting surface water flow measurements, for example, on the Salmon Trout River here located sort of in the left center part of the screen, it heads off. And each one of these (indicating) triangles is a surface water gage.
Q And is the placement of the surface water gages, from your view, Dr. Prucha, appropriate for the model that was performed here?
A Well, there were several models produced, but for the models that actually included the river flow, it is important because they used this information to help calibrate it to observed flow.
Q Dr. Prucha, I've had put on the screen the first page from Petitioner's Exhibit 61, which is entitled "Technical Report Number 3 of the Michigan Department of Conservation Geological Survey Division," entitled "Groundwater

Investigations of the Marquette Iron Mining District, Michigan," dated 1954. Have you reviewed this?
A Yes.
Q And what was your purpose in reviewing this document?
A I was interested in seeing whether nearby mines have had similar water inflows or dissimilar inflows predicted, whether they have associated surface water impacts.
Q And would a prudent modeler take into account the experience of nearby mines for purposes of modeling the groundwater flow in a proposed mine in the location of the proposed Eagle Mine?
A Yes. If it's a similar environment, yes.
Q Now, Dr. Prucha, we've put up on the screen page 20 from proposed Petitioner's Exhibit 61 and the text of this, which is pretty faint right now. But what's significant to you about the text of this report for purposes of modeling the groundwater flow at the proposed Eagle Mine?
A What I found here that it is a similar environment to the Yellow Dog Plains in that it has similar material, outwash sands, till material and this -- the thicknesses are 100, 200 feet thick. It overlies a bedrock. The bedrock is fractured, has dikes running through it. And so from that perspective, I think on this particular page, that was the point.
Q I see.

MR. HAYNES: Move the admission of Petitioner's Exhibit 61.

MR. LEWIS: No, objection, your Honor.

JUDGE PATTERSON: All right. No objection, it will be entered.

MR. REICHEL: No objection.

JUDGE PATTERSON: I'm sorry.

MR. LEWIS: Mr. Reichel's back today.

(Petitioner's Exhibit 632-61 received)

Q Now, why would a prudent modeler take into account the experience of nearby mines?

A My perspective it's to assess the range of inflows that are possible in an environment similar to the Yellow Dog Plains, the long history of mining where they're mining in the bedrock system. And I wanted to compare what had been predicted by models in the Yellow Dog Plains to what is reported in this report.

Q So would the range of inflows be related to what sometimes is known as "the worst case scenario"?

A Yes.

Q And is that also sometimes known as the upper bound?

A In this report, yes -- or these reports that I've reviewed from Kennecott.

Q And does that relate to your previous characterization of modeling in terms of the range of uncertainty?

A Yes.

Q That is, we have a lower bound and an upper bound for the range of uncertainty for any model?

A Yes.

Q And did you observe in your review of the Kennecott reports any analysis or discussion of the experience at nearby mines in terms of the inflow into those mines?

A In terms of the flow rates?

Q Yes.

A Yes.

Q And what did you find in those reports?

A I found several mines have reported inflows of up to several thousand gpm, so significantly higher than what I was seeing reported from the modeling and estimates done by Kennecott.

MR. LEWIS: I'll just place an objection, your Honor, to the last question and answer. Number one, the way I heard the question it was, had he read such information in Kennecott reports? So I took it that the question -- or the answer would be in that reference. However, it sounds like there's some testimony being offered about some mine inflows at other mines other than this mine. And to the extent that's the testimony, I would just remind the court of my continuing objection, I think, at this point about such use of evidence from other mines without sufficient foundation of similarity and would move to strike the last answer on that basis.

MR. HAYNES: Your Honor, I have two responses: One, I don't understand why Counsel needs to put the continuing objection on the record. You've already ruled that nearby mines are relevant, and so that's now done. And so the continuing objection is just slowing us down. Second, I'm going to ask the witness again the same questions because I didn't -- I mean, I thought the answer was a little off track, so I want to get back to that question.

JUDGE PATTERSON: That was unresponsive, so okay.

Q Dr. Prucha, I asked earlier whether you observed in the Kennecott reports in the models you reviewed any discussion of experience at nearby mines in terms of groundwater inflow to those mines?

A No.

Q Now, Dr. Prucha, I've had put up on the screen the first page and an enlarged portion of that of Petitioner's Exhibit 60 which is entitled "Technical Report Number 2, Groundwater Problems of the Iron River District, Michigan," prepared by the Michigan Department of Conservation Geological Survey Division, June 1948. Did you review this document for purposes of your testimony today?

A I did.

Q And is this a document that a prudent modeler would consider

in the conduct of his or her work?
A Yes.
Q And what was your purpose in reviewing this report?
A To assess mine inflows that were measured at mines in this area and to assess surface water impacts.
Q And how is the experience of nearby mines, if at all, relevant to assessing surface water impacts at this proposed mine?
A Well, it demonstrates that mines in the area can impact nearby surface water. And I point out that both this exhibit and the previous one, none of the mines that I looked at were sitting right underneath a river like the Salmon Trout River.
Q And why is that significant?
A Well, because I would expect more impact from the proposed mine at Eagle compared to the mines that I've seen here.
MR. HAYNES: Move to admit Petitioner's Exhibit 60.
MR. LEWIS: No objection.
MR. REICHEL: I have no objection to the fact that this is a report. I do have a concern that the subject of this document which is the Iron River District, is not a foundation sufficiently established that the geologic conditions observed in the Iron River District as defined in this publication are transferrable to or equivalent to those

at the Eagle Mine site.

MR. HAYNES: I'll clear that up, your Honor.

Q Dr. Prucha, for purposes of modeling -- modeling surface water impacts from a proposed groundwater dewatering, is it important to understand the impacts at other kinds of mines in the general vicinity?

A Yes, because I think fundamentally, even though there are differences in the exact configuration and type of bedrock material, components are pretty similar. You have unconsolidated material, overlying bedrock. The bedrock's fractured. They're pulling water from the bedrock, and surface streams are interacting with the unconsolidated material and the bedrock in both of these areas.

Q And so for purposes of modeling the effect of dewatering underground for a mine and its effect on surface waters, you would expect that a modeler would review experience at mines nearby?

A Yes.

MR. HAYNES: Okay. Again move the admission of Petitioner's Exhibit 60.

MR. REICHEL: Again I would note that it's still established that, quote, "this is a mine nearby." I think if -- when and if we get into this, if you look at the body of the document, the area is located some considerable distance away in the western Upper Peninsula.

Q Dr. Prucha, would that make a difference for you, that the mines discussed in Petitioner's proposed Exhibit 60 in the Iron River District are located some distance away?
A Not really, no.
MR. HAYNES: Your Honor, I think we've laid a sufficient foundation for purposes of modeling to admit this exhibit.
JUDGE PATTERSON: What was the number of the exhibit again?
MR. HAYNES: 60.
JUDGE PATTERSON: I'll admit it over objection.
(Petitioner's Exhibit 632-60 received)
JUDGE PATTERSON: Would this be a good time to break for lunch?
MR. HAYNES: Sure.
(Off the record)
Q Dr. Prucha, good afternoon. I would like to return for a moment to Petitioner's Exhibit 61. And I'm looking at -- it's identified for the record as HMC006188 which appears to be page 3? Okay. Page 3. And, Dr. Prucha, on the left-hand column of this exhibit is there some texture that is of particular significance to you in terms of using nearby mines for comparison for modeling purposes?
A Yes.
Q And could you point that out so that we can enlarge it,

please?

A This paragraph here (indicating) in the upper left.

Q And, if you could, read the portion that you find significant and tell us why.

A This part here (indicating) that says, "Induced recharge from the Carp River at the Morris Mine exceeds 400 gpm."

Q And what is the Morris Mine, if you understand it, and where is it located?

A It's a mine in the Marquette Mining District. It's about 15 miles or so from the Eagle Mine.

Q And what does the phrase "induced recharge" mean to you in the context of your testimony today?

A Effectively here it means that because of dewatering it, the Morris Mine, the study here has measured 400 gpm lost in the Carp River that runs by it. But I point out here that this mine is about 1,000 feet away from the river.

Q You mean the Morris Mine is about 1,000 feet away from the Carp River?

A That's right, as opposed to the proposed Eagle Mine being pretty much underneath the Salmon Trout River, and the drawdown cone or extent of that drawdown from the Morris Mine later in this report also indicates that it extends about 10,000 feet downstream of the Carp River so about two miles in terms of the zone that it's impacting along that river, so --

Q And why would that be important from a modeler's perspective?
A Because, a) it establishes that there is a connection between the pumping in the Morris Mine and the nearby river, a drop in the flow of the river.
Q Now, Dr. Prucha, I've had put on the screen on the first page of what has been marked Petitioner's proposed Exhibit 64 what appears to be a paper entitled, "Underground Hard-Rock Mining Subsidence and Hydrologic Environmental Impacts." Do you see that?
A Yes.
Q Have you reviewed this paper for your testimony today?
A I did.
Q And what is the significance, if any, of this paper for purposes of modeling proposed groundwater inflows into proposed mines?
A Well, a couple of things: One would be that this is sort of at a national level. So the first two papers that we went over are within, say, 15 miles. And the next one was maybe at 50 miles distance. This one is nationwide, and it specifically points out as one of the study sites the Athens Mine which is in this Marquette Iron Mining District area.
Q And how is that significant for you from a modeling standpoint?
A Well, I wanted to see what the impacts were in terms of the

amount of mine inflow at the mine -- at the Athens Mine. And also it points out that the subsidence issue is something that doesn't just occur in Marquette Iron Mining District or in the Iron River District.
Q All right. And we've pulled up now what's been marked HMC006327 from this report which is page 10 of the report. And is this where the discussion of the Athens Mine occurs?
A I'm not sure.
Q And what would be the significance from a modeling standpoint of the fact that the Athens Mine is now mentioned in a nationwide report dealing with subsidence?
A Oh, it's considered --
MR. LEWIS: I just want to note my objection for the record, your Honor.
JUDGE PATTERSON: Okay.
A I think it's significant because it's pointed out of one of many national mines that's had this problem associated with it.
Q And the problem is a subsidence issue; is that correct?
A Right, and they acknowledge here that it's not just a mine inflow problem, but it also is -- and they acknowledge that subsidence affects both groundwater and surface water, the mines that they go over in this report.
MR. HAYNES: Move admission of Petitioner's Exhibit 64.

MR. LEWIS: The objection I've stated from time to time, your Honor, as to the lack of necessary foundation under our Michigan Supreme Court law on the subject, lack of any necessary foundation of similarity to the only mine that's at issue in this case and therefore lack of relevance.

MR. REICHEL: I'll join in that objection.

JUDGE PATTERSON: I think I previously ruled that -- consistent with previous rulings, I will admit Exhibit -- I'm sorry. I missed the number again --

MR. HAYNES: 64.

JUDGE PATTERSON: -- 64.

(Petitioner's Exhibit 632-64 received)

Q Mr. Parker, we're back to slide 14. And I'd like you to, if you can, talk about where the bedrock wells were monitored in direction from the pump to L084.

A Well, I think what struck me about this pump task that was performed is that the monitoring wells are largely oriented east to west in relation to this pumped well instead of trying to monitor possible fractures, faults that might extend, say, for example along the north-west trending mapped faults through the area. So in other words, I would have put wells up in this (indicating) area to the north and south and an area around the area that they're going to need to dewater, for one, but not just sort of along an east-west

trend.
Q And would that have been best -- would that be best practices for modeling for this kind of a situation?
A Yes.
Q Now, Dr. Prucha, I've had put on the screen what is Kennecott proposed Exhibit 214, 2-1-4, which -- have you reviewed this proposed exhibit?
A I did.
Q And what do you understand this exhibit to show?
A The presence of faults or fracture lines that are oriented both north -- you know, roughly trending along this (indicating) line north to south and also faults through the area that appear to be oriented almost at 90 degrees to that, that trend up.
Q And just so the record is clear, we have -- we're showing the first page of this exhibit, and there seem to be two figures. Can you identify the various features that we've talked about this far, the orebody and so on, on these figures?
A My understanding is these are just horizontal slices through at different mine elevations and that the orebody I believe is shown here in red. And the faults --
Q The green vertical lines represent what, Dr. Prucha?
A My understanding would be that those are boreholes.
Q Oh, I see. And again I apologize if I've asked you this

question, that this exhibit shows faults or dikes; is that right?

A Faults.

Q And would you have expected those faults to have been included in any model that predicts -- tries to predict groundwater inflow into the mine?

A I would think that you'd need to include those. They're water conductive, and I don't see any reason why they weren't considered as not water conductive.

Q And did you see the -- did you see that these faults were included in the mine -- in the model that you reviewed?

A I didn't see it in the model or their analysis. And I think another significant point about this is that if you keep going down an elevation, I see similar fault features at various elevations. So it's not just something that occurs in the lower bedrock unit as they've defined it.

Q And then the next page of this exhibit we see a couple of figures. What do those show to you?

A Well, this figure on the top shows the drillhole trace map with above holes on level 275 of the mine. The lower one was sort of more interest because superimposed upon the fracture traces or faults are the pump test wells that they had performed in the bedrock.

Q Why is that significant?

A Well, for one, this was the first time I'd seen any reference to the faults there oriented here east-west. And these do appear to be significant because I see them in multiple layers going through the different mine levels. And to me, if I were developing a pump test to assess the flow through the faults which are going to control the amount of water flowing through the entire bedrock, which again is going to dictate how much mine inflow occurs, you want to design a test to acknowledge the existence of these, have wells that cross those and demonstrate clearly that they're connected or not connected.

Ultimately when I look at the pump test results, it looked like when they pumped the lower bedrock in 084, that I saw more of a east-west drawdown response. It seems to support the notion that there may be connected fractures, faults through this zone to the orebody. I don't see any information that suggests that these couldn't continue on and be further connected to the regional water conductive faults. That would be a critical element in the bedrock model that was used to predict mine inflows. So omitting that and assuming that you only had a very short connected fault is kind of presumptive in the sense that they calibrated the model and say, "This is really the only feature in here."

Q And do models normally, in your experience, assume that kind of a condition when you have multiple faults and multiple

dikes in a bedrock system?
A No.
Q All right. Dr. Prucha, we've put on the screen Kennecott proposed Exhibit 7, the Environmental Impact Assessment Appendix D-2, Figure 2-1. And what does this figure represent?
A Well, it shows a profile, a plan view of the boreholes in the top relative to each other. And there are horizontal lines showing the projection of where those wells extend to. The bottom plot simply shows the vertical projection of those boreholes in cross-section, and you can see the one well that's at an angle. This is their well 84.
Q And well 84 is the well that was pumped; correct?
A That's right. And the significance of this is that if you have identified near vertical faults through the area -- it could be water conductive -- the chances of hitting one of those near vertical water conductive faults is not that high with a vertical -- near vertical well.
Q And as a modeler, what would you have done in order to model the effect, if any, of the geologic structures that we've talked about?
A Well, before modeling I would have tried to assess how -- you know, I would have located boreholes and wells in areas where I suspected faults, large water conductive faults or the dike that might be permeable. And if you did put

verticals boreholes, that those would have to be pretty much right on those or going at an angle intercepting those and then testing those zones. But you can see from this picture that the majority of these are vertical and very localized compared to the entire orebody of the entire mined area which they'll be dewatering.

Q Now, Dr. Prucha, I've had put on the screen Kennecott proposed Exhibit 7, the Environmental Impact Assessment Appendix B-2, Figure 3-1, and what does this figure represent to you?

A Well, this is in color originally, and this had different geologic units on the left in this column and a legend describing what the geologic material is over here (indicating) on the right -- upper right corner. And then you see a series of columns of lines and dots and at the top different information like a caliper or resistivity, conductivity, flow rate, test information that they collect as they test the borehole through its vertical extent. And the point that struck me here was that when you look at these logs and the conductivity or the reverse of that, the resistivity information, which the conductivity can be translated into a TDS or, you know, effectively tells you how much salt you might have in the fluid at a depth.

Q Excuse me. Let me interrupt you for a second. What does TDS mean?

A Total dissolved solids. It's also an indication of -- it's been indicated that the water at depth has a higher TDS than the shallow pressure water, the surface water, and that this boundary between the two defines an upper bedrock zone and a lower bedrock zone.
Q You're saying that's what was interpreted here?
A Not from this information, but from this log, this information doesn't appear to have been used to help refine that definition of where the bedrock might be, upper or lower.
Q And where would you -- how would you have used that information if you were to design a model for this system?
A Well, you take all of these logs and align them vertically so that they're at the same elevation. The comparison of the curves that you see on this conductivity plot -- and when it jumps out here, you get a higher value or higher value of TDS. And this (indicating) is depth below ground surface up here. Going down, that will tell you where you get jumps in the formation of TDS.
Q And is that information relevant for purposes of modeling?
A Yes, because an important factor in the bedrock modeling that was conducted is this definition of where an upper bedrock zone and a lower bedrock zone occur and that contact between the two. The upper bedrock zone is assigned a much higher hydraulic conductivity. Water flows through it much

easier than the lower. And this -- if that zone had been put down lower, which some of these logs indicate, I believe that you would end up producing a higher mine inflow rate just on that basis alone.

Q All right. We're looking at Figure 3-2.

A This is well 54. And the conductivity log shows a very constant value for -- I can't make out what the depth is, but it's maybe 125 meters below ground. The depth that was selected without consideration of its uncertainty, was 90 meters, --

Q The depth for what?

A -- total vertical depth. For the break between the upper bedrock and the lower bedrock.

Q And can you tell from these figures or from the other materials you've read why that depth was selected?

A Well, from what I can see, it was based on a measurement in well 85 where they measured the TDS and said it looked like it had this value. And then they interpolated back up to near the ground surface, and they estimated 90 meters total vertical depth as the break.

Q All right. I think now we're at figure 3-6, and this looks like well 84, Dr. Prucha?

A That's right.

Q And explain for us what you just testified to.

A Well, the conductivity in this well shows a very low value to below 200 meters. The previous well 83, the previous plot for well 83 showed a similar depth. There's another well -- and by the way, 83 and 84 were sort of closer to the western part of the orebody. And as you go to the east you see higher and higher elevations for the conductivity. So it seems like spatially there's a trend. But this suggests to me that 90 meters, you know, they're claiming as an upper bedrock up here (indicating), and really it could very well be down 200-plus meters. And then this pulse actually goes back to a low value, suggesting maybe there's fresher water at depth below this. This also -- this depth down here (indicating) of close to about 260 meters also seems to suggest that this peak is where you have the -- this is where they read the high TDS which happens to correlate reasonably well with this conductivity jump here.

Q And the peak in the TDS would suggest what?

A Well, that you've hit a fracture zone right here (indicating) that may not -- that may have a higher TDS in it.

Q And what's the significance of that for modeling purposes?

A Well, again, the most important point is the definition of this upper and lower bedrock zone. The upper bedrock was modeled as being more permeable than the lower bedrock. And the depth that gets assigned to this upper and lower bedrock is important because in the lower bedrock, they assign

faults and put those in there, and in the upper bedrock they don't. The upper bedrock, if you increase the permeability and drop that depth and they're still mining in this upper bedrock, it will produce more water as a mine inflow rate if the depth is deeper.
Q Dr. Prucha, we've put up on the screen from Kennecott proposed Exhibit 7, the Environmental Impact Assessment Appendix B, as boy, 2, page 12. And there's some discussion in here of field work. What is significant here for you?
A I believe this is where they indicate that the -- the fact that you find high TDS at depth is indicating that it's not well connected -- the zone is not well connected to the surface water or shallow aquifer zone.
Q And what's the significance of that for purposes of modeling?
A Again the upper and lower bedrock contact is an important factor to have considered in the modeling. There was no effort made in the modeling to consider the uncertainty of that depth and its implication on the estimated mine inflows or the dewatering extent, magnitude.
Q Dr. Prucha, for purposes of modeling and for modeling bedrock flow systems, is it important to consider groundwater flow direction?
A Yes.
Q And is it important to consider groundwater flow velocity?

A Yes.

Q And is it important to consider hydraulic gradients?

A Yes.

Q What is a hydraulic gradient?

A It is the change in the groundwater potential from a high point to a low point over a certain distance. So a higher gradient has a steeper slope. It's like walking on the ground surface. And a flat gradient is walking on very flat ground like in this room. A steep gradient is walking in the mountains, and you would go from high points to low points. It's what drives the water from high areas to low areas in an aqua group.

Q And for purposes of modeling bedrock flow systems for -- in a groundwater system, is it important to consider three dimensional flow paths?

A Yes.

Q And why is that?

A Well, because water doesn't just flow horizontally. It flows in a three-dimensional path. It can flow from the lower bedrock to the upper bedrock or vice versa in addition to moving laterally. So it's important to define the three-dimensional flow path that water takes.

Q Dr. Prucha, I have put up on the screen from Kennecott Exhibit 7, the Environmental Assessment, Appendix B-3, page 41 which appears to have a table dealing with tunnels within

a weathered zone. Do you see that?
A Yes.
Q And what's the significance of this table for purposes of modeling?
A Well, these were inflow estimates for idealized tunnel within the weathered zone. Oh, I think it's the paragraph here under 8-2.
Q All right. And read the portion of the paragraph that's significant for you.
A "The conceptual model for the bedrock groundwater system below 90 meters true vertical depth is comprised of two components on weathered bedrock that is controlled primarily by matrix properties for the bulk of the rock mass and water conductive fractures with moderate hydraulic high activity with relatively sparse distribution."
Q And what does that mean for those of us who are not hydrologists?
A Well, effectively they're saying below this upper bedrock zone in the bedrock that they've defined, they're saying that they see that faults exist in there but apparently don't extend up into the upper bedrock.
Q And from the reports that you've reviewed and the slides that you've put up previously and that you've testified to previously, does that conclusion make sense?

A It doesn't.
Q Why not?
A Well, to have a permeable fault stop right at a boundary that you've defined very loosely doesn't make sense. But the fact is that if you have faults that are extensive and the fact that we saw this Exhibit 214 suggests that these faults do extend up through the upper bedrock. And the real importance of this is that when you go to predict mine inflow, by limiting faults to only the lower bedrock, you prevented a pathway for the water going into the mine dewatering system from impacting units above it. And I feel that's not very realistic to assume that the faults end right there at this presumed boundary. There doesn't seem to be any evidence that I see to the contrary.
MR. REICHEL: Excuse me. Counsel, I apologize for the interruption. Could you please state for the record what page --
MR. HAYNES: Yes.
MR. REICHEL: -- and which appendix of the Environmental Impact Assessment we have up there?
MR. HAYNES: It's Appendix B-3, --
MR. REICHEL: B-3.
MR. HAYNES: -- page 41.
MR. REICHEL: I'm sorry. I don't mean to be argumentative, but I have a hard copy of that document and

it doesn't seem to correspond. There may be something --

MR. HAYNES: Your Honor, let's take a short break and try to clear this up.

JUDGE PATTERSON: Okay.

MR. HAYNES: I want to make sure we're all on the same page here literally.

(Off the record)

JUDGE PATTERSON: We all set?

MR. HAYNES: Yes. Your Honor, I stand corrected. The reference there is Appendix B-2, not B-3.

JUDGE PATTERSON: Okay.

MR. HAYNES: Thank you, Mr. Reichel.

Q Now, Dr. Prucha, following that correction, I've put up on the screen from Kennecott Exhibit 2, the mining permit application Appendix C-1, page 12, which has a discussion about Eagle deposit geology. Do you see that?

A Yes.

Q And what of that discussion is relevant for purposes of your testimony today?

A I think what I noticed on this was actually the paragraph above that where it talks about joint patterns that often align with stream patterns suggesting that they have concerted control over the drainage development. I know when I read through reports like Exhibit 60 and 61, Marquette iron range, they pretty much stated the same thing; that they saw that faults joint patterns tend to align with the streams in the area. It suggests to me that there's strong correlation with faulting which would occur in the bedrock and the streams flowing over.

Q And did you see evidence in the models that you reviewed of those factors being taken into account?

A No.

Q On the screen is from Kennecott Exhibit 7, the Environmental Impact Assessment, Appendix B-1, figure 23. What does this figure purport to show, Dr. Prucha?

A It says that it's plotting the A Zone groundwater elevation contours.

Q And what does that mean?

A This is the groundwater surface from what is referred to as the A Zone in the reports, the upper most permeable outwash sand aquifer.

Q And for purposes of the model, do you consider the number of wells here to be appropriate?

A No.

Q Why not?

A Well, the main mine impacts -- the mine dewatering impacts would occur around the tunnel and mining area and orebody. And when you zoom into this area, that's where I would have concentrated the number of wells to gain a full three-dimensional understanding of the flow through all of the unconsolidated material, not just the A Zone. There's another significant aquifer zone in the unconsolidated materials in the Yellow Dogs Plain D Zone which underlies -- is below the A Zone, but it's separated over a good part of the plains by a lower permeability sequence as B and C Zone. But the key point here is again the distribution and number of wells around the key area of interest, which is the area that will be dewatered.

Q And how many wells are there just for the record?

A In the area around the mine?

Q Yes.

A I see three alluvial -- it's hard to tell right here. But the problem is that the system in this area for the unconsolidated material is very complex. And usually you design the distribution and locations of the wells to correspond with the complexity of an area.

Q And do you see that happen -- did that happen here in the model that you reviewed?

A No. There are complexities of units that are disappearing, that are pinching out in this area. You have actually bedrock that's exposed at the ground surface. There are maps that I've reviewed that seem to indicate a really large area is just void or absent with the unconsolidated material, and that seems to be --

Q Let me back up. When you say the "unconsolidated materials

is absent," what does that mean in terms of the relationship of bedrock to the surface?
A There's no more unconsolidated material overlying the bedrock. The bedrock, if you're walking around out there, you would walk over the bedrock at the surface.
Q I see. On the screen now is figure 24 from the same Appendix, Appendix B-1. And what does this figure show, Dr. Prucha?
A This shows the D Zone "Groundwater Elevation Contours," the title up in the upper right. This is the groundwater elevation map. And really you can't see on the black-and-white plot, but they have contour lines that show the actual surface of the water -- this aquifer system. And I guess some of the problems associated with a number of wells on this plot are, again, around the mine key area where you expect the most mine dewatering impacts to occur. They're saying that the de-aquifer is actually missing in these areas that are cross-hatched. And yet when you show an outline like this with no question marks, it is extending across the Salmon Trout River, and I see no wells or boreholes to show that this area -- over most of that area is actually controlled by points where you can actually drill a borehole out here -- I don't -- this is a complete guess right here. The D Zone could be there, and I think --
Q You're saying that the cross-hatched area is a guess?

A Yes. Well, with -- outside of the areas where they are showing actual boreholes. They have four points in this area. And this is important because in terms of their modeling to estimate the impacts of mine dewatering from the bedrock system, you dewater that zone below this unconsolidated unit where permeable aquifers disappear or occur are really important in terms of how that drawdown from the lower bedrock will impact the drawdown in the unconsolidated units or aquifers, the A and the D Zone.
Q Dr. Prucha, on the screen now is from Kennecott Exhibit 7, Environmental Assessment, Appendix B-1, figure 13. What does this show?
A In the report there are colored contours line. You can't really see them here. But the point is that they have a number of boreholes they've put throughout the orebody area and the treatment area, processing area. And they've estimated the thickness of the unconsolidated material or the quaternary deposit. And where you don't see points which represent boreholes, they have a lot of contours, no question marks. This is a complete guess in these areas. And yet this guess was never considered in terms of how it impacts the estimates of mine inflow, how the mine inflow dewatering would impact the overlying unconsolidated material.
Q Are you saying, Dr. Prucha, that the contour lines that

extend out from the various well locations cannot be interpolated?

A It's fine to interpolate an area. And by "interpolation," I mean that between wells you know what the thickness is. Maybe it's 60 feet at one point and 50 feet at another. Between the two points, you logically assume they're somewhere in-between; 55 feet. But in areas outside of where you have good borehole controls, you are forced to do what they call extrapolate, which means you're using data points locally here to try and guess what is going on out here to the south where you don't have control points.

Q And is extrapolation an appropriate method to use in modeling groundwater flow systems?

A It can be used, but there has to go along with it an understanding that you're introducing a lot of uncertainty into the conceptual understanding of where water is flowing. How thick is the aquifer? Is it 10 feet? 100 feet? In areas where you don't have the boreholes, you can't say anything about that, or you can but you need to say it's plus or minus a certain amount of distance and that --

Q And do you see such qualification in any the documents that you reviewed?

A I did not.

Q What we have on the screen now is figure 12 from Appendix B-5 of the Environmental Impact Assessment, Kennecott

Exhibit 8. What does this figure show, Dr. Prucha?
A This is a similar plot. The title is "Quaternary Deposit Isopack." It's just the thickness of the unconsolidated material. And this does show the contours pretty well in here, and you see that they're defined by these dark lines. And the pattern from this scale, I see contours almost two bull's-eyes right around the orebody and then East Eagle Rock which are elevated with respect to -- the bedrock surface in those locations is elevated with respect to the surrounding countryside with I think we showed a cross-section before that demonstrated that.
Q And how is that significant for purposes of modeling?
A Well, this has a strong control in terms of the thickness of the unconsolidated materials overlying the bedrock where the groundwater flows through those. Where it's thin, you don't have as much water possibly flowing in the unconsolidated or it gets -- the directions and flow rates get dictated by the bedrock surface.
Q And did you see these contours taken into account in the modeling?
A They did, but it's the uncertainty in the area where they didn't have boreholes that I think they didn't consider.
Q Now, Dr. Prucha, we've put on the screen Kennecott Exhibit 7, Environmental Impact Assessment, Appendix B-1, figure 15. And what does this show?

A Well, this plot shows the D Zone groundwater elevation contours, and they don't show up that well on the black and white. But they're -- the point I was going to make about this is that the contouring of both the A and the D groundwater elevations in my opinion are very poor around major features such as the Salmon Trout River.

Q Dr. Prucha, let me interrupt you for a moment. I misspoke. This is Appendix B-1, figure 24, but go ahead.

A Okay. I think this is a really important part of the characterization process where you collected water levels and you've posted them and you're estimating where the flow directions are going to go. And because of the lack of data in a lot of areas like, for instance, no wells south and west of the Salmon Trout River, you really can't say too much about what's happening in this aqua zone in that entire area. It's a very large area, and yet this is an area that would be impacted by the mine dewatering. Not accounting for the flow directions around the Salmon Trout River, this would have been a primary interest for me if I was going out there and trying to assess how the river interacted with the unconsolidated aquifers, how the bedrock interacts with the Salmon Trout River, and yet there's very little in terms of the number of wells and boreholes to tell you much in this area that would be impacted by mine dewatering even with their own modeling scenarios.

MR. HAYNES: Your Honor -- sorry -- we're going to have another exhibit switch here. This will take a moment.

JUDGE PATTERSON: Okay.

Q While we're switching for the color version, Dr. Prucha and I apologize. What we put up is Appendix B-1 to the Environmental Impact Assessment, figure 15, Kennecott Exhibit 7. What's significant about this figure, Dr. Prucha?

A Well, the significance is in the area that's black here, but --

Q Once again.

A -- I think I can still speak to that though. I think what's important is this intrusive associated with the orebody. It's visible even in the local area there at the surface. The letters above the surface, QAO-008, is a well here and to the left of that intrusive, QAL-004. This is the only information they have in terms of the geology of these aquifer units near the proposed mine facility and yet --

Q Would you expect more for modeling purposes?

A Yes; absolutely. And given the likelihood that you have Brecciated zones that are acting as permeable conduits, these aren't shown. They're not considered. Any faults through the area aren't considered on this conceptual hydrogeologic cross-section. I think another important thing is in other cross-sections I've seen it seems to be sort of confused where the actual country rock or surrounding metasedimentary rock surface contact with the unconsolidated material here shown in the black versus white color, actually shows it smoothly going up to the intrusive indicating that the intrusive was -- elevated the whole area as it was intruded up the bedrock surface. And here it's shown going directly in, and then you show unconsolidated materials. And with the color, you'll see them going directly into the side of the intrusive. And I don't understand geologically how that can occur. But fundamentally this is the conceptual model that so many books and standards indicate is absolutely necessary for producing a good sound defensible model. And I see this as a confusing diagram. It doesn't really iron out the details before jumping into a model.

Q All right. Well, thanks to Mr. Eggan, again, we've put up what appears to be the same figure and this is, for the record, MDEQ 011171, and if you could then illustrate your testimony, Dr. Prucha, with the colored stratigraphy shown on this figure?

A Just pointing out the red lean clay here on the left and right side of the intrusive. And again, my point about layers coming horizontally straight into the intrusive and the bedrock surface going straight in as opposed to being carried up. No intrusive brecciated zone associated with the dike. That's important because a lot of water from deep down where the mining's going to occur, the tunneling could easily interact with this -- not only the surface but the stream we showed at the former cross-section that -- where the intrusive was right under the stream. This one has it over off to the side. But here are other things. This green area here (indicating) is a clay glacial till.

Q What is a clayey glacial till?

A It is derived from glacial movement; it's really a mixture of fine grained material. It's generally considered to be a low permeability material, probably similar in hydraulic properties to the red clay, the red lean clays down here. But what's important about this is that it occurs in an area where there are no boreholes, so I'm not sure what information is used to define that that exists here. At the borehole locations this information comes from the logs that are collected in the field and used to define the aquifers. The A Zone is this upper blue and the B Zone is this lower zone.

MR. REICHEL: Excuse me, Counsel.

MR. HAYNES: Yes?

MR. REICHEL: Sorry to interrupt the flow of your exam, but just so the record is clear the slide that you have before this was Figure 15 from Appendix B-1. I was able to verify that.

MR. HAYNES: Yes.

MR. REICHEL: This one, although similar, appears to be from a different document. The previous one had a cross-section B to B Prime; this is --

MR. HAYNES: C to C Prime.

MR. REICHEL: I just want the record to be clear as to what document is being displayed; that's all.

MR. HAYNES: I appreciate that. So noted. All right. Let's go to the next page.

Q Dr. Prucha, I've had put up from the Environmental Impact Assessment Appendix B-8, Figure 23, which is Kennecott Exhibit 11. What's the significance of this figure for purposes of delineation of the stratigraphy?

A Well, the bedrock surface in this case you can clearly see being elevated and it's clearly associated with the intrusive on both sides. This controls the development of the unconsolidated deposits, but there's very little information around the actual intrusive. And this seems important, because this is where a lot of the mining will go on and the dewatering. And you can see that they have projected a well or borehole here, QAL025 which is from some distance, but there's not much control here. But I think the most important point about this is in contrast to the last cross-section conceptual hydrogeologic cross-section we looked at. The last one had the bedrock going straight into the dike; this one has it elevated. So I'm left wondering which is it and what information do you use to define this. To me, if I model this system, this is really critical information in terms of translating the dewatering in the mine -- the effects of the dewatering in the lower bedrock up to the surface.

Q And did you see any indication in the models that you reviewed of this -- these differences noted in the model?

A I did not.

Q All right. And just for the record, following up on Mr. Reichel's suggestion; this Figure 23 shows a cross-section D to D Prime, for the record?

A Right.

Q Okay. Dr. Prucha, we've had put on the screen from Kennecott Exhibit 8 the Environmental Impact Assessment, Appendix B-5, Table 2. What is the significance of this table for purposes of your testimony today? Well, let me lay some foundation, Dr. Prucha. Is it important for purposes of modeling to consider the hydraulic conductivity on consolidated materials?

A Yes.

Q And how does one normally go about doing that?

A There are a variety of tests that you apply in the field to collect hydraulic conductivity or the hydraulic properties of an aquifer system; there's some that you can do in a lab.

And there are different levels of quality in terms of the uncertainty associated with the tests. The highest level -- and it's even acknowledged in the reports I reviewed -- are pump tests where you pump one well and you observe the drawdown response from that pumped well and surrounding wells. And that's the best kind of test to perform because it tests a much larger area of the aquifer.

Q And what other kinds of tests can be performed to determine hydraulic conductivity?

A There are a variety of other sorts of tests, like -- I noticed in their report they have done a number of slug tests. This is where you introduce a small volume of water into the well or you -- and watch the response from that well; you don't monitor the response of surrounding wells. So effectively that test only is giving you information about that local well, around that local area. And my experience is -- and there are pretty well documented literature that you end up with a bias towards the low end of hydraulic properties or hydraulic conductivity even up in the order of magnitude plus where slug tests give you lower than -- lower hydraulic properties than what you would get from actually conducting a multiple-well pump test. Other tests are doing -- collecting the soil from the actual borehole and sending it to a lab and estimating the grain sizes and you can estimate, but only roughly, what the

hydraulic properties would be. In other words, if you get a value for a sand and you estimate it through this method the uncertainty could be orders of magnitude, which is -- an order of magnitude is about a factor of ten, so it could be ten to maybe a thousand times in error.
Q And what kind of tests did you see performed in the reports that you read dealing with a hydraulic conductivity?
A The majority by far were slug tests, seep tests, lab tests which produce values but the uncertainty is the greatest in those. And I saw one pump test in the unconsolidated material for multiple wells and that was really to test the interaction between the A aquifer zone and the D aquifer zone.
Q And would you have expected -- would you have expected to have seen in a model of this complexity that you've been describing more than one pump test?
A Absolutely. For the complexity that I see based on my review of the geologic logs, their plots, I would have expected more pump tests to test a broader area in the unconsolidated material; not only that, but between the unconsolidated and the bedrock. And I had a -- well, --
Q And in terms of the tests that you observed, did you note the length of the screens of the various tests that were performed?
A I did.

Q And what was -- what's your observation about those screens?

A Well, it seemed like a lot of the wells were screened much -- over a much shorter interval -- for example, five feet -- when the actual aquifer zone, like the A or the D zone, were on the order of 20, 30 feet thick and to me that just simply -- by doing that it introduces more uncertainty because the analysis is more complex and you induce flows that aren't as simple for the analytic method, the method that you would use to assess the hydraulic properties for.

Q Now, we've had put on the screen, Dr. Prucha, from Kennecott Exhibit 8, the Environmental Impact Assessment, Appendix B-5, Figure 9. And although it's in black and white and, therefore, not quite as readable as before, what's the significance of this figure for purposes of your modeling -- or for purposes of modeling?

A Well, I think the point to this plot here was that the mine, I believe, is at -- the orebody is up here (indicating) and the location of the one multiple-well test where they pumped -- where they were looking at the interaction of the pump test between A and the D zone to establish what level of communication hydraulically they have -- they performed a test well south of the actual orebody and it's confusing to me why you would go and establish the hydraulic communication in an area so far away from the area that would be most impacted by mine dewatering. And another thing is that when you look at the trend of the thickness of the lower permeability units between the A and the D aquifer zone in the unconsolidated material it actually thins towards the mine and it's actually absent near that over some distance or area that hasn't been well defined. But the point is, if I were doing the test I would have put it up by the orebody to test the influents there because that's the area I'd want to know -- it has the greatest potential for having dewatering from the lower bedrock impacting the overlying unconsolidated material, and I wouldn't have put it in an area that had a thicker zone between this A and D aquifer of lower permeability units.

Q Now, Dr. Prucha, we're back to Kennecott Exhibit 7, the Environmental Impact Assessment, Appendix B-1, Figure 23. And the -- I apologize, but the figure doesn't show contours very well, but on this figure are contours represented?

A I don't think I saw contours represented well on any of the maps that I reviewed based on the wells and -- posted and the obvious hydraulically significant features, such as the Salmon Trout River.

Q And when you say "hydraulically significant," are those features significant for modeling and are -- let me back up. Would it be important to -- for modeling purposes to have contours inputs -- contour inputs into the models?

A Well, for this kind of information you don't -- you enter in as an input the groundwater elevation as an initial condition, but really the importance of this data is in -- sort of two-fold. One is that you contour it up first, which means you take this information and you estimate where the groundwater flows based on contouring and the contouring, if you have enough wells in the right location, gives you a very good indication of how much interaction -- for example, you have between the Salmon Trout River and, say, the A Zone of the unconsolidated deposits, let alone the D aquifer zone, I don't even know from the available data whether the intervening B and C Zone, the low permeability unit between the A and D Zone is missing along a significant portion of the Salmon Trout River. I don't think it's been characterized well.

But this is the point where groundwater information you have to establish an understanding before you jump in the modeling of where you think the water is going and base it off of good sound data. A key area should have been an area right around the mine dewatering area. So initial modeling could say, "Here's the mine impact area." It looks like it's at least a mile in diameter over the extent of the Salmon Trout River. Why don't we have more wells in this complex unconsolidated system right there to establish clearly just based on data, not even modeling what the interaction is between the A and the D Zone and the unconsolidated and the bedrock zone?

Q I notice on this figure, Figure 23, that there are some arrows -- some sort of curved arrows pointing -- you know, northerly direction. What do those arrows represent, to your understanding?

A These are estimated flow directions of the groundwater in this A Zone groundwater elevation.

Q And from the materials that you've reviewed do those estimated flow directions appear to be accurate?

A No.

Q Why not?

A Again, a variety of reasons. Just even up in the northern area I think there's confusion about whether the A and D Zone even -- which zone occurs, whether the B and C Zone pinch out; whether they know whether water is actually flowing towards some of the seep locations. There's a variety of things when you zoom in and look at the contours. It looks around the Salmon Trout, the whole upper stream area, in a large number of these contours it looks like the contours are written right over the Salmon Trout River as though it has no influence on the groundwater. So then later I look at some of the modeling and it looks like the contours are very sharply pronounced right around the river indicating that some of the models reviewed it looks like they are simulating kind of something what you would expect

where that's acting as a discharge point for the local groundwater.
Q And would you find such contouring to be consistent or inconsistent with the topography in the area?
A I would find it inconsistent.
Q And is that important from a modeling perspective?
A Yes.
Q Now, Dr. Prucha, we've put up from Kennecott Exhibit 7, the Environmental Impact Assessment, Appendix B-1, Figure 30, which is denominated the contours of the wetland study area. Do you see that?
A Yes.
Q What is significant about this figure for purposes of groundwater modeling?
A Well, again, this is another attempt to contour and demonstrate that the flow directions of groundwater run to this natural condition or factor it, and I have problems again with where they've placed wells and what wells or data they're using to help constrain the contours. And you don't see those here, but there's a pretty big gap in the data everywhere on the other side of the Salmon Trout River.
Q Now, you're pointing your laser pointer to the west and south of the Salmon Trout?
A That's right. Immediately across from the orebody and upstream to the west. In addition, the contours don't seem

to take into account what is commonly done to help constrain groundwater contours in the area as the stage elevation or average stage of the river flow through the system. And that seems like a key to help constraining whether groundwater is going into the river or going out at any point. Although I believe most of this stretch is a gaining reach on the stream; meaning, the groundwater is flowing into the stream.

Q So can you tell, Dr. Prucha, from your analysis of the documents whether the -- whether groundwater flow direction can be verified in these documents?

A No.

Q And is that -- would that be important for modeling?

A Yes.

Q And why is that?

A Well, I think at this level if you can't understand the contours you're introducing a lot of uncertainty in any modeling exercise and say that the modeling is just destined to not produce very reliable results because you don't understand the basic system, and that is the fundamental step in hydrologic studies that are conducted as the standard.

Q Dr. Prucha, for purposes of modeling a groundwater flow system, is it important to establish the hydraulic communication between the bedrock and the unconsolidated

material?
A Yes.
Q And why is that?
A Well, you're going to be pumping water out of the bedrock and that will create a drawdown in the bedrock and that drawdown will induce an increased amount of flow from the overlying unconsolidated material; the greater the drawdown on the bedrock the greater the drawdown on the overburden. So I think that's critical to understand where that occurs, the extent over which it occurs and the magnitude of that.
Q And for some of the documents that -- or for the documents that you reviewed, Dr. Prucha, did you note any documents that showed that there was an absence of unconsolidated material over bedrock in portions of the study site?
A Yes, in critical areas right around the orebody. And there were several maps that I looked at that seemed to have just one control point, but one map showed it extending for quite a distance under the Salmon Trout River.
Q And did the groundwater flow models that you reviewed consider these -- this feature?
A No, and it's important because if there are faults through the area and brecciated zones that are conductive, the fact that you have bedrock right at the surface -- and in one cross-section we saw before that had intrusives right underneath the Salmon Trout River -- this is a direct

connection with the mine dewatering and --
Q Go ahead. I'm sorry.
A -- flow rates significantly higher than estimated.
Q Now, for purposes of modeling is it important to characterize the surface water flow system?
A Yes.
Q And why is that?
A Well, because that is where the drawdown from the mine dewatering will eventually propagate, and without characterizing the current system and its interaction with the underlying unconsolidated aquifers and bedrock, it's -- you wouldn't be able to assess the relative impact when you went in to predictive modeling. So you need to understand that interaction now.
Q Now, Dr. Prucha, I'm putting back up for purposes of this portion of your testimony Kennecott Exhibit 7, Environmental Impact Assessment, Appendix B-1, Figure 30, which deals with the wetland study area. And in terms of the spatial distribution of the wells in the wetland area, what does this figure tell you?
A Again, I don't think it's adequate to characterize the stream-aquifer connection, so this is a pretty standard terminology in hydrology these days and it just means that if you have a stream that's connected hydraulically with the underlying aquifer you need to characterize how much flow

goes in and out of the river and interacts with the groundwater. And they have some wetland wells that they show on the north side of the Salmon Trout River here but they're shallow. And I think if you were doing a study to assess this interaction over the length that would be impacted by mine dewatering, you would put wells shallow and deep; nested well pairs right below the river and assess the interaction.
Q What is a nested well pair?
A A nested well pair would be wells that are screened at different depths. Wetland wells they have here are nested, but they only go down nine feet, nine and a half feet, and the A aquifer zone is deeper than that. And I think to fully establish this connection you'd just not want to do it at two or three locations here but along a length that would over -- where the mine dewatering would be impacting it.
Q Dr. Prucha, on the screen is from Kennecott Exhibit 11, the Environmental Impact Assessment, Appendix B-6, Figure 6, which is "Denominated Wetland Hydrological Classification." And what's significant about this figure for you, Dr. Prucha?
A Well, they had three different zones of the wetlands defined on this map; one that was precipitation driven that was largely over where the mine is but apparently only there and not anywhere down to the south, and then they had a

groundwater-driven zone that was running adjacent to the stream but not directly underneath it, and then a third wetland zone that they called a "stream-driven wetland." And I guess I was surprised to not see a detailed conceptual picture, a cross-section through the orebody, through both sides of the stream that clearly showed the dynamics and the soil horizons, what's really controlling these zones and showing arrows of where -- where does water really come in and sustain these. Is it groundwater? Where does the groundwater-driven system versus precip really end? Is this -- are these boundaries seasonal? Do they vary spatially? This is one plot in time perhaps.

Q And, Dr. Prucha, we've had in earlier testimony and exhibits in this case some pictures of beaver dams along the Salmon Trout River. Would beaver dams be significant for purposes of groundwater modeling?

A Yes.

Q Why is that?

A Well, because they artificially dam the water up behind them and increase the elevation of the stage of the water and this could certainly mask potential fault discharge along different lengths of the stream.

Q In your review of the documents -- the modeling documents, did you see any discussion of the beaver dams?

A I did.

Q And was it sufficient for purposes of modeling in your view?
A It's really just a statement saying that it looked like they were significant, but nothing seemed to be considered; it wasn't considered in the modeling and didn't seem to be considered in their conceptualization of the flow around the critical orebody dewatering area.
Q Dr. Prucha, on the screen now is slide 31 from Petitioner's Exhibit 63. Is this a slide that you prepared?
A Yes.
Q And what does it represent?
A Well, it represents a plot that showed post-closure groundwater monitoring locations and I put flow arrows in green where I think it would probably occur and I put the orange boxes where I would put appropriate monitoring locations downstream of the temporary rock storage area closer to the actual stream.
Q And does this slide also indicate the placement of -- or the proposed placement of monitoring wells for -- by Kennecott's proposal?
A Yes.
Q And where would those be?
A They're shown with the circles with a cross through them.
Q And why did you place the orange boxes as opposed to -- where you did as opposed to where the monitoring wells are proposed by Kennecott?

A To me those would be more likely to intersect any water flowing through that had impaired water quality than where their proposed locations are.
Q Can you tell, Dr. Prucha, based upon your experience whether the proposed monitoring well locations proposed by Kennecott would be able to determine the potential for measurable impact on surface water?
A Would you rephrase that?
Q Sure. Can you tell from the proposed locations here proposed by Kennecott for monitoring wells whether those monitoring wells would be able to measure impact on surface waters from the groundwater inflow to the mine?
A From their monitoring wells?
Q Yes.
A No.
Q And from their monitoring wells would you be able to determine in your view the measurable impact on groundwater from the groundwater inflow to the mine?
A Yes. The ones that I located were within their groundwater-driven wetland, whereas the precipitation -- it seems like the ones where they proposed were more in the wetland-driven precipitation area, which conceptually doesn't seem like it's being driven by the groundwater in that area. So if there are groundwater impacts from lower mining propagating up you might be more likely to see them as groundwater-

driven wetland area.

MR. HAYNES: Your Honor, I'm going to move into a slightly different area. Perhaps we could take a break.

JUDGE PATTERSON: Okay.

(Off the record)

Q Now, Dr. Prucha, we put up on the screen Kennecott Exhibit 11, the Environmental Impact Assessment, Appendix B-6, Table 2 which talks about water elevation measurements. Do you see this?

A Yes.

Q And the discrete water elevation measurements. What, Dr. Prucha, about this table is significant for purposes of modeling?

A There might have been the second page on this table. Is there a second page on that? That's it.

Q All right. We'll try this one. What is significant about this page? This is Table 2, second page.

A Well, this is where they've shown in the report a number the wetland wells that they put in, piezometers, and they're at different depths; one four and a half and nine and a half feet below ground surface. And there are a number of F's over on the right-hand column refer to "water thawed prior to measurement" and I've never seen this before, but it makes me question the validity of those actual water elevations, the fact that they had to thaw the sample out.

The change in density; the fact that the material around that immediately thawed zone would still be probably frozen. I'm just not sure how to interpret that, but it seems like it dramatically influences their estimation of the vertical gradients that would occur over pretty -- a pretty small vertical elevation. So --

Q And I note that the columns on this table show that measurements were taken in November and December. Is that significant for purposes of modeling?

A Well, probably it would have been nice to show what happens during the summer months to know -- I mean, this really is kind of a wintertime effort. The gradients -- if you're trying to produce a model it would be nice to understand whether the wells in these different wetland zones are behaving dramatically different than the one plot that says here are the three different zones.

Q When you say "it would be nice to know," would you consider it best practices to take seasonal measurements in wetlands?

A Yes.

Q Dr. Prucha, on the screen now is Kennecott Exhibit 7, the Environmental Impact Assessment, Appendix B-1, Figure 32, and what -- this says, "Wetland Hydrologic Classification." I think we've had this one before, but what does this show for purposes of modeling for any relationship between the stream and the wetland?

A I think I made the point on the last exhibit when you brought it up.

Q It is important from a modeling perspective to show groundwater discharges into streams?

A Yes.

Q And what is -- how is that important?

A In trying to determine the impact of the mine inflow modeling -- or, you know, the impact from the mine dewatering that was done in the bedrock model you need to consider the groundwater discharge and estimate it through measurements before connecting the modeling so that you have something to compare against.

Q Dr. Prucha, is it important for purposes of modeling to have an appropriate conceptualization of the flow in the system?

A Yes.

Q And why is that important?

A If you don't conceptualize the system well in the model that you produce based on that conceptualization will be only as good as the conceptual model. So if that's flawed, then your numerical model will start off flawed.

Q Dr. Prucha, I've had put on the screen from Kennecott Exhibit 7, the Environmental Impact Assessment, Appendix B-1, Figure 6 which is the "Generalized Geologic Cross-section." For purposes of a conceptualization of the flow in the system, how is this exhibit important, if at all?

A Well, they produced a model that covers this area over the Yellow Dog Plains that's noted on the upper left, and this is a south to north cross-section. And I think the color version of this would show the intrusive dike coming up in here (indicating) in this -- through the sediments. But I'm not sure how realistic this is to show just one conceptual picture slice like this when you have a groundwater that's flat here and then it suddenly drops off and mysteriously disappears. I'm not quite sure I understand the mechanism by how this all occurs. Does it have all of the important features? I think one important feature they do show here is that at the edge of the Yellow Dog Plains that the topography does actually increase somewhat and I don't think I saw any adequate explanation for why that might occur.

Q Now, Dr. Prucha, we've had put on the screen Kennecott Exhibit 8, Environmental Impact Assessment, Appendix B-5, Figure 34 which is another "Conceptual Hydrogeologic Cross-section." What's the significance of this figure, if any, for purposes of modeling?

A Well, I think here's another example of a conceptual hydrogeologic cross-section for the system and I don't see the intrusive dike here or the four others that look like they traversed across this zone from the one exhibit that we showed that was produced by their geologist. And they show groundwater seeping out the site over here. I'm not sure what the mechanism is for seepage over here (indicating) well above a bedrock surface. But this also seems inconsistent with the previous cross-section that I just saw.

Q And how is it inconsistent?

A Well, just in -- for example, what I mentioned before, the intrusive not being shown, faults not really being shown in here.

MR. HAYNES: Courtesy of Mr. Eggan we're now going to look at a color version of this.

Q This is, again, Figure 34, "Conceptual Hydrogeologic Cross-section" from Appendix B-5 and in this color version what does the blue represent, Dr. Prucha?

A That represents the area where the groundwater is -- that aquifer is saturated. If you drilled down you would hit groundwater at that point, at this contact, this upper contact. This doesn't show the detail of the unconsolidated material, the different aquifer zones that were defined; and yet that seems pretty important not only around the mine area but also at the discharge gallery TWIS, the Treated Water Infiltration System.

Q Dr. Prucha, are you familiar with guidelines for conceptualization in modeling?

A Yes.

Q And are the figures that we've shown here, Figure 6 from

Appendix B-1 and Figure 34 from Appendix B-5, consistent with those guidelines for conceptualization?
A I would say no.
Q Why not?
A Well, again, when you produce a model you should produce a model that is as defined as well as you can and if you do identify alternative models or hypotheses that's sort of your obligation to show why those alternatives aren't valid and that the one you decide to use in predictions is more valid than others. But there's a process that you go through to eliminate those and I don't think that was followed here or considered.
Q For purposes of modeling the inflow to this proposed mine, how important is it to conceptualize the groundwater flow system?
A I think it's critical.
Q And for purposes of the model how does the flow system then feed into the model?
A Could you rephrase that?
Q Sure. The flow system that is described by Exhibit -- or Figure 6 and Figure 34, these two exhibits; how is that flow system then translated into the model for purposes of deriving some sort of a prediction of the inflow into the mine?
A Well, this conceptualization is used to guide the definition

of the structure of the numerical model that you develop, how you see the interaction between the different aquifer zones within. For example, the unconsolidated material; how you see the interaction between the unconsolidated material and the underlying bedrock and, for that matter, what code you use -- what computer or mathematical code you use to actually simulate the flow in the system. And it also is important in terms of how you define things like boundary conditions or conditions that control how the water gets into the system and then how it gets out of the system.

Q Dr. Prucha, I've had put up on the screen the first page of Petitioner's Exhibit 62, which is a "Groundwater Modeling Guidance" from the Michigan Department of Environmental Quality, draft 1.0 from, I believe, 1990- --

A 2002.

Q 2002. I'm sorry. Have you reviewed this document, Dr. Prucha?

A Yes.

Q Have you in your career and your experience reviewed other various modeling guidance documents from other states?

A Yes.

Q In your view are such modeling guidance documents helpful for purposes of preparing models?

A Yes.

Q In your view are the guidelines that are in proposed

Petitioner's Exhibit 62 appropriate for modeling at the Eagle Mine site?
A Yes.
Q Do the guidelines discuss worst-case modeling?
A Yes.
Q Is that appropriate?
A Yes.
Q Is worst-case modeling what some might feel to be equivalent to conservative modeling?
A Yes.
Q Are the two phrases synonymous or equivalent?
A Yes, but I think sometimes you can get the word "conservative" confused; you need to define is it conservative one way or another. And by "worst case," the way I interpret that is what is the worst case in terms of how mine dewatering will impact, say, for example, the aquifer, the A Zone aquifer, the shallow aquifer? The worst case would be what's -- what do you think the largest drawdown would be? What's the magnitude of that? What's the worst-case dimension that would be impacted or area that would be impacted?
Q And is worst-case modeling standard engineering practice?
A Yes.
Q Would such worst-case or conservative modeling use site-specific data?

A I'm sorry?

Q Would such worst-case modeling use site-specific data?

A Yes.

Q And for a proposed underground mine what kind of worst-case -- excuse me -- what kind of site-specific data would you expect such worst-case modeling to use?

MR. LEWIS: Objection; foundation, your Honor.

MR. HAYNES: Your Honor, I'm not quite sure how to respond to that objection. I think I've laid a foundation for this witness to discuss modeling -- worst-case modeling, underground mines, so I'm not quite sure how what I have to do further.

MR. LEWIS: My objection goes to the lack of any information about any experience that Dr. Prucha has had with modeling the amount of water that might be expected to flow into an underground mine, and the question was specifically phrased in those terms.

JUDGE PATTERSON: I'm trying to recall if he testified to any experience in that.

MR. HAYNES: Well, all right.

Q Let's be more general, Dr. Prucha. You have experienced modeling groundwater inflows into underground structures; correct?

A Yes.

Q All right. And that would include underground mines?

A Well, open pit mines, not necessarily underground mines exactly like this, but --

Q Okay. But for purposes of groundwater modeling does the structure make a difference if it's a mine, an open-pit mine, an underground mine or some other underground structure for purposes of groundwater modeling of inflows?

A No.

Q Okay. So what kind of site-specific data would you expect for modeling water flow to a proposed underground mine?

A Would you repeat that?

Q Sure. What kind of site-specific data would you expect in a model for purposes of modeling underground flow into an underground mine?

A I would expect adequate numbers and locations of wells throughout the bedrock and the unconsolidated material, a zone that would be impacted by the mine dewatering.

Q And would site-specific data assist in limiting the range of uncertainty in any models?

A Yes.

Q Would site-specific data assist in limiting the range of uncertainty for baseline conditions of a model?

A Yes.

Q Do the guidelines, Proposed Exhibit 62, call for an understanding of the importance of transport processes at a site?

A Yes.
Q What are transport processes?
A Well, the movement of water and in this case contaminants in the water.
Q Are transport processes related to site characterization?
A Yes.
Q And how so?
A Well, if you don't characterize how that transport of a particular component in the water is moving, then it would be difficult to model it accurately.
Q If you were to model the groundwater inflow into a proposed underground mine in Michigan, would you consider the groundwater modeling guidance prepared by the DEQ as part of your task?
A Yes.
MR. HAYNES: Move the admission of Exhibit 62.
MR. LEWIS: No objection.
MR. REICHEL: No objection.
JUDGE PATTERSON: No objection. It'll be entered.
(Petitioner's Exhibit 632-62 received)
Q Dr. Prucha, in your view, has there been proper site characterization of the flow into this system?
A No.
Q And why not or how not?
A Lack of data in the right spots; lack of proper hydraulic

testing; lack of interpretation of -- poor understanding -- characterizations -- very poor characterization of an interpretation of groundwater flow directions in the various units.

Q Dr. Prucha, when we started with you today, you spoke of the term "calibration of models." What does calibration involve?

A It involves trying to reproduce the system -- the observed system behavior. That would include groundwater levels in wells that vary over time; the discharge of flow at rivers; discharge from the groundwater system as evapotranspiration

Q Can calibration include calibrating steady-state conditions?

A It can.

Q And can calibration of a model include calibrating transient conditions?

A Yes.

Q And would you explain those two, please?

A Well, a steady-state calibration is what was done for the models that I've reviewed here, and my opinion, it's the basic level of modeling. And you can develop those kinds of models, but it's pretty well-known in the industry that -- the practice that steady-state models often are associated with large uncertainties and are associated with a problem we call non-unique. In other words, the models that get developed, you don't really have enough constraint on the model to define hydraulic properties accurately within the model to reproduce the system. And this is why the next step of calibration is to go into transient calibration, where you're trying to match the fluctuation, say, of groundwater levels in time or discharge to a river.

And then the next step after that is -- and it's stated in these -- this modeling guidance here by the DEQ -- is to go and verify that your calibration is correct. And you can't do a verification on a steady-state model because, by definition, the steady-state model only simulates a constant groundwater elevation. Nothing is -- groundwater moves through the system, but it's at a constant rate. And it -- this non-unique problem, a good analogy to that is that you have a bathtub and you're filling it with water at some rate of inflow, and you have a pipe that you don't know the size at the base of the bathtub coming out.

And you can pour in a huge amount of water, and your objective is to simply match the water level in the bathtub. But if you make the pipe at the exit larger or smaller, you can maintain this. It doesn't -- you're not calibrating the system. There are -- recharge can be adjusted very high, and the pipe diameter can be adjusted very high, and you can still get the same water level in the bathtub. It's the same concept in the groundwater flow model.

Q I see. In this case, based upon your review of the documents, was transient modeling done?
A It was not.
Q If you were to model this system, Dr. Prucha, would you have performed transient modeling?
A Well, they performed a transient model simulation, but they did not do a transient calibration of the model for the unconsolidated material. In the bedrock model that they used for FEFLOW or developed with FEFLOW --
Q Wait. Let me stop you.
A Yeah.
Q "FEFLOW," a new term. What is it?
A It's a computer code that's used to simulate flow through a groundwater system.
Q And is FEFLOW a model that is normally used by groundwater modelers?
A It is.
Q I'm sorry. I interrupted you. Go on.
A In the FEFLOW model, they actually -- that they prepared, they calibrate -- they say in their report that they calibrate to the pump tests that they performed on this well 084 that we talked about earlier.
Q Now, Dr. Prucha, for purposes of predicting outputs from a model, should outputs be produced as a single outcome or as a range of outcomes?

A As a range of outcomes.
Q And why is that?
A Well, because your models by design are uncertain. And the examples I give there are the contour maps we looked at earlier of, say, for example, the thickness of the unconsolidated material outside of the areas where they actually have borehole data to constrain that estimate.
Q Dr. Prucha, is there something called code selection in model design?
A Yes.
Q And what is that?
A Well, that's the process of selecting an appropriate mathematical code. And I distinguish code from model in that a code is actually the computer code or software that was produced to develop a model. The model is of the actual site. You develop a model of the actual physical site. But there is a process where you go through selecting an appropriate code that can simulate, for example, fracture flow. Not all codes can simulate the flow of fractures -- flow-through fractures in a system. This is in fact why we have read report -- the reports here on modeling that indicated they used FEFLOW to model discrete fractures, where they used the more common code, MODFLOW, that was developed by the USGS to simulate the unconsolidated material. But they actually end up simulating the bedrock

later in later versions of the model.
Q And is it appropriate, in your view, to mix the two kinds of models, FEFLOW and MODFLOW?
A No.
Q Why not?
A Well, for the reasons that they pointed out in their document. FEFLOW has the capability of simulating discrete water-conducting fractures, and MODFLOW really doesn't have that capability. And so they -- that's -- that was one of their main justifications for using FEFLOW, to simulate the flow in the bedrock system, which was then used to estimate the amount of mine inflow.
Q Dr. Prucha, are you familiar with the American Society for Testing and Materials, --
A I am.
Q -- so-called ASTM?
A Uh-huh (affirmative).
Q "Yes"?
A Yes.
Q What is ASTM? What does it do generally?
A It's a standard. It's actually a series of quite a large number of different standards that have been put forth by a group of professionals in the industry. And the guidelines aren't absolute, but they are used in the industry to help guide the development of models that are more defensible and

credible.
Q And, Dr. Prucha, are there ASTM standards for selecting appropriate codes for modeling?
A Yes.
Q And have you observed any adherence to those standards in the models that you reviewed for your testimony today for selecting codes?
A They have statements as to why they chose their codes, but it was certainly not rigorous, in my --
Q And is such rigor required for modeling?
A In this system I believe that it should have been.
Q You testified just previously about the two models that -- the FEFLOW and MODFLOW models are the methods; correct?
A Yes.
Q In your review of the documents, is there a reason that you can determine why two models were used here instead of one?
A I'm still unclear as to why they used two models.
Q And in your view, Dr. Prucha, from modeling this system, would it have been preferable to use a single model?
A Yes.
Q Why?
A Well, the problem with using two different models, one for the overburden or this unconsolidated material and the bedrock, is that separating those two out leads to problems translating the drawdown that you see and that develops in

the bedrock to the overlying unconsolidated material. And you're forced to choose boundary conditions that aren't really appropriate and don't really simulate what's really going on in terms of the interaction between the unconsolidated material and the bedrock.

Q When you're forced to choose those conditions, is that appropriate for modeling?

A I think there are better alternatives.

Q And what would those be?

A Using one single code like FEFLOW to model both the bedrock and unconsolidated material.

Q Now, Dr. Prucha, we're going to back to Figure 8.1 of Appendix B-3. You spoke early on in your testimony about model calibration. Do you recall that?

A Yes.

Q And was the bedrock model in this -- in the model that you reviewed your calibrated?

A It was calibrated to the pump test performed at well 84 here.

Q I'm sorry. Let me back up for a second. What do you mean by "calibration of a model"?

A Depends on the type of model you're trying to calibrate. The model that's used here covers 87 square kilometers, which is a large area. And you needed a model that size, because the prediction of mine inflow is unknown at the beginning of the simulations, but it's clear, even from the initial simulations they do, that the area is 1 to 2 miles in size in terms of the drawdown zone. The model that they're claiming to calibrate is calibrated. It's calibrated to a pump test. And it's arguable that you could calibrate to a pump test where wells are spaced couple-hundred meters apart and extrapolate what you find there over 87-square kilometers, and that doesn't consider the 4 mapped miles-long dikes that they had that brecciated zones around them; doesn't consider the faults that they'd mapped, the large miles-long west-northwest-southeast-trending faults that seemed to align with water drainage features.

Q Dr. Prucha, just for the record, the 87 square kilometers, for those of us who think in terms of miles, what's that area in terms of square miles?

A It's about 33 square miles roughly.

Q You spoke of the faults -- the east-west dikes and the north-south faults, Dr. Prucha. How is the orientation of those faults important, if at all, for purposes of calibrating a model?

A Well, the orientation that you put into your model -- impose on your model ought to be consistent with what you're mapping. And what was imposed in the models that I reviewed were a set of north, south, east, west regularly spaced fault. But primary issue I had with that is that they were only included in the lower bedrock, and they did not extend to the upper bedrock, which, just by design doesn't allow any transfer of -- or much transfer of the drawdown impact that you see in the lower mine and dewatering into the overlying unconsolidated material.

Q In your view from a modeler's standpoint, is it realistic to exclude faults in that way?

A No.

Q And is there such a thing in modeling called bias?

A Yes.

Q And how would you define bias in modeling?

A Where -- when you model you can choose to adjust parameters up or down to look at worst-case or not-such-a-worst-case scenario, and bias would be selecting things that maybe are biased towards your opinion or what you want the outcome to be.

Q And would characterizing the faults here as ending in the lower bedrock reflect any sort of a bias?

A I believe so, yes.

Q In what way?

A Well, again, if they had considered what I believe is more realistic, the faults to extend all the way into the overburden, this would have allowed direct connection between the dewatering that's occurring in the orebody and

tunnel area to translate up into the overlying unconsolidated material and would have impacted a larger area and larger impacts on the Salmon Trout River.
Q Dr. Prucha, in your review of the documents, did you note whether or not a FEFLOW model was used for 2004 model?
A Yes.
Q And in your view, was that FEFLOW model appropriate to use?
A Well, this model was the -- what was referred to as a preliminary model -- preliminary numerical model, and that is the model where faults or fracture zones were simulated in the model but only in the lower bedrock zone. And effectively, this is like putting a small permeable slit in a block of concrete and, if the slit is entirely contained in the bedrock or the concrete block and it's not allowed to connect to other permeable water bodies, there's not really any effect of that fracture or fault.
Q In this 2005 FEFLOW model, what was the groundwater used in that model? Was it constant, or was it variable?
A In the 2005 model?
Q Yes.
A The groundwater elevation was constant.
Q Is that appropriate?
A No.
Q Why?
A It doesn't reflect reality.

Q That is, groundwater is -- groundwater levels are variable; correct?
A That's right. And in this case they didn't produce a map of the water level in the bedrock, but you would assume that it was probably close to what is in the overlying unconsolidated material, and that certainly -- the number of maps that we've seen here for the A and D zone show the gradients approximately.
Q And what is the effect on this -- or what would be the effect on this 2005 FEFLOW model of using variable groundwater levels rather than steady-state groundwater levels?
A More realistic inflows.
Q So in your view, is this -- are the results from the 2005 FEFLOW model realistic?
A No.
Q What did those results predict for purposes of inflow into the mine?
A For -- that model was referred to as the upper bound, and that was 215 gallons per minute. Actually, their initial one, I think, was 180 gallons after three years; sorry.
Q And so, Dr. Prucha, in your view, the upper bound limit for the 2005 FEFLOW model is not realistic at 215 gallons per minute?
A No.

Q Based upon the data that you've reviewed, do you have a view as to what would be a realistic upper bound?
A I believe it's much high.
MR. LEWIS: Objection; objection; foundation, your Honor. There's no foundation for this witness having done anything which I assume would be necessary to present some alternative calculation. I've heard nothing about the steps taken by this witness. I've heard nothing about all these modeling details, calibration of his model, none of that. I don't believe there's any foundation for an opinion by this witness as to some alternative modeling results.
MR. HAYNES: I'll rephrase.
Q Dr. Prucha, have you had a chance to go through the data presented by Kennecott in its 2004 FEFLOW model to determine if those data are sufficient for determining an upper bound?
A Yes.
Q And what would those steps be?
A I've looked at the four FEFLOW model exhibits which were FEFLOW model input files, and this preliminary numerical model was used to simulate several scenarios.
Q And did you in fact simulate several scenarios?
A Yes.
Q And did you then calibrate that model?
A No.
Q Were you able to -- do you think that -- based upon the data

that you had available, that you would be able to calibrate the model?

A No.

Q In your simulation -- Dr. Prucha, was your simulation similar to that carried out by Kennecott?

A I used their model and their data as introduced in their -- you know, in the file that I started with.

Q And based upon their data, were you able to arrive at a figure for an upper bound inflow into the mine?

MR. LEWIS: Same objection, your Honor; same basis. The witness has just testified in effect that he has no basis to offer an alternative opinion. He would have no basis to offer anything that's been calibrated and -- nor anything that would apparently be realistic since that's the way he's characterized all the modeling has gone before.

MR. HAYNES: I think I've laid enough of a foundation, your Honor, for the witness to testify.

JUDGE PATTERSON: I thought he testified he couldn't make a calculation from the data that he reviewed.

MR. HAYNES: Well, he said he didn't calibrate, but he did testify that he used Kennecott's data in his model, and that's what we're basing this on.

MR. LEWIS: Well, there's nothing about what he did with that data; how he computed the data; what calculations he did. And he's already testified it's not calibrated. He's already testified that calibration is a necessary function to derive any kind of result with any relevance to the Court, I believe, your Honor.

JUDGE PATTERSON: I'll allow him to go ahead and answer it if he can.

Q Dr. Prucha?

A That range, based on simulations I conducted, ranged from about 280 to over 3,000 g.p.m.

Q And the 280 to 3,000 g.p.m. is your range of uncertainty for this model based upon Kennecott's data?

A Effectively, yes.

Q Now, Dr. Prucha, in your review of the models prepared by Kennecott, did you also review a 2006 FEFLOW model?

A Yes.

Q And what is your understanding of the purpose of preparing the second model by Kennecott?

A The second model apparently was calibrated to this pump test at 084.

Q And is that the only change between the 2005 and 2006 model?

A They made a change to the boundary condition at the surface contact between the bedrock and the unconsolidated material.

Q And what was that change?

A A boundary condition, which changed it from a constant head boundary condition, where they'd specified a constant head to what they call a general head boundary condition, where

they're specifying a head or a water level and a conductance term or a term that's used to define the flow between -- the resistance effectively between the unconsolidated material and the bedrock.
Q And how would that change affect the model results between the 2005 and 2006 FEFLOW models?
A The 2005 FEFLOW model -- and I'm not sure if I'm correct on this -- estimated 180 g.p.m. after three years. The 2006 FEFLOW model estimated an upper bound mine inflow of 215 g.p.m. or gallons per minute. And actually, you know, I'm going to make one more clarification. The model that I -- the other model that was produced that I reviewed was a model that they adjusted the fault lengths in the north-south direction and got rid of faults in the east-west direction. And I think I may have to correct that that was what was calibrated to this model, where they based their reevaluation of this pump test data and used that as the basis for calibrating -- stating that the model was calibrated.
Q And in your view, was that appropriate?
A No. Because for this kind of model, it's not calibrated to the actual flow in the bedrock system. So for example, they developed another model that they claim is calibrated to the unconsolidated material, and they try to reproduce the observed groundwater flow directions and water levels. But

in the bedrock they don't try to do that at all, because they didn't have any other bedrock wells other than these in this test.

Q Now, Dr. Prucha, did you review as part of your assignment here a 2005 baseline model for the unconsolidated quaternary deposit?

A Yes.

Q And how was the unconsolidated material model calibrated?

A That was calibrated at a steady-state level, and they used groundwater levels and base flow estimated from the stream gauges that are along the various stretches of streams.

Q And was the steady-state calibration one that was appropriate, as far as you know, for purposes of preparing such a model?

A I would say that it's calibrated at a very high level.

Q All right. Dr. Prucha, I put up on the screen Kennecott Exhibit 8, the environmental impact assessment, Appendix B-5, Page 6, which has text dealing with boundary conditions. What portion of this text was significant for you?

A I'm not sure that's the exhibit. Yeah, that's --

Q All right. We'll pass that exhibit. Dr. Prucha, you may have testified about this before, but what are boundary conditions in a model?

A Things like rivers, evapotranspiration where water is being pulled out by plants or soil evaporation, wells recharge, which is derived mainly in this case through precipitation or rainfall, snowfall.

Q And for the model that was produced for the bedrock flow -- excuse me -- the mine inflow in this case, what boundary conditions -- what would boundary conditions be for such a model?

A For the bedrock model, did you say?

Q Yes.

A Well, you would have boundaries laterally. What was used in the model were no-flow boundaries but --

Q Excuse me. Low-flow boundaries?

A No-flow boundaries, --

Q No-flow. Okay.

A -- where water is assumed not to flow in laterally. It all comes in from above.

Q And for purposes -- I'm going to -- I'm sorry. I got a little ahead of myself. I'm going to move back to the quaternary deposit model. What was used as a boundary condition for the quaternary model deposit -- the quaternary deposit model?

A They had recharge in at the upper boundary. They had -- the rivers like the Salmon Trout and the Yellow Dog were exchanging flows with the shallow groundwater.

Q And how is bedrock system characterized in this quaternary deposit model in terms of boundary conditions?

A In the 2006 quaternary deposit model? Is that the one you're referring to?
Q Yes.
A Yeah. That was -- took the estimated flows from the FEFLOW model, which is a separate model that simplified the boundary condition, which represents the contact between the unconsolidated material and the bedrock, and they took that estimated flux or flow at every -- at a few points in their model domain around the mine area and the tunnel area, and they imposed that as a flux on their unconsolidated model at those locations. And they calibrated -- they ran a transient model, where they used every year a new flux from that bedrock model that was calculated. And that seemed strange to me. I think the problem with that unconsolidated model was that it wasn't re-calibrated after a number of modifications were made, based on my review of the report.
Q Dr. Prucha, is recharge an important parameter for modeling groundwater systems?
A Yes.
Q And why is that?
A Well, typically, in models like this, there's a significant control on the groundwater and your ability to calibrate a model and on the -- it's one of the more sensitive parameters in the model.
Q Do ASTM standards apply to recharge in models?

A I don't know the specific ASTM standard for recharge, but I think it is acknowledged that parameters like recharge and hydraulic conductivity can be adjusted in steady-state models, and you can end up with non-unique solutions. In other words, you can adjust either of those parameters and end up calibrating the model to observe levels and discharge, and you really don't get a unique set of parameters, which you're after to go predict. The idea -- objective is to determine hydraulic conductivity parameters throughout the model so that you can calculate accurate velocities. But if it's uncertain in terms of what those values are, then this is this problem you get with steady-state calibrated models.

Q I put up on the screen Kennecott Exhibit 8, Appendix B-5, Figure 3, which is the bedrock geology of the Eagle Project area. Does this exhibit illustrate how recharge was handled in the Kennecott models?

A No.

Q Dr. Prucha, how, in your estimation, was recharge handled in the Kennecott model?

A I don't think there was sufficient basis for defining the number of zones and the values of recharge that were imposed on the model. And this again is a very important parameter in a model such as the unconsolidated deposit model.

Q Dr. Prucha, what is sensitivity analysis in modeling?

A It's a process where you adjust parameters or adjust model input and assess the sensitivity of the output. And there are really two types of sensitivity analyses that can be performed. One is kind of associated with the calibration process. And there's another process that I think is more important that I think was not done here, and it's the sensitivity that you would do -- a sensitivity analysis that you would do on predictive simulations.

Q And would you explain that for us, please?

A It's more important to do a sensitivity analysis on predictive simulation so that you can assess the uncertainty of your predictions based on range of uncertainty in your input parameters. This is described in an ASTM standard pretty well.

Q And how did Kennecott's models handle the sensitivity analysis?

A My understanding is that they're more oriented at the calibration process, and I'm not sure that they really used that information beyond performing that and identifying that things that -- you typically find when you simulate flows in, say, an unconsolidated aquifer, you'll typically find that parameters like recharge and hydraulic conductivity are the most important parameters governing your solution or your estimates of where the water table is and where it's discharging and how much.

Q And did you find those -- that kind of discussion in the Kennecott models?
A No.
Q If you were modeling this groundwater flow regime, Dr. Prucha, would you have used such parameters in your sensitivity analysis?
A I would have conducted a sensitivity analysis of -- you know, associated with the predictive simulations that were done, and I think I would have referred to the ASTM standards on that. When you do sensitivity simulations, the ASTM standards have very clear guidelines in terms of identifying different types of sensitivities and how to document that.
MR. HAYNES: Your Honor, perhaps we could take a short break here. I want to make sure that the next set of exhibits are consistent with where we're going.
JUDGE PATTERSON: Okay.
MR. HAYNES: Thank you.
(Off the record)
JUDGE PATTERSON: Mr. Haynes, are we set?
MR. HAYNES: Yes, in just a few minutes.
Q Dr. Prucha, you testified about the 2006 model that you reviewed, that Kennecott FEFLOW model; is that right?
A The bedrock model, yes.
Q The bedrock model. Did the 2006 FEFLOW model include upper

bedrock layers in the model?
A Yes.
Q Did the code used for this model, as far as you can determine, allowed designation of discrete geological features in the model?
A Yes.
Q Did the 2006 model re-calibrate for current conditions from the 2005 model?
A Well, they didn't calibrate any of the bedrock models to actual site conditions. They only claimed to calibrate the 2006 bedrock model, which they used FEFLOW -- the FEFLOW code for to this 084 well pump test in the bedrock.
Q And, Dr. Prucha, did the modelers for Kennecott, as far as you can tell, attempt to merge the unconsolidated and the bedrock models?
A No.
Q Now, did the Kennecott modelers attempt to predict drawdowns from mining in the groundwater flow regime --
A Can you --
Q -- in the bedrock model?
A Did they try and estimate the drawdown in the bedrock?
Q Yes.
A Yes, with the FEFLOW model.
Q And what was the drawdown that was predicted in the FEFLOW model?

A Well, it was equivalent to where they had their drains in the mine at the different levels. I don't remember off the top of my head what level that was but --
Q And in your view, does the bedrock model accurately predict drawdown?
A No.
Q Why not?
A It's very much based on the assumptions of the faults, their fault lengths, the vertical extent of the faults and how they connect with the upper bedrock and the overburden. I believe the assumptions that they had were very limited in terms of faulting. They did not consider the permeable dikes that -- you know, the brecciated zones around the dikes. They didn't consider the major water-conductive features that were mapped in the area.
Q Now, Dr. Prucha, did you attempt to model the mine inflow for this proposed Eagle Mine?
A I did.
Q And would you describe for Judge Patterson what you did for your model?
A Yes. As opposed to trying to develop a new model from scratch, I wanted to see what a more realistic range of the mine inflows would be, so I started with a model I believed was the more realistic model, which they claimed to be their upper bound model. That was the -- this 2005 version of the

model with faults imposed on it that were 1 to 2 kilometers. Those were short in terms of their extent laterally, but I believe they actually didn't extend those faults vertically through the upper bedrock, which really limits the amount of mine inflow to those faults. So I -- that's just a conceptual problem right upfront with that model. My new simulations were intended to extend more realistic assumptions in these -- in this FEFLOW model.

Q And what did you do?

A So I ran several simulations. One was starting with just extending the upper boundary condition at the contact of the upper bedrock and the unconsolidated material. They did not simulate any flow in the unconsolidated material, which I think was limiting. It was very presumptive to model that that way. I put an actual thickness of the unconsolidated material in there, which allows the model to calculate the amount of flow more realistically to -- from the unconsolidated material into the bedrock. And that was one scenario, where I think I came up with a better boundary condition. That was -- that boundary condition alone increased their upper bound estimate, which I thought was more realistic of the two they'd done before, from about 215 gallons per minute to maybe about 280 gallons per minute.

The next several scenarios were devoted towards assessing the effect of vertically continuing their faults that they'd specified in the lower bedrock through the upper bedrock so that they stopped at the overburden or the unconsolidated material.

Q And, Dr. Prucha, why did you put those conditions into your model?

A Because it doesn't make sense to me to stop discrete water-conductive features that are more permeable in the lower bedrock right at this upper bedrock and lower bedrock contact.

Q All right. And what else did you do for your model?

A Well, in addition to putting in those -- this extension vertically on the fault, I extended them laterally. And probably the most significant adjustment, which is well within reasonable bounds of adjusting parameters, was I increased the permeability of the actual fault zone by a factor of 10, and that one particular simulation led to over 3,000 g.p.m. mine inflow. So that's where I came up with this range of 280 to 3,000. If you increase the fracture -- fault permeability, it would be even greater inflows.

Q And would increasing the fault permeability be an ordinary task for such a model?

A Yes. The uncertainty associated with major water-conductive features in the area could easily have hydraulic properties that are within what I simulated.

MR. HAYNES: Sorry, Judge. We're having one of those electronic moments again.

Q Now, Dr. Prucha, we've put up on the screen Proposed Kennecott Exhibit 399, which is a technical memorandum relating to additional mine inflow predictions and sensitivity analysis. Do you see that?

A Yes.

Q Have you had a chance to review this document?

A Yes.

Q And what is it that you understand this document to try to do?

A Well, it's a new model that was developed very recently. It has a number of changes to it compared to the previous Fletcher Driscoll and Golder models for the unconsolidated material.

Q And what changes are those?

A Well, they changed the number of model layers to represent the unconsolidated aquifer system.

Q Is that appropriate?

A I think it's appropriate to use a new set of model layers. But this model is similar to the previous ones and the problems that I saw with the previous ones, which were it didn't consider simulating the whole area of the bedrock that's been de-watered all in one model. So you're not forced to try and guess what the impact of mine dewatering is as it crosses into the unconsolidated material. So this model only simulates the unconsolidated material.

Q And what is the effect on the model outputs of such a simulation?

A I'm sorry. Could you rephrase that?

Q What is the effect on the model outputs of such a limited simulation?

A Well, when I reviewed this report, my sense is that the model output is somewhat uncertain like the previous models, because it's based on the same characterization and conceptual model that was presented before. And I don't see that this is any real improvement over the former models for the unconsolidated material.

MR. HAYNES: Your Honor, I'm going to go to Kennecott Exhibit 591. But again because of a technical glitch, we don't have the whole exhibit in our system. And I've asked Mr. Lewis if he would be -- if he could be assisted to put it up on the screen, and he's assented. So we're going to make a small technical change here.

JUDGE PATTERSON: Okay.

(Off the record)

Q Now, Dr. Prucha, we've had put on the screen -- and I appreciate Mr. Lewis' indulgence here -- Kennecott Exhibit 591, which is labeled "Technical Memorandum" dated April 1, 2008, and it's a draft. The subject is "Quaternary Groundwater Model." Do you see that?

A Yes.

Q Have you had a chance to review this proposed exhibit?

A Yes.

Q And what is your understanding of what this -- what is contained in this document?

A Well, this is the -- an updated, very recent model for the unconsolidated flow system.

Q And have you had a chance to review it?

A Yes.

Q And does this quaternary groundwater model improve or not improve the previous models that you've testified about?

A In terms of the drawdown estimates?

Q Yes, in terms of drawdown.

A I would say it's equally as uncertain as the previous models developed.

Q And again, by "drawdown" -- just for Judge Patterson's purpose -- edification, what do you mean by "drawdown"?

A In the unconsolidated material above the actual mine dewatering that's occurring, it's going to be drawing water from that unconsolidated material. So the water level in the aquifers above the bedrock will start to -- the aquifer levels will actually start to decline, and the drawdown is simply the difference between what they start at and where they end at.

MR. HAYNES: Now, if we could, go to figure 25 of

this exhibit, which is about three pages from the end.
Thank you.
Q Dr. Prucha, Figure 25 of Kennecott Exhibit 591 is labeled "Simulated Head Change in Layer 2 Calibration Scenario 2." Can you explain that designation for us?
A This is a plot just showing the change in the groundwater levels and the de-aquifer. The red indicates a drop in the water level, and the greenish color there is an increase in the groundwater level.
Q Now, I noticed that, for purposes of explaining this -- the contour lines on this figure, the red contour lines are in positive integers, and the green contour lines are in negative integers.
A Right.
Q So the positive integers mean a drop from existing?
A Right.
Q And the green and the negative integers means a rise in existing; correct?
A Right.
Q So for the red contour lines, does this Figure 25 show the orebody?
A It does.
Q And would you point that out with your pointer, please?
A It's in this area right here (indicating).
Q All right. And it seems to be in the center of all of the

red circles; correct?
A Yes.
Q And the red contour lines start at 0 -- I'm sorry -- start at 0.5, and then they increase in value to what around the orebody?
A 8.
Q And what does the "8" then signify?
A The drop in the water levels in that aquifer.
Q And this would be around the orebody?
A That's right.
Q So the new model prepared April 1st by GeoTrans suggests that there would be a drawdown from the mine operations of 8 feet in the water levels around the orebody?
A That's right. And this is for the case where they only simulate 60 gallons per minute.
Q And so under the simulation that you derived from your models of between 280 and 3,000 gallons per minute, would you expect the drawdown to be more or less from what this model shows?
A Substantially more.
Q Now, Dr. Prucha, if you can sum up your concerns with the modeling that was performed for Kennecott for this case, what would those concerns be in summary?
A I believe that models developed are inadequate to predict mine inflows because they weren't -- the underlying

conceptualization and characterization was inadequate. I believe that they substantially underestimated the amount of mine inflow, and I believe that they substantially underestimated the impacts to the unconsolidated aquifer zones and the stream flow in the Salmon Trout River.

MR. HAYNES: Dr. Prucha, thank you. I have no further questions at this time.

MR. EGGAN: Your Honor, I think the ball passes to me at this point. I would inquire of the Court's perspective on this. I could begin. I probably have two and a half hours with Dr. Prucha. It's about almost -- well, it's five after 4:00.

JUDGE PATTERSON: Right.

MR. EGGAN: What I would propose to do is go back and prune out some of the information that has already been elicited from Dr. Prucha that I probably would have asked about. Do you mind if we end now and pick up with him tomorrow at 8:30?

JUDGE PATTERSON: No, on that assurance, certainly not at all.

(Hearing adjourned at 4:07 p.m.)

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I certify that this transcript, consisting of 197 pages, is a complete, true and correct transcript of the hearing and testimony taken in this case on May 7, 2008.

May 9, 2008

Marcy A. Klingshirn

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STATE OF MICHIGAN

STATE OFFICE OF ADMINISTRATIVE HEARINGS AND RULES

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

HEARING - VOLUME NO. IX

BEFORE RICHARD A. PATTERSON, ADMINISTRATIVE LAW JUDGE

Constitution Hall, 525 West Allegan, Lansing, Michigan

Thursday, May 8, 2008, 8:30 a.m.

APPEARANCES:

For the Petitioner Keweenaw Bay Indian Community:

MR. ERIC J. EGGAN (P32368)
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Thursday, May 8, 2008 - 8:32 a.m.

MR. EGGAN: Good morning, Judge. How are you this morning?

JUDGE PATTERSON: Good. I'm fine.

MR. EGGAN: We are ready to go when you are.

JUDGE PATTERSON: I'm ready.

MR. EGGAN: All right. I think Mr. Haynes has a housekeeping matter he wants to --

MR. HAYNES: Yes, your Honor. A housekeeping matter in terms of exhibits, I would like to move the admission of the slides that Dr. Prucha identified yesterday from Plaintiff's Exhibit 63. And those slides are slide 13, slide 14, and slide 11.

JUDGE PATTERSON: I think you said "Plaintiff's exhibit." You mean Petitioner's?

MR. HAYNES: Yes, Petitioner's Exhibit 63.

JUDGE PATTERSON: Okay. I assumed that, but --

MR. HAYNES: Yeah. Sorry. I misspoke.

MR. LEWIS: I just don't recall what they are, your Honor.

JUDGE PATTERSON: I don't either, frankly. I was hoping you would.

MR. EGGAN: Oh, just trust us on that.

MR. HAYNES: I apologize, your Honor.

MR. LEWIS: I suggest maybe at the break or lunch Mr. Haynes can show me and Mr. Reichel what they are and take of it after that if that's agreeable.

JUDGE PATTERSON: Is that all right?

MR. HAYNES: That's fine.

JUDGE PATTERSON: Okay.

MR. HAYNES: Thank you, your Honor.

JUDGE PATTERSON: Okay.

MR. EGGAN: Are you comfortable, Mr. Prucha?

THE WITNESS: Yes.

ROBERT H. PRUCHA, PH.D.

having been recalled by the Petitioners:

DIRECT EXAMINATION

BY MR. EGGAN:

Q Doctor, at this point you've been talking about your hydrologic assessment of mine dewatering and the impacts as they relate to the mine permit. I'd like to turn our attention now to those very same issues as they relate to the Part 31, groundwater discharge permit process.

A Okay.

Q So with that as our overall theme, let's go ahead. Tell the hearing officer, if you will, some of the information you have reviewed so that you are able to talk about the groundwater discharge permit. Did you review the permit application?

A I did, yes.
Q What else did you look at?
A I looked at the permit, the groundwater permit, MDEQ groundwater perimt. I looked at modeling done by --
Q Well, that would have been my -- that would have been really the focus.
A Right.
Q We talked about you having looked at the groundwater discharge permit application that was submitted by the company.
A Right.
Q Did that include all of the appendices that were attached to that?
A That included all -- yes.
Q And I think there was some modeling done in that process.
A That's right; yes.
Q It was a hydrologic investigation, if you will, --
A Yes.
Q -- done by the company. You looked through all that?
A Yes.
Q Now, there's been some new modeling, some new work done. Have you looked at the new work that has been done by the company in preparation for this hearing?
A Yes.
Q Did you take a look at the Department of Environmental

Quality's file materials related to groundwater and hydrologic issues?
A Yes.
Q And what about the reports that were submitted by the company's hydrogeologists and hydrologists related to the groundwater discharge issue?
A Yes.
Q Now, I want to -- without belaboring it, I'd like to review a couple of issues that you talked about yesterday with Mr. Haynes pertaining to the mine permit and the hydrologic investigation. You talked about professional standards and guidelines and key steps that really need to be followed as one is doing a hydrologic investigation. Do the same standards, if you will, apply to the investigation that we're going to talk about now with respect to the groundwater discharge permit?
A Yes.
Q So I guess my -- what I'm getting at is, rather than cover the whole area of ASTM standards and that kind of thing, those same rules apply here as we're considering this permit?
A Yes.
Q Now, you talked yesterday about some steps, and essentially they are steps to investigating groundwater flow. And I want to talk about groundwater flow as we begin this

morning. And you talked about these steps. Can we talk about those key steps again? What are those steps, the key steps in doing a hydrologic investigation as you would do?
A It starts with collecting the right data, characterizing the system, using that data and then developing a good, sound conceptual model or alternative hypotheses, and developing models that are based on that conceptualization.
Q Now, Dr. Prucha, I have in my very poor handwriting, written these steps here on this dry-erase board. Okay? And I just want to make sure that we cover these three steps that you have talked about and you talked about yesterday for a hydrologic investigation. You talked about the collection of accurate data. Why is that so important in a hydrologic investigation?
A Well, you need to establish what information exists in a subsurface and the correct location. You need to have data there to make any estimates of what's going on in terms of groundwater flow.
Q So when we talk about the collection data, what we're really doing is, we're trying to find out what we can about the site so that we can begin to decide what the groundwater flow is going to look like and where the water is going to go?
A Yes.
Q Now, talk about this characterization step because I think

that's an important part of the steps.
A Typically when I look at data from the site I look to see how that data has been interpreted, whether the correct hydraulic tests have been performed, the interpretation of that is consistent with the data collected. I think that's an important step in terms of developing a sound conceptualization.
Q Okay. So, again, this is an investigation of the site of the area so that you have a good handle on what the site really looks like hydrologically?
A Right.
Q Okay. Now, what is this process of conceptualizing the flow? What does that really mean?
A That means taking the interpretations that you've made through your characterization of, for example, the groundwater flow conditions, the geologic conditions and putting that into a consistent diagram that shows clearly where the water flows from, how it enters the system, how it flows through the system and then where it discharges.
Q Are these three -- these three steps, are they conditioned -- are they precedent to doing modeling?
A Yes.
Q Okay. Do these three -- and I don't want to put words in your mouth. I don't want to be leading you. Okay? But do these three steps -- are they critical before you really can

begin modeling?
A Yes.
Q It's got the building blocks, if you will?
A Yes.
Q Okay. Let's talk about modeling now. Let's assume we've collected accurate data, which is critical. We have characterized the groundwater flow and we've gotten a sense of the characterization and then we've conceptualized the flow, and now we're ready to begin modeling. How do you construct the model?
A From the conceptual model that you've developed in step 3, there, you construct a model where you identify the aquifers that the groundwater is going to flow in. You've defined external boundary conditions which control the flow in and out of the system, and that's the basic step.
Q Is that the first step?
A Yes.
Q Okay. What's the second step, this calibration issue?
A The second step is your efforts to reproduce with that model the actual site observations that you've collected from the field, for example, groundwater elevations or flows that have been measured.
Q Okay. And is that the calibration phase?
A That's right.
Q Okay. Give us an analogy for calibration. Why is this step

important?
A Well, this is where there are two types of calibration and it's important to distinguish between the two. One is called a steady-state calibration where it is sort of an initial step to calibration, but it's not as credible as a transient-state calibration which you would do. And the difference is basically that in a transient calibration you are trying to reproduce the time bearing conditions in the model.
Q Now, there's a third step: Verify the current system behavior. How do you do that?
A Well, if you do it --
Q And I should say, why is that important and how do you do that?
A Well, if you have developed a transient-state model and calibrated it, this next step is considered demonstrating -- it's a demonstration of -- that shows that the calibrated model in step 2 there -- it adds more credibility to that. It verifies that under one set of conditions that you've calibrated to, that the model reproduces a second set. And that's a very good demonstration that your underlying conceptual model for the system is closer to reality than an alternative one that you may have had.
Q So this verification of current system behavior, this is just another check that you have to make sure that you're on

the right track with modeling?
A That's right.
Q Okay. Now what about -- what about step number 4 which is to run predictive simulations? What is that?
A Well, this is a step that is really the objective of the modeling, and it's to predict what will happen when you change the conditions of the hydrologic system. So, for example, if you start pumping a well and you want to know what the impacts of that pumping are on the system, this is where you would run a predictive simulation. It's trying to assess what happens when you change the flow conditions of the calibrated model.
Q Now, let me ask you something. We've talked about modeling. We've talked about these three steps. If you don't do steps 1, 2 and 3, what does this modeling look like? If you don't do steps 1, 2 and 3 and get it right, what does the modeling end up looking like?
A Well, in effect, there's no point to doing that modeling because you'll be simulating a condition that's not realistic. So the modeling won't be right.
Q In effect, what you're talking about is, garbage in; garbage out?
A That's right.
Q Now, let's talk for a moment to make sure where we were going. Why are these steps important in the context of this

particular groundwater discharge permit? Why were these steps important?

A Because predictive models have been developed to estimate the effects of the discharge on the groundwater system. And it's a complex system. Simple tools don't work to assess that. And so this whole series of points or steps applies as it did in the mine permit.

Q Well -- and thank you for that answer, but let me ask it in maybe a slightly different way. Why does the Department of Environmental Quality need modeling to decide this particular permit?

A To assess what the predictive model -- you know, a prediction is -- to assess the prediction that's put forth, the model is the way that you would demonstrate or show that your estimate is correct.

Q Okay. Can you tell from the information that you have looked at whether the Department of Environmental Quality did its own modeling?

A I can't tell.

Q If they didn't do their own modeling, what did they rely on based on what you looked at?

A The reports as submitted by Kennecott.

Q The company's modeling?

A That's correct.

Q Now, did you do any of your own modeling in this situation,

in this case?
A I did for the bedrock flow model file that was provided.
Q Okay. Talk to our hearing officer about the modeling that you did so that we have an understanding. Did you go out to the site and collect your own -- you know, sink your own wells? How did you handle this?
A I used the model input as provided and developed by the mine, Kennecott. And I simply made adjustments to that model that I believe are more realistic. So I used their input and model and as we received it.
Q You used -- essentially used the company's data --
A That's right.
Q -- and the information that they had gathered --
A Right.
Q -- to create your own -- your own model?
A Yes.
Q Okay. Did you apply this conservative approach that you and Mr. Haynes talked about yesterday? Did you use a -- what scenario did you use so that Judge Patterson knows a little bit more about the modeling you did?
MR. LEWIS: I don't mean to interrupt the direct, but it sounds like the same subject matter we covered at some depth with Mr. Haynes yesterday.
MR. EGGAN: We did discuss this with Mr. Haynes and "asked and answered" is going to be a welcome objection.

I have no problem with it. But that was late in the day yesterday.
Q I just want to make sure that Judge Patterson has a sense for the work that you did in deciding some of the issues we're going to talk about now with respect to inflow. So, again, what we're looking for, is you applied their -- essentially used their data, the data they had created to do your own model?
A Yes. I mean, that was effectively these top three steps. It was, you know, the data they collected, characterized and conceptualized, the model that they developed based on that. And I simply extended that to include what I think are more realistic conditions at the site.
Q Okay. Now, when you say "more realistic conditions," why are your conditions more realistic than theirs, I guess is maybe the essence of the question.
A Because I didn't see information on the faulting as I -- implemented in their model the way I saw that it would likely be implemented in a model if I were to develop the modelings.
Q Okay. You talked about faulting, and I think you had mentioned yesterday these dikes, perched aquifers and that sort of -- that is the issue we're talking about?
A Yes.
Q And those are the more realistic calculations that you built

into the model that you did?
A Yes.
Q Now, so that Judge Patterson is aware of where we're going here, I'm going to ask to have the wastewater treatment plan scheme put on the screen, and then you and I can talk about that for a minute. Okay?
MR. EGGAN: Can I have Bates number 101716? Your Honor, I've provided a book that should be on your table. And the document that we're looking for is under Tab 1.
JUDGE PATTERSON: Tab 1?
MR. EGGAN: Tab 1. Your Honor, are you at Tab 1?
JUDGE PATTERSON: I am.
MR. EGGAN: And, Mr. Reichel, are you at Tab 1 also? And, Mr. Lewis, Tab 1?
MR. LEWIS: Yes.
MR. EGGAN: All right. I think we can do this one the old-fashioned way, Judge.
JUDGE PATTERSON: Okay.
MR. EGGAN: Okay?
Q Now, Dr. Prucha, maybe I'll come up and come close to you. Now, this is Figure 7.1 from the Kennecott Eagle Minerals application. And it is -- "Monitoring Well Data" is what it's titled. But what it is, is --
MR. EGGAN: Your Honor, I just want to make sure you're in the right place. I'm looking at --

JUDGE PATTERSON: Yeah, I'm lost. I've got Tab 1, but I have no idea where you are within that.

MR. EGGAN: There it is, right there (indicating).

Q Okay. Let's look at this together, Dr. Prucha.

MR. EGGAN: And, again, for those who have the tabbed book, this is Tab 1.

Q Now, as you can see, Dr. Prucha, the main elements of the wastewater treatment system that they have created are the contact water basins here (indicating). See them here --

A Yes.

Q -- down on the lower left-hand side. Then here (indicating) in the middle is the wastewater treatment plant.

A Yes.

Q And then from the wastewater treatment plant, the next basic element is the treated water infiltration system.

A Yes.

Q Okay? So those are the basic elements of the wastewater treatment system that has been generated or created by Kennecott; am I right?

A Yes.

Q Now, as I understand it, the wastewater treatment system that the company is presented is based on -- in part on the inflow that's going to be coming into the system. Can you explain that?

A Well, the inflow from the mine dewatering will be routed to

this system, and there were two estimates for that.
Q Okay. Well, we're going to talk about what their estimates are in terms of inflow in a minute.
A Okay.
Q I just want to make sure I've got an understanding. The inflow that we have been talking about, the inflow from mining operations, the wastewater, is going to be going up, and it's going to go into these contact water basins where it's going to remain; am I right?
A Yes.
Q And then what's going to happen?
A Then it will go to the wastewater treatment plant, and that will be routed to the TWIS, the treated water --
Q We call it the TWIS; the treated water infiltration system?
A Right.
Q Okay. Now, what is the impact on -- of flow, of inflow on this system?
A It controls the design, I mean, the sizing of each of these units or components.
Q Okay. So that the system was based, at least by the company, on certain assumptions and sized its treatment facilities based on those assumptions?
A Yes.
Q And one of those assumptions was inflow?
A Yes.

Q Okay. What happens if those assumptions are not correct?

MR. LEWIS: Objection; foundation, your Honor. I think this question presumes this witness has some knowledge of the wastewater treatment system itself, how it will work and so forth, and there's no foundation for that. He's a groundwater modeling person, as I understand it.

MR. EGGAN: He is a groundwater modeling person, your Honor, but I think he does have some basic knowledge of this system and how it's supposed to work.

Q Are you competent to answer that question, what happens if there's -- if the assumptions are incorrect?

A Well, the sizing of these would --

MR. LEWIS: Well, just a minute. Same objection. The witness' view on his competence has no relevance here, your Honor. Again I don't think there's any foundation for him to offer any opinions which presume knowledge as to the design, construction, operation of the wastewater treatment plant. And I think he's being asked to do so.

Q Do you have an understanding the company has made estimates about the capacity of this system?

A Yes.

Q And we're going to be talking about that capacity in a few minutes, but do you have an opinion as to what will happen to the system generally if those assumptions are incorrect?

MR. LEWIS: Same objection, your Honor.

MR. EGGAN: Your Honor, I think this witness can answer. It's a basic question. If there's too much water, the system isn't going to be able to handle it. I think that's the essence of what he's going to say and we'll move on.

MR. LEWIS: There's no foundation for this witness knowing what the design capacity of this system is, your Honor.

MR. EGGAN: Well, I think I'll be showing that in about a minute.

MR. LEWIS: Well, we'll see, but it hasn't happened yet, Mr. Eggan. So I'm afraid I have an objection to foundation.

MR. EGGAN: Okay.

JUDGE PATTERSON: Yeah, I don't think there's been a proper foundation yet.

Q Do you have an understanding of the design capacity that the company has decided upon for the system?
A What they used as the basis for the design?
Q Yes.
A Yes.
Q Okay. And where does that information come from?
A Discharge application permit -- or permit application.
Q Okay. Let's take a look at that right now. Let's talk for a minute about the company's estimates of inflow, and then

we'll go back to my question.

MR. REICHEL: Excuse me, Counsel. Since this is being projected up, could you identify for the record what you're asking to look at?

MR. EGGAN: Yes; yes. This is page 14 of the application. It is from MDEQ Exhibit 141.

MR. REICHEL: Thank you.

MR. EGGAN: And it is Tab 2 among the materials I gave you this morning.

MR. REICHEL: Thank you.

MR. EGGAN: Okay?

Q Now, looking at this page, we're going to go through a number of figures that the company has estimated, and we'll get to the figure that Mr. Lewis was concerned about in a moment. Does the company provide an estimated inflow rate into the system?

A Yes.

Q And what is that estimate based on this exhibit?

A They have two: 75 gallons per minute and an upper bound inflow rate of 215 gallons per --

Q Okay. We're going to get to that in a minute. What is the -- you said the estimated inflow rate into the system is 75 gallons per minute?

A Yes.

Q Okay. Now, you talked, then, about an upper bound of

inflow. Where is that -- where is that on this document?
A It's in the first bullet, second sentence.
Q Okay. And let's read that together. The upper bound estimated inflow rate is approximately 215 gallons per minute.
A Yes.
Q And this is what the company is estimating --
A Yes.
Q -- in the documents that they provided to the Michigan Department of Environmental Quality.
A Yes.
Q Now, what is the inflow rate in gallons per minute that the company itself used to size the wastewater treatment plant?
A That's in the second bullet. It's 250 gallons per minute.
Q And let's read that together. "With the design basis mine inflow rate of 250 gallons per minute, the water balance for the site shows that on an average discharge rate" -- so what we're talking about here is the design basis inflow is 250 gallons a minute?
A Yes.
Q Okay. What about this (indicating) line? And this is the first bullet in this document. "The design basis in developing the water balance for the project and sizing the wastewater treatment plant assumed an inflow rate to the mine of 250 gallons per minute"?

A Yes.
Q So to answer Mr. Lewis' question, we do know what the projected design inflow rate was, and that's 250 gallons per minute?
A Yes.
Q What is the permit maximum under this document?
A That was listed as 504 gallons per day, which is 350 gallons per minute.
Q Okay. I'm looking at this (indicating) figure here with the third bullet. It says, "The wastewater treatment plant will be sized to accommodate up to 350 gallons per minute in treatment capacity to accommodate peak stormwater runoff events." What does that mean?
A Well, in the local area water will run off of the surface and be captured by the treatment system, and that was sized up to accommodate that.
Q Sir, I have shown you -- I am now projecting on the screen MDEQ Exhibit 141.
MR. EGGAN: It's Tab 3 for those of you who have the tabbed document. Okay?
Q And what I'm going to ask you to look at on this document, Mr. Prucha, is this reference -- do you know where this comes from, by the way -- where this document comes from?
A I believe this is the management plan.
Q Yes. This is page 47 of the company's application for a

groundwater discharge permit.

MR. EGGAN: And, again, it's MDEQ Exhibit 141, Tab 3, for those of you who have the tabbed document.

Q And what I'd like to look at is paragraph 7.2.2 on this page. Okay? Does that tell us anything -- does this tell us anything about the designed flow rate for the treated water infiltration system?

A Yes. It says that it's going to be designed for a flow rate of at least 400 gallons per minute.

Q Okay. Thank you.

MR. EGGAN: Your Honor, at this time I would like to offer the documents that are identified in Tabs 1, 2 and 3, and those documents are MDEQ Exhibit 141, Figure 7.1, MDEQ Exhibit 141, which is page 14 of the application, and MDEQ Exhibit 141 page 47 of the application.

MR. LEWIS: No objection.

MR. REICHEL: No objection, your Honor. I think actually the MDEQ Exhibit 141 should be admitted in its entirety.

MR. EGGAN: I'm happy to admit MDEQ Exhibit 141 in its entirety, your Honor.

JUDGE PATTERSON: Okay. Mr. Lewis, you don't have a problem with that, I assume?

MR. LEWIS: No.

JUDGE PATTERSON: Okay.

(Respondent's Exhibit 141 received)

Q Okay. We've talked about these various rates, and we're going to get back to the rates that were predicted in a minute and your perspective on what a more reasonable rate will be. But if the inflow rates are higher than the designed capacity of the facility, what will be the impact?

A It may have to be redesigned.

Q Okay. Let's go back, then, to the first document. I want to particularly focus your attention on the TWIS at this point -- okay? -- and talk to you about the configuration of the TWIS based on your observations and the inflow rates that are going to happen. You and I talked about a concern over the configuration itself, how it's -- the direction it is configured on this diagram. Can you talk to Judge Patterson about that and explain what your perspective is on that?

A The orientation of the TWIS or treated water infiltration system is oriented with the long axis heading off to the north --

Q Mr. Prucha, why don't you get out and get up and walk over to the document and show us with your pointer?

A The TWIS is oriented its long axis in this (indicating) direction to the northwest. And the presumed flow is to the northeast. I believe that orientation is probably taking advantage of that assumption in its design.

Q Okay. And if your analysis is correct, is there going to need to be any change in the TWIS in the orientation?

A I believe that should be considered, yes.

Q All right. Well, tell the court what that consideration would be and what the result might be.

Q If the flow direction from the TWIS is not primarily to the northeast, you may end up getting more mounding or mounding effects that are building up over each other. This is an efficient -- if the groundwater is flowing to the northeast, this is an efficient orientation, but if, in effect, it's more oriented towards the east or southeast, then this may not be as an efficient way of introducing the water into the groundwater system. The mounding would be affected.

Q Okay. Now let's get back to the inflow issue and the company's predictions as to inflow. And I have created a non-electronic old-school way of sort of presenting this issue to Judge Patterson. Let's talk about this. Okay. Let's go through this again, Dr. Prucha, to talk about the information that has been provided by the company and which has been approved by the MDEQ. And these are inflows, aren't they?

A Yes.

Q Okay. And we can see from looking at this exhibit, Exhibit 141, that the estimated inflow rate that the company has used and which has been permitted by MDEQ is 75 gallons per minute. Based on your analysis and the work that you did, what conclusion do you reach about what the estimated inflow rate will be?

MR. REICHEL: Objection for the record, your Honor. Counsel's misstatement mischaracterized in a couple of respects. The status of this, I believe he asserted that the DEQ has approved, quote, "the information presented." He also misstated -- there's no foundation that the DEQ in the permit has specifically approved the estimated inflow rate. I don't think either of those -- there's any foundation for either of those contentions. I think what the DEQ approved is reflected in the permit, --

MR. EGGAN: Okay.

MR. REICHEL: -- not every word in the application.

MR. EGGAN: If the MDEQ wishes to reject these numbers, it should say now, and maybe we can stop the proceedings.

MR. REICHEL: That's not the point, Counsel. I'm simply stating that what the DEQ approved is reflected in the text of the permit. I don't think it is accurate or there is a foundation to say that the DEQ approved every word, every figure in the application.

MR. EGGAN: Well, I'll have an opportunity to examine MDEQ witnesses on whether they agree with these figures or don't agree with these figures, and maybe we should just leave it at that. Let me rephrase.

MR. REICHEL: Thank you.

JUDGE PATTERSON: All right.

Q From the company's application we know what their basic estimates were --

A Yes.

Q -- in gallons per minute of inflow, don't we?

A Yes.

Q Okay. And looking at this exhibit we can see that, "The company's expected inflow rate" -- and I'm reading this. "The company's expected inflow rate of water into the mine is going to be approximately 700" -- excuse me -- "75 gallons per minute."

A Yes.

Q What do they say about the upper bound inflow?

A 215 gallons per minute.

Q Okay. And what do they say about the rate used to size the wastewater treatment plant?

A 250 gallons per minute.

Q All right. And then we call it "the permitted rate." What is the permitted rate?

MR. LEWIS: Objection to form, your Honor, and in conjunction with the prior objection in conjunction with what Mr. Reichel said. I don't know that there's a permitted rate. I agree Mr. Eggan has established with some documentation that on this documentation there appears to be a design capacity of 350 gallons per minute, but I don't think it's proper to equate that with a so-called permitted rate.

Q Then let's change this. We'll call it the "treatment capacity." Okay? And maybe we should call it the "maximum treatment capacity" because what we're talking about here -- and you correct me if I'm wrong -- the wastewater treatment plant will be sized to accommodate 350 gallons per minute in treatment capacity to accommodate peak stormwater runoff events.

MR. LEWIS: Objection. Leading, your Honor.

Q Can we call that the maximum treatment capacity, Dr. Prucha?

A I'm sorry. I was dealing with that. Can you repeat the question, please?

Q Sure. Can we call -- this figure of 350 gallons per minute for the wastewater treatment plant, can we call that the maximum treatment capacity?

A For the wastewater treatment plant, yes.

Q Yes. And we looked at the other document and we established the rate that was used to size the TWIS?

A Yes.

Q Now, if you wouldn't mind, Dr. Prucha, what is the estimated inflow rate that you conclude here on this document? Would

you mind writing that in?
A Well, as I said yesterday, I based -- I used the FEFLOW model for the bedrock and generated a new range, and the estimated low end, I guess would be maybe 280 gpm.
Q Okay. What about the upper bound inflow?
A This would equate to that 3,000 gpm.
Q All right. How did you get to 3,000 gallons per minute when the company only got 215 gallons per minute?
A Again I used their model and made adjustments that I thought reflect the system features, hydraulic features, more realistically. So this represents sort of upper range of that.
Q When we talk about upper bound inflow, what are we really talking about? What is upper bound inflow, I guess is the question.
A Well, this is important because this was used to -- as the basic design parameter for the subsequent components for this wastewater treatment plant.
Q All right. What rate would you utilize -- if you were doing the analysis here, what rate would you use to size the wastewater treatment plant?
A Well, I would just -- following their number here, I would add the difference between their upper bound and the 250. So I would add 35 gpm to this.
Q Okay. So what would your figure be?

(Witness writes on board)

Q So your upper bound inflow into the wastewater treatment system would be 3,035 gallons per minute?

A Yes.

Q Okay. What about the maximum treatment capacity?

A I would simply just take the difference between the 350 and the 250 gallons per minute, so adding another 100 gallons per minute --

(Witness writes on board)

Q 3,135 gallons per minute?

A That's right.

Q And what rate would you use to size he treated water infiltration system based on your calculations of inflow?

A Again I would just take the difference between the size used for the TWIS and the treatment capacity. So adding another 50 gpm, it's 3,185 gpm.

Q So you come up with the maximum for sizing the TWIS of 3,185 gallons per minute?

A Yes.

JUDGE PATTERSON: Counsel, can you ask Dr. Prucha to -- what's the definition of an upper bound inflow?

Q Yeah, tell us what this upper bound inflow is. What are we talking about here when we talk about upper bound inflow? Is that the maximum?

A From the dewatering at the mine, it represents a range that -- you know, if you go much higher it starts getting into an unrealistic amount that could come in there just based on a water balance of the area. But this was developed through a simulation that --

Q You know, Dr. Prucha, I think the question is a lot more simple. What is upper bound inflow? What does that term mean?

A It's a maximum amount of inflow.

MR. EGGAN: Your Honor, does that answer that your question?

JUDGE PATTERSON: I think so.

MR. EGGAN: It's the maximum amount of inflow into the system based on Kennecott's calculations and now based on ours.

JUDGE PATTERSON: Okay.

MR. EGGAN: Okay?

JUDGE PATTERSON: Yeah, I think -- thank you.

MR. EGGAN: Okay.

Q There's a substantial difference between your predictions and the company's predictions. Why are your predictions more realistic?

A I think they include more realistic -- they were -- they included more realistic features of the system in the model of the bedrock system locally; for example, how the faults were implemented in the model, how the boundary conditions were implemented in the model. And I'm referring to the model as the FEFLOW bedrock model that was developed.

Q Okay. Go ahead. Continue.

A And it also -- this particular 3,000 gpm is based off of a range for the water conductive features like the faults in the area within a reasonable hydraulic conductivity for that in a feature.

Q And I don't want to repeat all your testimony from yesterday, but it sounds to me as if you were considering faults and dikes that were just plain not considered by the company?

A I did not even include the dikes, the potential for those to be water conductive features within the system. This was really just the faulting as it was implemented in their model.

Q Did you also consider the information that you gathered related to other mining in the area of the Kennecott Mine Project?

A Yes.

Q Tell the hearing officer about that.

MR. LEWIS: Same objection for the record, your Honor.

MR. EGGAN: The objection from yesterday?

MR. LEWIS: And several days running.

MR. EGGAN: Understood. Understood.

A When I looked at the nearby mines in the Marquette Iron Mining District, that has a -- it's similar in terms of the components of the hydrologic system. I see flows from the mines reported in -- and I'm not sure what the exhibit number was. I think it was Exhibit 61, Eric?
Q Okay.
A I think it was 61?
Q It was Exhibit 61. I'm not going to take the time to show it --
A That's fine.
Q -- because we showed it ad nauseam yesterday, but --
A But there were several mines in that area that indicate fairly high flow rates. The Mather A -- B Mine had 4,000 gpm over several days when they intercepted a water conductive feature. The Maas Negaunee Mine area was 3,000 gpm as reported in this report. The Morris Mine had flow rates of 1650 to 2,000 gpm, of course the Athens Mine up to 600 gpm. So in my opinion, these demonstrate that it is possible to get this flow rate. And I would also point out that one difference between this mining area is that the river flows effectively right over it. And none of the mines I just mentioned have the river flowing over that. I think the closest river to any of these is at the Morris Mine which is about 1,000 feet away.
Q What difference does it make that this particular mine has a

river flowing directly over it? What impact will that have on inflow?
A If there's a direct communication between the bedrock water conductive features underneath this river which has been hypothesized in this report that faults are typically aligned with drainages or rivers as well as has been stated here in the Yellow Dog Plains, then that water in the Salmon Trout River can act as a direct source of water. And it doesn't just come from groundwater storage. It would be also supplied by direct communication of the river.
Q You talked about -- you talked about these other mines in the area. Are the geologic conditions -- I should say the hydrogeologic conditions similar to the mine that we are considering, the Kennecott Mine Project?
A I believe that the essential features are very similar. The thickness of the unconsolidated material overlying the bedrock is about the same range as we see here. The bedrock has dikes and faults that run through it and noted faulting. There's a clear indication in this report that water is really supplied to these mines through a fracture -- a fracture network.
Q And that is the essence of what you're talking about here, this fracture network?
A That's right.
MR. EGGAN: Your Honor, what I want to do -- I'm

about to move into a different area, but I want to respond to Mr. Reichel's objection to my reference that the numbers that Dr. Prucha is utilizing -- the upper bound inflows and the numbers that were provided by the company, Mr. Reichel has suggested that they were not incorporated into the permit. I would like to offer -- your Honor, this is Department of Environmental Quality Exhibit 117 and page 1 from that document. I just want to, in response Mr. Reichel's objection that the MDEQ has not -- I don't know -- utilized or adopted these numbers, I would just like to have the court take notice of the language here:

> "The terms and conditions that are set forth in the Application for a Mining permit (the Permit Application) submitted by Kennecott Eagle Minerals Company to the Eagle Project including all supplemental documents are incorporated in and become a part of this mining permit."

So, again, the suggestion that the MDEQ has not adopted these numbers is correct.

MR. LEWIS: Your Honor, just to the extent Counsel is apparently making argument and not posing any questions, I guess I'll object to that and secondly note that although the permit does, in fact, incorporate the mine permit application materials and other materials, the inference that all the various numbers set forth in the mine permit application materials are -- in effect become permit conditions and limitations, there's no foundation for that, and that's not the way this works.

MR. REICHEL: I would -- again, I don't think this is the appropriate time for argument. I made what I continue to believe was a legitimate objection. I would also note for the record that ostensibly what this witness is being asked by Mr. Eggan about is the groundwater, the Part 31 application. And what he was asking this witness about was a question directed to the contents of the Part 31 application. This is the Part 632 application. But rather than burden the record with further argument of counsel, which I think this is really a legal thing, I do continue to maintain that there was a basis for my objection. But I think the issue is moot.

MR. EGGAN: Well, if it's mooted, then we can go on.

JUDGE PATTERSON: All right.

Q All right. I think we can agree, Dr. Prucha, that your numbers are different than the company's number with respect to inflow.

A Yes.

Q And what I want to ask you is a little bit about where we think the company went wrong. Okay? Why do you think the company's numbers are incorrect?

A I don't think they considered a realistic upper range of inflows to the mine.
Q In what respect?
A In terms of the magnitude.
Q Well, let's look at -- let's look at your steps in terms of -- in terms of determining inflow. Where did the company go wrong in terms of collection of data?
A I think that they did not collect data in the appropriate locations or --
MR. LEWIS: Your Honor, as I said earlier, and maybe Mr. Eggan can -- a lot of this seems to me that we're going through the same ground we spent a lot of time yesterday going through. I believe, if the intent is to ask these three questions, that we covered that yesterday. And is there some way we can avoid doing some of that?
MR. EGGAN: Well, I'm certainly all for avoiding repetition, your Honor. My concern is that that was related to the 632 permit and there were certainly groundwater issues there. I'm asking for a basic summary from Dr. Prucha as to where the company went wrong in terms of its predicted inflow that is the basis for design for this system.
MR. LEWIS: And it's exactly that that was covered in detail yesterday, the basis for the inflow. That's the point, as I understand it, of yesterday's testimony.

MR. EGGAN: Your Honor, I --

JUDGE PATTERSON: That was my understanding too. I --

MR. EGGAN: Well, I do think that, for the Part 632 Permit, I am entitled to have this witness testify as to what he thinks -- I'm sorry -- for the Part 31 Permit --

JUDGE PATTERSON: Right.

MR. EGGAN: -- I think this witness is allowed to testify as to where he thinks the company went wrong in terms of inflow. And I did -- I do think he testified about this yesterday. I intend to just do this as a brief recap.

JUDGE PATTERSON: All right.

Q Basically, Dr. Prucha, without repeating everything we did yesterday, where did the company go wrong?

A Basically in the steps that you've listed on the board in terms of collecting the correct data, characterizing the system, conceptualizing the flow and developing adequate models.

Q Was the company's investigation of inflow consistent with ASTM standards?

A No.

Q You indicated you had an opportunity and you talked to -- yesterday to Mr. Haynes about the Department of Environmental Quality's guidelines for groundwater modeling. Was the company's investigation of the inflow consistent

with the MDEQ's guidelines for groundwater modeling?
A No.
Q Was the company's methodology in determining the amount of inflow consistent with what a reasonably prudent hydrologist doing this kind of analysis would have done?
A No.
Q Why not?
A I don't think they considered realistic upper bound inflows to the system.
Q Did the company submit a plan that accurately predicted the amount of inflow that is to be treated?
A Can you rephrase that?
Q Yes. The company submitted a plan --
A Yes.
Q -- for inflow -- for analyzing inflow. Is -- that plan describing this inflow, is it accurate?
A No.
Q Why not?
A Again, I think they underestimated or understated the upper bound inflows.
Q Do you have an opinion, based upon a reasonable degree of scientific certainty, as to the significance of their error?
A Yes.
Q How wrong were they?
A Well, I think this diagram we put up here indicates that

it'd be off by a factor of 10 for the upper bound.
Q Which would be what we might call an order of magnitude?
A An order of magnitude.
Q Given the errors that the company committed, were -- the inflow volume assumptions that they presented to the Michigan Department of Environmental Quality, were those assumptions valid in terms of their sizing of the wastewater treatment system?
A No.
Q Why not?
A Too low.

MR. EGGAN: Your Honor, this might be an appropriate time for a break, if you wish.

JUDGE PATTERSON: Yeah, that's fine.

(Off the record)

MR. EGGAN: Your Honor, as a housekeeping matter, this small chart we did on inflows that Dr. Prucha and I created while he was on the stand --

MR. BRACKEN: We're all set.

MR. EGGAN: Your Honor, as a housekeeping matter, this small chart we did on inflows where Dr. Prucha offered his estimates of inflow rates, et cetera, we would offer that as Defendant's Exhibit Number 44 -- I'm sorry -- Petitioner's Exhibit Number 44.

MR. REICHEL: I assume that would be the Part 31 exhibit?

MR. EGGAN: Yes.

MR. LEWIS: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay. No objections. It'll be entered.

(Petitioner's Exhibit 31-44 received)

(Counsel marks on document)

MR. EGGAN: What I've done, your Honor, is written "Petitioner's Part 31 Exhibit Number 44." As an additional housekeeping matter, Judge, I think that I want to make sure that the record is clear that, while we have identified Part 31 exhibits and Part 632 exhibits, I would invite any of the parties to utilize all of the exhibits for the -- these are being presented in a consolidated proceeding.

JUDGE PATTERSON: Correct.

MR. EGGAN: So if Mr. Haynes is utilizing exhibits during his examination and they're admitted during the Part 632 case, those would still be available to me to use in the briefing and documents and other materials filed with the court.

JUDGE PATTERSON: I just understood it was a matter --

MR. EGGAN: Does everybody understand that to be the case?

MR. LEWIS: I have no problem with that.

MR. REICHEL: That was my understanding, Counsel. And just to be clear, I simply suggested that this latest exhibit; that is, 44; be designated by reference to Part 31.

MR. EGGAN: Yeah.

MR. REICHEL: Because as you well know, Petitioners have two separately numbered listed exhibits.

MR. EGGAN: We do, and I've been thinking about this through the proceeding, and I just wanted to make it clear that we can all use each other's exhibits and for whatever purpose that we need to use them for.

JUDGE PATTERSON: I just thought it was a matter of identifying them --

MR. EGGAN: Me too.

JUDGE PATTERSON: -- as opposed to any substantive determination.

Q Dr. Prucha, let's move on now to a different area. And, Doctor, what we are going to be talking about is the vicinity of the treated water infiltration system -- okay? --

A Yes.

Q -- and the company's analysis of flow direction and flow speeds essentially in the fate and transport of the water that is going to be reinjected into the system by the treated water infiltration system. Okay?

A Yes.

Q So that's what we're going to be talking about now. Have you reached any conclusions about the validity of the company's investigation of the fate and transport of water as it leaves the treated water infiltration system?

A Yes.

Q What are your conclusions?

A I believe that the estimates of flow direction are incorrect.

Q Well, let's talk about that. What difference does it make in terms of which direction the water goes and how much of it there is? What difference does that really make?

A In terms of the amount of water that gets applied at the TWIS, if the volumes are -- if the flow rates are significantly higher than it was designed for or even if it was designed at this level, the potential for mounding to reach the surface is large, and I think that the direction of flow may have been miscalculated.

Q Well, we're going to talk about that.

A Yeah.

Q I'm interested in going through the steps that the company took in assessing the hydrology from the TWIS discharge to the venting area. Okay?

A Okay.

Q But we need to define some terms. Where is the area of the

TWIS discharge, and where is the area that is the venting area? And we're not going to get very specific here, but I want you to get up and show the court essentially what we're talking about here.
A On this diagram?
Q Yes.
A Well, as I understand it, the water will be applied in this area here (indicating) of the treated water infiltration system through a series of pipes. That water will infiltrate the ground and at some point will start flowing laterally in some --
Q Or in some direction?
A In some direction.
Q Okay. Now, there's -- there are areas -- and we're going to identify some of those areas in a few minutes. But there are areas called venting areas. What are those?
A Well, that refers to the area where groundwater will discharge to the surface water or to the ground surface.
Q Okay. So this is the area where the groundwater essentially comes to the surface and goes somewhere?
A Yes.
Q Okay. Now, you talked a moment ago about a concept called mounding, and I want to give the judge some basis of understanding about what we're talking about when we talk about mounding. What is that?

A That's when groundwater will -- when it's -- in this particular case, when groundwater is -- when the discharge from the TWIS infiltrates down and it intercepts either a low-permeability zone or the groundwater that exists underneath the TWIS, it will begin to mound locally or elevate.

Q Would it help you to draw a little drawing of that on one of the pages that we have?

A Sure.

(Witness draws diagram)

A If this is the infiltration system, the TWIS, and water is applied in here at the ground surface and at depth -- this symbol means the groundwater table -- water will infiltrate down. And if water hits this groundwater surface, it will cause an increase in the elevation of that groundwater surface. It changes the gradients, and the gradients are basically defined as the slope of this water table.

Q Okay. So when we talk about mounding, what we're talking about is water that's being injected into the ground from the treated water infiltration system. And what happens to that water when it hits the water table?

A If it hits the water table, it will mound, and this mounding and this increased gradient will cause the groundwater to move away from that area of mounding. And if this occurs and it intercepts the groundwater at a gradient, this mounding may be projected off in the direction of that groundwater gradient more so than back towards the opposite end. But either way, it --

Q So when we talk about "downgradient," we're talking about water that is essentially flowing downhill?

A Effectively, yes.

Q All right. Now I'd like to go through the steps that the company took in assessing the hydrology from the TWIS discharge to this venting area that we're talking about -- okay? --

A Okay.

Q -- and see what your opinions of each of the steps that the company utilized are. You outlined the steps that one should take in conducting this kind of investigation, both with Mr. Haynes and me, and here they are again: collection of data, the characterization of that data and then the creation of a conceptualization of that flow; the direction the water's going to go. Okay?

A Yes.

Q Let's talk about this in the context of this case -- these steps in the context of this case and the company's investigation. Did they collect hydrogeologic -- hydraulic data in the appropriate locations to assess the flow conditions?

MR. LEWIS: Objection; foundation.

MR. EGGAN: I'd like a little bit more understanding of what that objection is.

MR. LEWIS: I haven't heard any basis for his knowledge about where they collected this data or what he knows about it; no reference to any maps of all the various wells that have been put to do exactly that; no reference that he has reviewed any of those documents; no reference that he can testify based on the knowledge that would be necessary in this case.

MR. EGGAN: Okay. I think that's a fair objection, your Honor. Let's see if we can't get to that point. Can I have MDEQ 010712? And I need you to blow up the part that is right --

Q Will this cover it?

A I would blow up this zone right here (indicating).

Q Is that large enough, Dr. Prucha?

A Yes.

Q Now, again, this is in response to the objection. We need to establish for the judge that you have some basis by which to conclude something about whether or not the company collected data in the appropriate locations. Talk to us about that.

MR. REICHEL: Excuse me, Counsel. Please identify for the record what's on the screen.

MR. EGGAN: Thank you. This is Figure 2-2 of the discharge permit application. It is MDEQ Exhibit 141.

MR. REICHEL: Thank you.

Q Okay. Dr. Prucha, again, tell us what this means in terms of the appropriate locations to assess the flow conditions from the TWIS to the venting areas.

A Okay. The pink dots represent wells with boreholes, and the location of the TWIS is located in the center of this figure. The outline of that TWIS isn't actually shown, but these eight sort of equally spaced locations here are included in that TWIS. I guess the important point I'd like to make that seems fundamental about locating data in an area where you would want to assess the -- what happens to the water once it leaves the TWIS, is the area from this TWIS up to the northeast, this whole area up here that's in the area of the presumed flow is completely void of data and --

Q Now, when you say "in the area of the presumed flow," whose presumed flow is that?

A The various models that have been produced; the groundwater contour maps that I've seen in the mine permit application; appendices EIA; various groundwater flow maps that --

Q Yeah. I'm asking who it is in this case that has decided that the flow is to the northeast.

A Well, the mine applicant -- the discharge permit applicant.

Q The company?

A Kennecott Company.

Q Okay. Go ahead, then. What would you do?

A Well, if you're trying to assess the impacts of mounding in this area and where it's going to eventually vent or discharge to the ground surface, I would want to have data in an area where I'm presuming the flow goes based on groundwater plots that I've made for the area. The only well out towards the east and -- is this well 09; really virtually no data down to the south, southeast for a good distance. So it just seems to me that there's a lack of information outside of the local TWIS location, and this seems like a critical flaw to not have that information to allow you to --

Q So if you were trying to determine the effect of this mounding and the flow data, what would you have done?

A I would have placed wells in presumed pathways. So I would have put wells between the TWIS and where, say, for example it's believed the water discharges to, these streams here or out in this area. And that would have allowed me to assess what the geology's doing, confirm what I was hypothesizing here about the geology, the aquifers, their extent.

Q What does this tell you about their collection of data, which is one of your three steps?

A Just seems fundamentally flawed because, if you're asked to go assess where this flow is going, you can't even begin to do anything beyond this point. You haven't even collected the basic data needed to characterize the flow direction and confirm that it is in fact towards the northeast.

Q Dr. Prucha I'm showing you Figure 23 from the application, which is Appendix B-1. Does this add anything more in terms of your conclusion with respect to their collection of data?

A Yes. Maybe we can zoom in here, the small area around here (indicating).

Q Again, Doctor, what we're talking about is the company's collection of data that they utilize to create their model. So talk about what this tells us with respect to their collection of data.

A Well, a critical bit of data, in addition to the geologic information that you would collect to confirm aquifers that the water would be flowing from the TWIS location, which is in this area right here (indicating), would be the groundwater elevation data. So just to confirm that your presumed groundwater flow direction is to the northeast, you need wells in this area here to confirm that. I believe that these wells placed a good distance out are not necessarily the ideal locations to define the groundwater flow conditions that you would expect to occur around local seep areas.

Q Does this map give us a better idea of where the so-called venting locations are?

A From their contours, I don't believe that you could actually say that the venting locations are well-defined. I don't think that they accounted for the venting locations in the development of these contours. I think -- the site visit that we took out there, we went to one of the seeps at the very top, and we noticed groundwater flowing out of the seep, and yet it doesn't seem like that information -- at the head of the seep, and yet that information isn't used to help define the basic groundwater contours that are kind of the basic foundation of developing a conceptual model that's valid.

Q Okay. Where do you think they focused their collection efforts -- the data collection efforts?

A Well, they focused more in the TWIS area or the treated water infiltration system located in the upper corner right here (indicating) and towards the orebody -- Eagle Rock and the orebody.

MR. EGGAN: Your Honor, the first exhibit that I showed was Figure 2.2 of the discharge permit application. That's MDEQ Exhibit 141. That's already been admitted. This figure is Figure 23 from the application at B-1. It's from the EIA. I believe it's MDEQ Exhibit 32. I would offer that. These are found at Tab 7, by the way, in the materials I provided this morning.

MR. LEWIS: And they're identified by Bates stamp number and MDEQ exhibit number; is that right?

MR. EGGAN: They are. That's correct.

MR. LEWIS: I have no objection, your Honor.

MR. REICHEL: I have no objection. Again, Counsel, are you -- is your proffer just to this particular thing, or are you --

MR. EGGAN: It's just of this particular thing at this point, yes; yes.

MR. REICHEL: As opposed to Exhibit 32, which is of course --

MR. EGGAN: Which is a multi-page document, yes.

MR. REICHEL: I have no objection.

JUDGE PATTERSON: No objection. It will be entered.

(Respondent's Exhibit 32, Figure 23 received)

Q Dr. Prucha, we were talking about the focus of their study. Can you talk a little bit about what you determined about the focus of their collection efforts?

A Well, I believe that the focus of their efforts was really at and beneath the TWIS.

Q Do you believe they focused on the correct areas, Doctor?

MR. LEWIS: Asked and answered.

MR. EGGAN: I don't think it has been.

Q Do you believe that they focused on the correct areas?

A No.

Q Ok. Does this exhibit --

MR. EGGAN: -- which is MDEQ Exhibit 143, Tab 8 at your documents, Counsel.

Q Does this exhibit assist you in reaching that conclusion?

A Yes.

MR. EGGAN: And this again is Figure 15 from the -- from MDEQ Exhibit 143.

Q Tell us why, Doctor.

A Well, in this diagram the TWIS outline is shown in green here, and these lines that they have labeled with letters A through F are various cross-sections that show the geology and groundwater levels. But the problem I see is that there is an inferred or a presumed direction of groundwater north -- to the northeast or up in this (indicating) direction, and they've put their cross-section starting at the TWIS going to the southwest in the opposite direction of the presumed flow. And it's unclear to me why you would do that. I -- if I drew cross-sections to assess the flow of the discharge from the TWIS, I would start here and go up in the presumed direction of flow. So this is --

Q So in other words, their cross-sections are in the wrong location?

A The cross-sections A, B and C are in the wrong location, in my opinion -- A, C and D -- no -- B, C and D; sorry. I can't see that from here.

MR. EGGAN: Your Honor, I would offer this Figure 15 from the application as Petitioner's Exhibit 45 -- Petitioner's Part 31, Exhibit 45.

MR. LEWIS: Is that a new exhibit, Mr. Eggan?

MR. EGGAN: It is not. It's part -- it's actually part of MDEQ Exhibit 143.

MR. LEWIS: We've been in the practice, I thought, of offering them as MDEQ exhibits.

MR. EGGAN: Okay. And I'm fine with that. I'm fine with that.

MR. LEWIS: Can we do that?

MR. EGGAN: If you want to do it, let's go with -- we would offer MDEQ Exhibit 143, then, at this time.

MR. LEWIS: And it's the Figure 15, --

MR. EGGAN: Correct.

MR. LEWIS: -- Bates stamped MDEQ 10814?

MR. EGGAN: Correct.

MR. LEWIS: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: All right. No objection. It'll be entered.

(Respondent's Exhibit 143, Figure 15 received)

Q Doctor, I'm going to show you Figure 15.

MR. EGGAN: And again, this is from Exhibit 1- -- MDEQ Exhibit 143, your Honor. It's at Tab 8 in the

documents I presented this morning. This is Figure 21.
Q Dr. Prucha, does this offer any additional information as to their location of -- or their collection of data and the focus of their data collection efforts?
A Well, again it indicates to me that their interpretation of the geology and hydrogeology is in the wrong location. The infiltration gallery would be over where it says "HS investigation area" roughly. And this is a cross-section that starts at that point and goes to the southwest in the opposite direction of the presumed flow. You can see that flow direction is towards the northeast by the fact that this blue contact with the red -- the brown color is oriented towards the northeast.
Q So the groundwater flow is going to at least naturally be this (indicating) way under their depiction, yet these three monitoring wells would suggest that they're collecting data back in this direction, which is the opposite direction of the flow?
A That's right.
Q Okay. Did they collect data on the bedrock surface?
A They have, but -- yes, they have.
Q Okay. I want to show you an exhibit which is Figure 17 from Exhibit 143 -- MDEQ Exhibit 143. So that's Figure 17.
MR. EGGAN: MDEQ 010816. This is Tab 9, your Honor.

Q Dr. Prucha, what does this tell us about wells north of the Yellow Dog Plains?
A Well, if we could zoom into this area right here (indicating) roughly, the bedrock surface is very important in terms of -- as an input in terms of controlling the groundwater flow through the unconsolidated material through the system. And this is a map that was produced that shows the surface with the contours of the bedrock surface. And they have labeled various boreholes, wells here with the elevations. The TWIS is located right here. And if the presumed flow is off to the northeast or really in most directions from the TWIS, there are no bedrock wells to help control the estimate of that bedrock surface, which is very important in terms of controlling flow in the unconsolidated materials.
Q Well, it sounds like they collected data, then, from the bedrock area, but they just didn't put it in the right place?
A They didn't --
MR. LEWIS: Objection; leading, your Honor.
JUDGE PATTERSON: Can you rephrase it?
MR. EGGAN: Sure.
Q Did they collect it from the right place?
A They did not.
Q Okay.

MR. EGGAN: Your Honor, I would offer this exhibit, which is Figure 17 from the -- from Appendix B to the discharge permit application. It's MDEQ Exhibit 143. It's Tab 9 in the back of this.

MR. LEWIS: To be of continuing assistance, I believe it's Bates number 10816.

MR. EGGAN: That's correct.

MR. LEWIS: Thank you.

MR. EGGAN: Yeah.

(Respondents Exhibit 143, Figure 17 received)

Q All right. While we're talking about data collection, I just want to go to one more exhibit on this subject, and that is this latest GeoTrans modeling that they did in April. Okay? Now, you testified yesterday that the company has had another attempt to model, another attempt to gather data?

A Yes.

Q And that's this GeoTrans model. When was that done?

A It looks like in 2008.

Q Do you know when?

A April, I think they stated.

Q April of 2008?

A That's the date of the report.

Q Okay. Does that correct anything? Does it provide additional data that would be useful in determining this

issue, flow direction?
A No.
Q Well, let's look at Exhibit -- excuse me -- Figure 8 to that GeoTrans exhibit.
MR. EGGAN: This is KEMC Exhibit 591. It's Bates number KEMC 186845. It's at Tab 10 in your books.
Q Is this the exhibit we're looking for, Dr. Prucha?
A Yes.
Q Tell the hearing officer what this is and whether or not this provides additional data that would be useful; corrects the errors that you've pointed out.
A Could we zoom into this area here (indicating)? Again, the implication in terms of predictions of where flow is going to go is very dependent on the accuracy and understanding of this bedrock surface. And I would point out that the TWIS location, as shown here with a rectangle and the little symbols here, crosses that are pink, I guess, are representing where they have controls on -- where they have information on the bedrock surface. So from the TWIS location, there are just no bedrock controls anywhere out here. And so this estimated surface for the bedrock is an entirely extrapolated or, to a large extent, guessed surface. And to me this gets into -- creates a lot of uncertainty about what that actually is. Is this off 100 feet? Is it off 22? Is this the correct orientation of

that bedrock surface? This could be oriented in the wrong direction, and this has a big influence, I believe, in controlling the direction of groundwater flow in the area from the TWIS.

Q Do you think that they collected enough data to characterize the potential migration pathways?

A No.

Q Let me show you what is -- hang on.

MR. EGGAN: I need to go back to this document. I need to admit this document. This is Figure 8 to the GeoTrans report that was done in April. It's KEMC Exhibit 591. I would like to offer that into evidence, your Honor.

MR. LEWIS: Do you want to offer the report?

MR. EGGAN: No. I'd like to offer this figure.

MR. LEWIS: No objection, your Honor.

MR. REICHEL: No objection.

JUDGE PATTERSON: All right. No objection. It'll be admitted.

(Intervenor's Exhibit 591, Figure 8 received)

Q All right. Again, we're looking at whether or not the company collected enough data to really adequately characterize the potential migration pathways.

MR. EGGAN: Show me MDEQ 010823. Your Honor, this is from MDEQ Exhibit 143. It is Figure 24 from Appendix B of the groundwater discharge permit application, MDEQ

Exhibit 143, Tab 11 at your book.

Q What does this tell us about whether or not they identified -- they collected enough data to characterize the migration pathways?

A Well, this is sort of a critical point here in terms of the vertical nature of how water will enter the system from the TWIS or from the infiltration gallery at the ground surface here. And what I see is low-permeability units well above the water table that I believe the water can easily mound upon. And this particular cross-section is taken through lengthwise along the TWIS -- the TWIS' longer access. But I guess what concerns me is that beyond this location there are no data points to confirm that -- in fact this low-permeability unit. And they've colored this on other slides as a more regional unit that extends over a good portion of the Yellow Dog's Plain.

There's, in my opinion, almost a presumption that this unit actually disappears and that what they have been calling an A zone or this upper permeable outwash sand aquifer and the lower de-aquifer zone were two separate units but that at the TWIS they combine and become one. From these cross-sections at the TWIS, I don't necessarily see any indication that these would necessarily pinch out. They may thin here.

But I still -- with the lack of data off to the

northeast, east, south seems difficult to show that that actually occurs. And this, in my opinion, can be significant because, if water is infiltrating from the TWIS straight down, it may very likely mound up here and not really affect where the actual groundwater level is right now. Examples like this, in this particular figure where they have a lean clay in this borehole here and one right in the one next to it, this interpretation that they're disconnected yet connected between two others seems sort of like picking this in a biased fashion to indicate that there are pathways down. But in reality, why aren't these connected?
Q You said "picking." Do you mean -- is there another word you might use?
A Like cherry picking the answer to a -- the conclusion that water infiltrates readily down to this existing water table as opposed to hitting the low-permeability units in this vadose zone or the zone from the groundwater table up to the ground surface. And having done a lot of models where you actually try and simulate the flow in this vadose zone from the ground surface down to the groundwater table, these low-permeability units are critical and are much lower permeability than the surrounding ground which they're referring to here as unsaturated sand.
So if these are in fact continuous out to the

northeast or whatever direction the groundwater flows, then these become critical elements in finding the hydrogeology of the system and what happens to the water once it leaves the mound -- the TWIS. So in fact, the presumption that the groundwater below -- existing groundwater below this TWIS actually mounds, I would submit that groundwater can easily mound over these. And the wells that they have placed in here may not capture that.

Q May not capture what?

A That there may actually even be water in here now. I didn't see that on the logs. But this -- I know, when you inject a lot of water into an unsaturated zone like this, these become critical.

Q Are there other areas -- with respect to data collection, are there other areas where the company was deficient?

A I would say in hydraulic testing of the area.

Q Tell us about that.

A I would say that there are no multiple aquifer well tests in the area where they're attempting to pump from one well and monitor several nearby wells to -- that gives you probably the best information about how well connected a system is over -- provides an effective hydraulic property over a larger area. The types of hydraulic tests conducted were very localized, so you really can't get a sense of how important these low-permeability layers are throughout the

system in this area.
Q Now, we know what the company did not do. What do you think a reasonably prudent or a quality hydrologist would have done to really collect data here?
A Do you mean at this cross-sectional --
Q No. In order to really collect data, on the flow conditions from the TWIS to the venting areas, --
A Yes.
Q -- what would a reasonably prudent investigator have done --
A Right.
Q -- a reasonably prudent hydrologist have done?
A I would have put more wells in between that TWIS location and venting locations in directions -- all directions that I think mounded water could flow towards.
Q Let's go to Part B of the groundwater investigation. That's the characterization of this data that they collected. Did the company -- well, let me ask you it this way -- the Part 22 rules require a three-dimensional flow path?
A Yes.
Q Did they do that?
A No, I didn't see a three-dimensional flow path.
Q Did the company evaluate or develop an adequate geologic profile over the potential pathways of this water?
A No.
Q Why do you say that?

A Well, they have no wells from the TWIS to the venting location, so they couldn't.

Q Did the company's cross-section support that conclusion?

A Sorry. Can you rephrase that?

Q Yeah. Let me show you --

MR. EGGAN: Can you show us MDEQ 010814?

Q I guess what I'm getting at is, when we discussed this, you indicated that the company's cross-sections and borehole logs beneath the TWIS show something about this issue. Can you talk to us in that context using this exhibit?

A About what issue? I'm sorry.

Q Well, I think what we're talking about is the low-permeability units in zones B and C?

A Right. I think the point is that, without data out in areas that are presumed to be where groundwater would flow -- I'm not understanding this concept of these low-permeability units that appear above the water table are important. And they just don't have data in the areas that would allow them to assess that thickness of the -- of these low-permeability layers where water could perch on. And "perching" means that water would mound up above a low-permeability unit above the water table. That's what I mean by "perching."

Q Okay. Now, what is your thought on the geologic logs that were provided by the company?

A I noticed several inconsistencies in those logs that again

seem to be somewhat biased towards not acknowledging the existence and importance, I think, in terms of this mounding related to these low-permeability units.
Q Okay. Let me show you one of the logs.
MR. EGGAN: Let's go to MDEQ 010919.
Q Okay. Is this one of the logs that we're talking about?
A Yes.
Q All right.
MR. EGGAN: This is a log from Appendix B to the groundwater discharge permit. It's MDEQ Exhibit 143.
Q Doctor, what does this show you?
A Could we zoom into this area here (indicating)?
MR. REICHEL: Excuse me. Counsel, what figure or page is that?
MR. EGGAN: It is a log from Appendix B to the permit, and it is -- hang on. Let me see if I can get that from the -- it's page 2 of 5 from a boring/well construction report from the North Jackson Company. It's from MDEQ Exhibit 143. It's page 2 of 5.
MR. LEWIS: Is it in the tabbed notebook you provided?
MR. EGGAN: It is. It's Tab number 13.
JUDGE PATTERSON: I have two page 2 of 5's, which appear to be different.
MR. EGGAN: Yes, your Honor. There -- at Tab

number 13, there are a number of documents, and we're going to use -- probably just use the first one in at that tab.

JUDGE PATTERSON: But what I have as the first page doesn't correspond to what's up there.

MR. EGGAN: At Tab 13?

JUDGE PATTERSON: Right.

MR. EGGAN: Okay.

JUDGE PATTERSON: That's my problem.

MR. EGGAN: All right. Go back to the page so I can see that.

JUDGE PATTERSON: The second page does. I have two page 2 of 5.

THE WITNESS: Should be on page --

JUDGE PATTERSON: The first one is not what's up there. It's the second page.

THE WITNESS: Page 2 of 5, I think.

MR. EGGAN: Okay. My mistake, then. Let's go to the --

JUDGE PATTERSON: I just want to make sure we're all on the same page, so to speak.

MR. EGGAN: No. I -- that's -- we need that, Judge, yeah. That should be it, your Honor.

JUDGE PATTERSON: That is it.

THE WITNESS: Right here (indicating), please.

Q Okay. Doctor, what is this telling us?

A Well, the geologic log and text says "silty sand," and yet this classification indicates sort of an inconsistency. You would only label a silty sand "SM." This is a soil classification system. And the "SP" refers to a more permeable sand. So I find it a little misleading to put "silty sand" in the text; no indication that it's anything but a silty sand, which is a reasonably low permeability. And this permeability for this sand -- for a standard silty sand several orders of magnitude lower, can be then just a standard sand that doesn't have the silt in it. So this sort of inconsistency I've seen in several logs.
Q So there are again instances that you have seen in their logs that have been, from your perspective, misleading?
A Right; yes.
Q And this again relates to their characterization of flow direction?
A That's right. The point is, this particular log, this occurrence right here (indicating) is well above the water table. And so this sort of suggests the existence of low-permeability units that would promote this shallow mounding -- mounding or perching, I guess, above -- on units above the water table.
Q What impact does this have on your thoughts of their study -- their hydrologic study of this site?
A Well, it makes me question whether they accounted for this.

And I -- in terms of any kind of predicted groundwater flow direction. And I -- having reviewed their models, I don't see that they include this. The models they used don't simulate the flow in this vadose zone, and yet this seems like it'd be a very significant -- have a very significant impact in terms of how much mounding below the TWIS and what direction the flows could be and velocities that they could be.

Q There are other pages of the well construction report, the well logs. Did you see a pattern of this sort of reporting in the materials that you reviewed?

A Yes.

Q What impact would this have had on mounding?

A Again where you're implying that it's more permeable in the vadose zone, water would go straight down probably without impediment to the groundwater table. If, in fact, you have a low permeability unit as described here by silty sand well above the water table, I would expect groundwater to mound up above that layer.

Q So there may be shallow mounding?

A That's right, well above the water table that is shown on the cross-sections through the area for the current system.

Q What does this tell you -- this kind of work tell you about their characterization in this report?

A I'm thinking it's pretty biased and not -- it's inaccurate.

Q Did they identify all of the aquifers in the pathway from the TWIS discharge to the venting area?
A No.
Q Did they consider -- did they make any estimate of the thickness of aquifers in that pathway?
A They didn't define the thickness or really, in my opinion, identify the -- clearly the aquifers that exist in -- in potential pathways from the TWIS.
Q What difference does that make?
A Well, it makes a lot of difference in terms of how they predict the three-dimensional flow paths, the velocities, the venting locations of groundwater, the extent of mounding.
Q Do you think they considered the effect of dikes on the possible flow from the TWIS to the venting locations?
A No.
Q Why do you say that?
A It doesn't appear to be included in their modeling.
Q At all? Not at all?
A That's right.
Q Why would that have been important? Why would the effect of dikes have been important?
A Well, along the intrusive that is at the orebody and East Eagle Rock, the bedrock from their own bedrock surface maps appears elevated with respect to the surrounding

metasedimentary rock. And my thought is that, if other dikes occur and they're parallel to this intrusive, that it may very well be that other dikes are elevated as well. That would, in turn, control probably the thickness of the unconsolidated materials. And dikes may prevent flow going from the TWIS to the north and may actually end up orienting it more towards the east. But this doesn't appear to have been considered as an alternative hypothesis.
Q Okay. Can you draw for us when you mean on this issue on -- using one of the little flip-chart pages?
A I probably have an exhibit on this. I'm not sure. Maybe it comes up later.
Q Is this (indicating) what we're talking about, Doctor?
A That's right.
Q Okay. Good.
A Probably easier, but I can do both here. The point is that the yellow areas on this exhibit here, the left one is the orebody and the right one is the East Eagle Rock.
Q Doctor, I need to stop here, just to slow down a little bit. Okay. Where does this come from?
MR. REICHEL: Excuse me, Counsel. Could you identify for the record what --
MR. EGGAN: We're going there right now.
Q Where does this graphic that is on the screen come from?
A Right.

Q Is this from the KEMC Exhibit 596?

A The underlying color graphic is the magnetic survey results that, I think, Exhibit 5- --

Q 596 from the company's exhibits.

A 596. Right. All I did was bring this into a geographical information system. It's a mapping program. And I georeferenced this to existing site features. So it's basically bringing this in and just -- all I wanted to do was line it up with other information at the site. I was interested in looking at where the faults are and where mapped dikes have been placed. Yesterday when we presented some figures, those were shown. These pink lines that are laying at east-west are mapped dikes from the Kennecott reports that I reviewed. And the TWIS is located roughly around this location right here (indicating). I can probably point to it easier here, with these four dots. And the red dots in the background apparently are a number of boreholes that exist throughout the area, which I haven't seen in any of the reports. I didn't have the opportunity to review those.

Q Okay.

A But the TWIS is located here (indicating). And my thought is that, as you progress to the northeast, when we made a site visit and saw the first seep over here, we drove up over the hill and around, that there's a pretty noticeable increase in the topography. And it's shown on a number of the cross-sections and reports that I've reviewed as you go down towards the TWIS. So in other words, from the TWIS going north, you see an increase in the topography and before it goes down and steeply drops off into the drainage to the north. I think it's equally plausible that, given the number of dikes that run east-west through here, that an underlying could be -- could exist that's oriented in the same directions parallel to existing dikes. This may cause the topography to be elevated in that area.

And if that's true, the presumed northeast flow -- and again remember no data exists in this area to prove or disprove that. But if a dike does exist there and it's elevated with respect to the surrounding metasedimentary rock, it's very possible that this could cause water to flow to the east-southeast effectively as a barrier. And that's important because this is a significant change to the underlying conceptual -- my opinion presumed conceptual model for the pathway that groundwater would be flowing from that TWIS.

Q Does the company's application materials, the materials you have reviewed, take that as a possibility?

A They don't. And this is where the ASTM standards on characterization and conceptualization clearly state pretty standard in this industry to consider multiple working hypotheses where you have a good level of uncertainty about information. And this is clearly an area where no data exists. I showed you the bedrock surface that was produced before, no borehole data in this whole area, and yet that surface is now estimated or guessed by modelers and used in the model. And that has a pronounced effect in terms of estimating where the groundwater goes from the TWIS, the velocity, the amount of mounding, et cetera. But this should have been considered, I think.

In addition, I see a point out to the east, this well QAO009 of the TWIS. And the thickness of the unconsolidated material rapidly increases to the east-southeast from the TWIS. This wasn't really considered. But that thickness increased and the bedrock sloping down sharply to the east-southeast as well in my mind also kind of further supports an argument that groundwater from this TWIS could very much be heading to the east-southeast.

Q Did you see additional data in the application materials that they provided that would suggest that the water is not flowing to the northeast as they suggest but in a different direction?

A I did not see any information -- I'm sorry. Could you rephrase that?

Q Yeah. Did you see any data that they provided -- okay --

that might suggest that the water is not, in fact, going to the northeast?

A No.

Q Okay. I want to show you Figure 2 to Appendix B1 to the EIA, which is MDEQ Exhibit 32. What does this exhibit tell you?

A Well, my understanding is that the development of the unconsolidated material, you know, in geologic time in its development, was draining -- flows were draining to the southeast into this Mulligan Plains area as a big deposit. But the fact that the development and the increasing thickness of sediments, outwash sands, et cetera, to the southeast suggests that water may preferentially flow that direction as well. It's just an added support for the previous conceptualization that I offered.

Q Okay. And your previous conceptualization showed what? You said --

A That the flow could be to the east-southeast rather than to the presumed northeast direction.

Q Okay. Do you think the company has sufficient data to really conclude that the water is going to go to the northeast?

A No.

Q In your opinion, Doctor -- in your expert opinion, did the company correctly estimate the groundwater flow directions

from the TWIS?
A No.
Q Why do you say that?
A They had insufficient data. They didn't characterize the system well enough to determine -- you know, to support their presumed groundwater flow directions. I don't think they hydraulically tested an adequate area to confirm the details of the aquifers. I don't think they characterized or identified whether one aquifer or two aquifers actually exist beyond the TWIS in any direction really that's been inferred.
MR. EGGAN: Your Honor, I think this would be a good time for a break, if you please.
JUDGE PATTERSON: Fine with me.
MR. EGGAN: Okay.
(Off the record)
JUDGE PATTERSON: Mr. Eggan, are you ready go to?
MR. EGGAN: I am, your Honor.
JUDGE PATTERSON: Okay.
Q Keeping with our theme now of whether they collected and correctly interpreted the data, collection and interpretation of data, let's talk for a minute about their contours. Okay?
A Okay.
Q And I want to show you an exhibit that I think is

particularly important in the context of these contours.

MR. EGGAN: Can I have MDEQ 002353? Your Honor, this is Figure 23 from the groundwater permit application, Appendix D1 -- I'm sorry. It's to the EIA. It's MDEQ -- a part of MDEQ Exhibit 32, Tab 7 for those of you that are keeping track.

Do you want the -- Mr. Lewis, would it help you to have the Bates number?

MR. LEWIS: Not until you want to offer something.

MR. EGGAN: Well, I'll offer it in a minute.

Q Doctor, does this tell you -- does this particular figure show you anything about the contours that were developed by the company in their application?

A Yes. I think this is a fundamental piece of information that you use to develop a sound conceptual understanding of flow through the system. When I looked at these contours and the flow directions as --

Q Just to make sure that everybody understands, what are we talking about when we talk about contours on a map like this?

A Right. The different blue lines represent constant elevations like in a ground surface topography. And --

Q Are these contours geographic contours or are they hydraulic contours? Are we talking about water or land here?

A The blue lines are water, groundwater elevation. And they are at constant elevations. And where they're more dense or closely spaced together, you have a steeper slope on the water surface. In any case, what is fundamental about this to understand is that where you have noted streams and then at the heads of the streams you have what has been referred to as seeps -- they are probably more likely springs because they flow year around, but either way what struck me initially about these was that the elevations of these contours as they cross over these notable topographic depressions is that they don't seem to consider the fact that groundwater is at the surface here.

And so when I checked independently in this geographical information system, the surface topography compared to these groundwater elevations, I see errors in these contour -- in these groundwater contours that indicate that groundwater is on the order of 10 to 30 feet above ground surface in these drainage areas. And to me, that has a big impact in terms of where you're trying to assess where groundwater is going to vent and probably also had some influence on placement of wells that they have out in these locations.

Q Well, Doctor, I think I've made it abundantly clear to everyone. I'm no expert in hydrology. But what we're saying is that we have contours here on their documents that they submitted to the MDEQ that is showing groundwater or

water 30 feet above ground level?
A Yes.
Q Does that seem odd to you?
A Well, that's just wrong. And in reality, they have the surface topography. And it's just standard practice to, when you prepare a plot like this to, at a minimum, subtract the ground surface and make sure that your groundwater contours here aren't above ground surface. This has a lot to do with the flow arrows that they show here. And I think, if they had considered that, they would have seen much tighter arrows flowing directly towards the blue drainage lines there than is shown.
Q Is there any evidence that the Michigan Department of Environmental Quality caught this error and corrected them on it?
A From what I reviewed, I didn't see any comments towards this issue. And this is important because it's information that's sort of fundamental to developing a sound conceptual model which forms the basis for subsequent models where you're going to predict where flow goes and discharges or vents.
Q Let me show you a couple more exhibits not related to contours but perhaps on more to this point. Okay. Doctor, what is this showing us? This is -- this is a Quaternary Deposit Characterization, TWIS infiltration characteristics.

MR. EGGAN: Your Honor, this is Petitioner's Exhibit 29-S.

Q What does this show us, Doctor?

A Well, the focus was really on the two cross-sections that were placed on a long axis of the TWIS sand. In these cross-sections -- I don't know if it's possible to blow up one of them perhaps. The important point is that the blue line -- the blue area here and its contact with the ground is the groundwater table. And you can see that flowing from the northwestern part of the TWIS down to the southeast there's a pretty significant drop in the groundwater table. And that gradient is actually stronger than the gradient going to the northeast. To me -- when I saw this, I immediately thought, why don't the contours seem to be aligned more towards the east-southeast that are consistent with these contours -- I mean, this groundwater table as it's drawn here on this cross-section?

Q Okay.

MR. EGGAN: I'm going to go back to the exhibit on the contours and offer into evidence MDEQ Exhibit Number 32, which is Figure 23 from Appendix B1 to the EIA. It is Bates numbered MDEQ 002353.

MR. LEWIS: Tab, please?

MR. EGGAN: Tab 7.

MR. LEWIS: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: No objection, it will be entered.

(Respondent's Exhibit 32, Figure 23, Tab 7 received)

MR. EGGAN: All right. And also, your Honor, this document is Figure 25, which is one of the exhibits that we have. It's Petitioner's Exhibit Number 29. It is Figure 25 from a document created by the North Jackson Company, Conceptual Hydrogeologic Cross-Section F-F5. And we would offer this into evidence.

MR. LEWIS: As for clarification, is this the original condition of that figure from the mine permit application or has Mr. Prucha added something?

Q Have you added something to this, Mr. Prucha?

A I added the photo and this title called "gradient."

Q The photo.

MR. LEWIS: And then in your Part 31 exhibit list, Mr. Eggan, as you indicated earlier, this is under Exhibit Number 29-S, as I understand?

MR. EGGAN: This would be, yes, 29-S.

MR. LEWIS: And according to the list, there's actually two figures there. I'm not clear whether you're trying to offer the entire 29 -- 29-S or part of 29-S.

MR. EGGAN: The entire Exhibit 29-S.

MR. LEWIS: 29-S only, I mean.

MR. EGGAN: For right now, 29-S.

MR. LEWIS: The configure?

MR. EGGAN: That's correct.

MR. LEWIS: And would that be made -- is it labeled as such in your exhibits, 29-S?

MR. EGGAN: Yes.

MR. LEWIS: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: No objection, it will be entered.

(Petitioner's Exhibit 31-29-S received)

Q Doctor, you have indicated with this gray line here the flow line.

A Yes.

Q So what does this suggest to you?

A Well, on the plots that I've seen of groundwater flow direction, this seems inconsistent with the northeast trend.

Q Okay. Who had -- let's go slow here so we understand. The northeast trend was something that was predicted by the company in one of their flow models?

A No, based on their field data and incorporated into their models.

Q Very good. And this would suggest what? That those -- that that northeasterly direction may not be correct?

A That's right.

Q Okay. Let's look at -- Doctor, as you can see, I've shown you what has been marked as Petitioner's Exhibit 31-29-T -- excuse me. I'll say that again -- Petitioners in the Part 31 matter, that's our Exhibit 29-T. Okay. That's the document that I'm showing you now, which is the Quaternary Deposit Characterization TWIS infiltration area. It looks like it was part of a submission provided by Kennecott. It's Figure 27. Have you seen this document before?
A Yes.
Q And what does this show us?
A It shows in the red arrows, these were --
Q Can you get up and show us, Doctor, show us with your pointer?
A The groundwater contours that were developed based on the available data that they did have show -- are shown in light blue here. And the red arrows barring these two over the TWIS were included on the original figure and are showing estimated flow directions of the groundwater.
Q So the three long arrows on this exhibit are Kennecott's estimation of groundwater flow direction?
A That's right.
Q Okay. I simply placed the arrows over the TWIS area based on my assessing the previous cross-sections which were aligned with these arrows that showed a very strong gradient or drop in the groundwater elevation from the northwest down

to the southeast. And I would have expected contours in light blue and the flow areas that are shown on this diagram to be showing something that's consistent with those cross-sections. Instead I see something that's at least 90 degrees different.

Q All right. So the shorter two arrows that we have on this document are based on your examination of the data including the two cross-sections we just talked about?

A That's right.

Q And what conclusion do you reach based on those cross-sections and the data you looked at?

A The groundwater flow directions on this plot are incorrect.

Q Okay. They're showing northeast. What are the two arrows that you have added -- what direction do they show?

A Southeast.

Q Now, we talked about the contours and the groundwater between 10 and 30 feet above the ground. We talked about the errors that they've made on their other mapping. What does this tell you about the company's knowledge of the flow direction?

A It seems like it is not really well understood or known at this point.

Q Does their analysis -- their analysis of the flow and the direction of the flow have any implication as to the placement of monitoring wells by the company?

A Yes. I think that there's a presumption that groundwater flows to the northeast. They have no wells northeast of the TWIS. And their placement of wells down north of the Yellow Dog Plains downhill from that point seems like maybe they're not placed in the right locations or in adequate locations for assessing true flow direction.

Q Okay. Now, I want to talk about the company's modeling. We've gone through their data collection, their characterization of flow, their conceptualization of the flow. And I think we've identified some significant problems. But I'd like to discuss the company's modeling, the modeling that they did. What is the reason that the company modeled in the area of the TWIS?

A It was to predict where -- the mounding, the horizontal and vertical mounding beneath the TWIS and to determine three-dimensional flow paths of the discharge water, the velocities and the venting locations.

Q Okay. I want to show you something from the latest modeling that they did.

MR. EGGAN: Let's go to KEMC page number 186852. This is at Tab 31 for those of you that are looking.

Q Does this particular document tell you anything about flow direction?

A Yes. Is there a second page to this exhibit?

Q Yes, there is.

A I think the second page is --
Q 186853. Is that the second page you're looking for, Doctor?
A That's right.
Q Okay. Tell us what this tells us about flow direction. And this is from Kennecott Exhibit KEMC 591, and it's Figure 16, Tab 19. Tell us what that -- what this particular exhibit shows us about their modeling.
A I believe that this latest modeling compared to previous modeling, there is a little bit more of an eastward trend in the flow direction from the TWIS. So my understanding of the modeling results is that they seem somewhat variable in the directions that they're estimating where the discharge goes to.
Q But it sounds like, at least with the latest modeling, they're coming around to your perspective, that it's going a different direction than northeast?
A It appears to be more of an eastward direction.
Q Now, you indicate --
MR. EGGAN: Well, let me offer this, your Honor -- this exhibit. It's KEMC Exhibit 591. And I want to offer this particular Bates page 186853 into evidence.
MR. LEWIS: No objection.
MR. REICHEL: No objection.
JUDGE PATTERSON: No objection, it will be entered.

(Intervenor's Exhibit 591, Figure 16, Tab 19 received)
Q Now, you've indicated the company has done a number of different groundwater models?
A Yes.
Q Have they been consistent with one another? Have the groundwater models done by the company been consistent with each other?
A No.
Q Can you tell the hearing officer about the inconsistencies? And maybe this is a time to show this history of modeling slide that we've developed.
MR. EGGAN: Can you bring up 101075? This is at Tab 32, Counsel.
Q Dr. Prucha, is this something that you created?
A Yes.
Q And what is it intended to show?
A Well, that there have been a number of models produced for both the unconsolidated material and the bedrock flow system.
Q Okay. Just to make sure that we're on the same page here, how many models have they actually done?
A Well, from what I can tell, there's four different models for the unconsolidated material done by three different consultants and then three different bedrock models.
Q Well, that's quite a number of models. From your

perspective as a hydrologist, any sense for why they needed this number of models?

A It's unclear to me why, but it suggests that the results -- the system may be complex and they wanted different perspectives.

Q Are they consistent with one another? Do they track one another as they go?

A No. But they do rely on the same flawed characterization and conceptualization, limited data, and there's just different ways of producing a model off the same conceptualization, different model layers, different boundary conditions. But really they're relying on the same, in my opinion, flawed set of data and characterization. And to me, that's the most important part of developing the model.

Q Tell the hearing officer about the inconsistencies that you have seen in the various models that they have done.

A Well, I'm going to just focus on the unconsolidated model, because it really is that that relates to the Part 31 issues, if that's all right.

Q Okay. That's fine. Yeah.

A Although I do show some red arrows, and the importance of arrows going from the bedrock models into the unconsolidated flow models is that information in the unconsolidated model or the models depend on what was modeled at the bedrock.

And that's changed over time. And so it's been pretty difficult to actually see what's changed. But at the same time, this plot here was an attempt to try and clarify that. In 2005 -- let me just explain the chart, too, that the boxes in the center of the diagram label the years 2005, '06, '07 and '08. And the first model that I reviewed for the unconsolidated material appears to have been prepared in 2005 by Fletcher Driscoll. It was a MODFLOW model of the unconsolidated flow system. And can I draw a diagram here to represent that real quick?

Q You may, absolutely.

(Witness draws diagram)

A So this 2005 model that was produced, from my understanding, included what I'll just simply refer to unconsolidated, abbreviated "unc," and then I guess I'll just write this out. My understanding is that the model simulates flow using the USGS code MODFLOW, which is different than the FEFLOW code used to model flow in the bedrock system, but that the -- this initial model simulated flow in the unconsolidated material and also included flow in the upper bedrock. It did not include the lower bedrock material. But this initial model appears to be developed to simulate the current conditions. And this is claimed to have been calibrated to site water levels and groundwater discharge.

In 2006, apparently two different models were developed, one by Golder and then one by Fletcher Driscoll to look at the flow system. And the 2006 version of the Fletcher Driscoll model is similar to the 2005 but, in that case, they actually simulated the lower bedrock. So --

Q What significance does that have, the simulation in the lower bedrock?

A Well, for one, they're using a code MODFLOW again to now simulate the bedrock flow. And the problem I had with that is that they made -- had discussion when they selected FEFLOW to model the flow in discrete faults as to why MODFLOW was not as good of a code really doesn't handle discrete faults. That's why they selected the FEFLOW code. And now they're modeling the system that they had modeled with FEFLOW that had discrete faults in it. And they're in addition now doing a coupling that -- with the bedrock flow model that I -- is certainly not a standard approach and I believe has issues in terms of the mass balance or the flows that you get translated from the bedrock model from the dewatering to the actual unconsolidated material.

Either way they in 2006 made several modifications in addition to including the lower bedrock. They adjusted things like the recharge at the top of the model. They adjusted hydraulic conductivities inside the model. And in the lower bedrock, they also appear to have tried to translate the effect of the lower bedrock pumping on the model. The issue here, though, is that this, they claimed, was a calibrated model, the 2005 model. It was a steady-state model, which I believe has a number of issues in terms of demonstrating that it's really valid.

2006 they made all these changes. But then they apparently didn't recalibrate or I can't tell that they recalibrated from the report. And that seems to violate sort of the basic approach that's outlined in guidelines like the AS10 or DEQ groundwater modeling guidelines. You don't just make significant changes to a model and then jump right into predictions. This is like sending a car out with a brand new type of engine, different tires, a different types of transmission and you haven't test run it and you said, "Just go ahead and drive this. Trust me. It'll work." This seems like a fundamental issue to me in terms of the modeling.

The Golder 2006 model, my understanding, is just taking the unconsolidated flow zone. But that was done in a very simplistic way where it was assumed -- they made several very simplifying assumptions about the flow system. They didn't model the bedrock. They assumed it was, I believe, unpermeable. They had constant hydraulic properties for their unconsolidated materials. They had -- anyway, to me, it was a rectangular square. They didn't consider important water sinks and sources or, you know, effectively where groundwater is discharging into rivers like the Salmon Trout. Yes, their models don't include that. So it's overly simplified. And I was not clear on exactly why that was done other than to get maybe a preliminary assessment of what mounding might be.

And finally we have the GeoTrans model. And that's different from either of the Fletcher Driscoll models where they only consider the unconsolidated unit.

Q Doctor, just so that I'm clear, the GeoTrans model which was done in 2008 is different than the Golder model in 2006?

A Yes.

Q Is it different than the Fletcher Driscoll model in 2006?

A Yes.

Q Is it different than the Fletcher Driscoll model in 2005?

A Yes.

Q Is it consistent with the other three?

A No.

Q Is the 2008 consistent with the other three?

A No.

Q Were the other three consistent with each other?

A No.

Q Okay. What is unusual about all of this?

A Well, to me, it's dramatically different underlying assumptions about what the aquifer units are, which ones should they include. Should they include the upper bedrock?

Should they include the -- which of the unconsolidated aquifers should they include? The Fletcher Driscoll certainly had more detail in it for the unconsolidated. The Golder and GeoTrans tend to have fewer layers. So the GeoTrans now just has two layers. And to me, there's been a change every year -- every attempt at a new model.

Q Well, does this evidence that the company has a concept -- a good concept of the area -- the groundwater in this area?

A My understanding is this probably reflects, to a large extent, the poor data that they have available, their poor characterization and this conceptualization that just doesn't seem to be well thought out. And they're really considering one conceptualization where they're presuming flow at least in the area of the TWIS to the northeast. And yet I think we show a number of diagrams here that suggest that there are probably significant alternatives that they could considered. But I sense that -- at least in my experience having reviewed a lot of models in the past is that it doesn't seem like they're tying this to a well-thought-out conceptualization and that this is maybe one reason why they have multiple models that have such dramatically boundary conditions, dramatically different structures, layers.

Q Awhile ago when you were testifying, you talked about garbage in, garbage out. How does that concept relate to

what we've seen in the modeling that they've done?
A Well, I believe that, if you don't have a good conceptualization, a foundation for developing the model and you develop the model anyway, that anything that you put into the model and expect to get out as a prediction is only going to be as good as what you've put in. And in this case, I don't think they've put in or considered adequate characterization and conceptualization for this system.
Q Did they get it right? Did they get it right in 2005 when they did the model?
A No.
Q Did they get it right in the first -- in the Fletcher Driscoll modeling in 2006?
A No.
Q Did they get it right in the Golder modeling in 2006?
A No.
Q Have they gotten it right with the latest GeoTrans materials?
A No.
Q Is it important to get it right with respect to groundwater flow?
A Yes.
Q Why? Why is it important?
A Well, if you're going to try and predict with any sense of accuracy the degree of mounding, where the mounded water

flows to, at what rate, when it would get there and then the actual surface water venting locations, it's imperative that you have a good underlying conceptualization and a model that can demonstrate that.

Q Okay. I want to talk briefly about each of the models, and just ask you a few basic questions about them. Okay? The 2005 groundwater model that was done by Fletcher Driscoll, is there an issue with uniqueness?

A Yes.

Q What is that issue?

A Well, again it's a steady-state calibrated model that includes the upper bedrock. And I would see the upper bedrock as having, you know, discrete faults that they're clearly considering in the lower bedrock that wasn't included here. Either way, this model as a steady-state model really is subject to large uncertainties, and, you know, due to this non-uniqueness where, for example, the recharge input is a very important parameter into this model. And I didn't see really any good basis for the numerous zones that they have recharge applied over this model.

Q What is this concept of uniqueness? Because I think that's an important concept that the Judge needs to understand.

A Right.

Q What is uniqueness, and why is it important?

A Well, I had an example yesterday like a bathtub. And if you are -- the only information you have about a system is the level in the bathtub and you don't know how much water you're pouring into a bathtub or the size of the drain pipe coming out the bottom, you could put a huge amount of water into the tub, a large flow rate, and adjust this drain and still match your water level in the tub using different sets of combinations of the recharge and discharge out that pipe. And what it doesn't -- this is the kind of model that's been prepared here. And I don't believe it's adequately unique. And I think if they had done transient modeling, done verification on that like the ASTM standards suggest and DEQ standards suggest or guidelines, that these issues would have been less. It would have been less non-unique.

Q Okay. I want to talk about the 2006 modeling done by Fletcher Driscoll. Did they recalibrate that model?

A They did not recalibrate that model from what I can tell reviewing.

Q Tell us why that's an important issue.

A Well, again you don't want to apply a model that hasn't been calibrated because you can't verify that it actually reproduces observed system behavior.

Q You talked about their application of MODFLOW modeling in that Fletcher Driscoll report in 2006 --

A Right.

Q -- and your perspective that FEFLOW was the better tool to use. Talk to the hearing officer about why that's important.
A I think it would have been better from the perspective that, when they did the bedrock model down here having --
Q Down where?
A Oh, I'm sorry. In the bedrock zone here where I have the Golder models, the FEFLOW models. If just one model had been produced, then the model would have done the calculating of flows and impact from the mine dewatering area in the lower bedrock as defined by the company. This interaction would have been calculated by the model, which is important because one of the biggest issues I have with the modeling that was done here is that they were separated out. And this flow between what was estimated coming out of the bedrock isn't translated into this upper overlying unconsolidated material very accurately. And I have serious questions about how that's done.
Q Can this model -- this 2006 Fletcher Driscoll model be used for predicted simulations?
A I don't believe so. One important point as it relates to Part 31 is that MODFLOW doesn't have the capability to simulate the mounding in the vadose zone. It's just simply not in the code. It's the wrong code to use when you can show that there are shallow low permeability units above the

water table and infiltration that comes down from the ground surface to this infiltration gallery reaches that well above the groundwater table. There's no way to actually simulate that mounding in MODFLOW effectively.

Q Did the 2006 Fletcher Driscoll model -- were they able to verify that it reproduces current system behavior?

A No. They didn't recalibrate in what I could see and they made several changes to the model input.

Q Was that model consistent with ASTM guidelines and the requirements?

A No.

Q Was it consistent with the MDEQ guidelines for groundwater modeling?

A Not that I could see.

Q Was the Fletcher Driscoll 2005 modeling consistent with MDEQ guidelines -- groundwater guidelines?

A Right. No, in the sense that they require, as do any guidelines, that you have a sound conceptualization before jumping in and developing any kind of model.

Q Would that be the same for the Golder 2006?

A Yes.

Q Are the groundwater modeling efforts that were made in 2006 by the company, the Fletcher Driscoll and the Golder models -- are they in your view defensible?

A No; neither was calibrated. And again, they're relying on, in my understanding, inadequate conceptualizations.

Q I just want to -- I just want to talk briefly about this 2006 Fletcher Driscoll flow model. Can you show us graphically what they did?

A Yeah, I think I covered that right here in this particular diagram here where they included the lower bedrock and really they had -- the FEFLOW model had been simulating this but they included this in the Fletcher Driscoll 2006 model so that they could somehow translate the flow conditions that they got from the FEFLOW model into the upper bedrock and unconsolidated material. But my understanding is that they didn't translate the actual hydraulic properties of the medium; they ended up having to adjust those to try and match the flux coming out of these -- or the flow conditions coming out of these areas around the mine dewatering in the lower bedrock.

Q What are your -- what are your conclusions about Kennecott's predicted modeling of where this groundwater is going to get up -- is going to end up? And I'm talking about the 2005 modeling, the 2006 modeling by Fletcher Driscoll, and then the 2006 modeling by Golder.

A I think that they have issues in terms of the -- where they're predicting groundwater flow. They have issues in terms of the amount of mounding, where it occurs. They don't consider realistic inflow rates.

Q Do you think Kennecott -- do you think the company characterized the hydrology in the area of the flow direction and the hydraulic properties from the TWIS to the eventual seep areas?
A No.
Q Is there a concern about given the mounding that there's going to be a different flow path?
A Yes.
Q Can you explain that to Judge Patterson, please?
MR. LEWIS: Asked and answered, your Honor.
Q Talk about the radial flow path and the whether or not this -- some of this water could end up near the Yellow Dog River.
A I think that this is the TWIS location and considering much higher inflow rates -- and if this wasn't redesigned in terms of the size, that what I would expect is more mounding in a radial direction and flow directions from this TWIS in all directions rather than just a presumed assumption that it all flows to the northeast where they installed some wells up to the north, northeast.
Q Does radial flow, this flow that you're talking about with respect to this mounding, does that call into question the possibility that this -- some of this water could end up in the Yellow Dog?
A Well, the Salmon Trout River is really in this (indicating)

direction and the Yellow Dog is really to the southwest, to the southeast and -- yes, I think that some of that water could eventually drain into the Yellow Dog River. Depending on the infiltration rates, this is pretty close to a terrace elevation where the elevation drops off quickly and then a wetland is just to the south about 800, 900 meters.
Q I also want to talk to you about the GeoTrans modeling, the 2008 modeling. And this is -- what? -- the fourth in a series of models that the company has tried to do. Isn't this model a steady state? If that's the case, isn't that a good thing?
A No. I mean, the steady state is not as credible, in my opinion, in a large way to having done a transient model.
Q Why would they have utilized a steady state modeling for this particular site when a transient state is better?
A Well, it's simpler.
Q What other criticisms do you have the latest modeling effort, the 2008 effort?
A I think the largest one is just that it's still based on what I see as flawed characterization, data collection, conceptualization.
Q Does this model show a three-D flow path?
A It doesn't show a three-dimensional flow path like the -- it doesn't even show a two-dimensional flow path like the -- was done in the Fletcher Driscoll and Golder model reports.

It showed --
Q And what difference does that make?
A Well, if I were assessing the report and I haven't done my own modeling, I'd have to rely on whatever is the conclusion of the flow direction. I can't even determine the flow direction because the simulated head or the groundwater level with the effects the mounding weren't even included as a figure. They showed the change in head, which shows the extent of the mounding aerially, but I can't determine just based on any of the plots included in the report what flow direction occurs, how much flow is oriented back to the southwest or the southeast. It seems like that would have been a primary objective to show that as far as the hydrogeologic reporting requirements of Part 31.
Q Did they use FEFLOW for this particular modeling effort?
A They used an updated inflow rate from FEFLOW model -- a FEFLOW model that had been updated in late December. And actually, reduced the amount of mine inflow to 60 GPM instead of 75. But the GeoTrans report acknowledges that the -- they do not do an upper bound inflow rate to assess the mounding affect that the -- you know, the flow direction from the TWIS. So I'm uncertain what the benefit of that is. I think it would have been more beneficial to show, like the Fletcher Driscoll models, Golder model that, you know, you were simulating an upper bound estimate of

infiltration of the TWIS.
Q Let me show you Exhibit 591 from that GeoTrans groundwater modeling effort. It's KEMC 186849.
MR. EGGAN: This is -- your Honor, this is one of Kennecott's exhibits. It's this GeoTrans report and it is Figure 12 from that exhibit. It is KEMC, Bates number 186849.
Q What does this show you and what, if anything, does this tell you about their modeling effort?
A Well, it's a different model boundary that is being considered now compared to previous models. But this particular plot is showing a hydraulic conductivity zone and I see data points here that -- I'm not sure in the report, but it -- maybe these are used to constrain or estimate these hydraulic conductivity zones. In this particular location they show -- and I'm not sure that the color shows up or something, but a zone around the orebody that extends and seems to be following the Salmon Trout River where it's claimed that it's a low permeability in this upper A-B zone. And there's a lot of data over on the right side, but no data along the Salmon Trout to suggest that it actually exists over here. And without having the model I wouldn't be able to explore the implications, but it seems to me that it would be sort of presumptive. And the extent of that zone; there are no wells south or boreholes south and west

of the entire Salmon Trout creek; and yet, this is a critical area. The mine dewatering, you know, the impacts from the TWIS could easily be felt back on that area.

Q So does this reflect a quality effort on their part?

A No.

Q What does it reflect?

A Well, I think they're not considering necessarily the uncertainty that is associated with this conductivity zone. I can't tell whether there are hydraulic conductivities available for the lower aquifer. I believe most of these wells to the south off the Yellow Dog are in very shallow wells and wouldn't reflect the D aquifer. So over a large portion of the model they don't know what the hydraulic property is; it hasn't been tested.

Q So this goes back to our collection of data issue?

A Right. And at first glance you might think this isn't really important in terms of how it impacts this, but they half modeled the large because the impacts from the TWIS and the mine dewatering you don't want the boundary conditions to influence this area. So, you know, flow over here will impact this as opposed to trying to make an assumption that, you know, a closer model -- boundaries. They're modeling a large area. I mean, out to the east I don't see any data points out here except for one. So this is virtually unexplored territory.

Q So if the water is flowing to the east, are they going to be able to tell?
A No. It's entirely dependent on the assumptions that they make. And the bedrock surface, the aquifer thickness; these can vary significantly from west to east or north to south.
MR. EGGAN: Again, this is from the KEMC exhibit 591, your Honor, and it is from this latest GeoTrans modeling effort apparently done this spring.
Q What does this tell us about their --
MR. REICHEL: Excuse me, Counsel. What tab is that?
MR. EGGAN: That would be Tab 44.
MR. REICHEL: Thank you.
Q What does this tell us about their modeling effort?
A Well, again this is an important parameter in the model, the thickness of the second layer, the D and E Zone. And I don't see any of the constraints or the locations of boreholes used to define this pretty complicated thickness map.
Q What does that tell you?
A Well, that you're adding a considerable amount of uncertainty into the model. And this just wasn't considered in the simulation; it was one out of probably thousands of possible combinations of what the thickness could be. And my question is, when you put this in or another estimate,

which could be dramatically different than this but still honor the locations where you have borehole data, the results could be dramatically different.

Q And this is the GeoTrans report that was submitted by KEMC as part of Exhibit 591?

A Yes.

Q And it looks like it's Figure 11?

A Yes.

Q Okay. Let me show you again from Exhibit 591 --

MR. EGGAN: This will be Tab 46, Counsel. It's KEMC, Bates number 186846.

Q And this is the GeoTrans recent -- most recent modeling effort, the latest in a series of four. This is Figure 9, "Thickness of Layer 1, A and B Zone." Can you tell us what this tells you about their modeling effort?

A It's the same issue as the prior plot. Again, fairly complex estimate for the spatial distribution of this thickness for the A Zone, and I don't see the constraints or the boreholes placed here, which is standard to put on maps like this so that one gets a sense of how accurate -- or where you know actual information about this thickness.

Q Did the GeoTrans report simulate the 400 gallon-per-minute infiltration rate used to design the TWIS?

A Like the Fletcher Driscoll model? No.

Q Well, tell us the significance of that.

A Well, they're not evaluating the -- their upper bound limit. It seems if the TWIS has been designed towards that, that this is something we'd want to evaluate.
Q Do you have any other comments or criticisms regarding the latest GeoTrans report?
A Again, I think it simply adopts the conceptualization, the data, the conceptualization that was used in prior modeling efforts; it's just a different model prepared with some different assumptions. So I think it's subject to a lot of uncertainty and --
Q Garbage in; garbage out?
A Yes.
Q Is the latest GeoTrans -- does this latest GeoTrans investigation and the modeling -- do they get it right this time?
A No.
Q Is this latest GeoTrans modeling consistent with the Michigan Department of Environmental Quality groundwater modeling guidelines?
MR. REICHEL: Objection; asked and answered at least three times by my count.
JUDGE PATTERSON: I think it has been.
Q Do they get it right?
A Could you rephrase the question?
Q Yeah, let me -- I'll ask -- re-ask the question.

A Okay.

Q Is the latest GeoTrans model consistent with the MDEQ groundwater modeling guidelines?

A No.

Q Did they get it right this time?

A No.

Q I want to talk briefly about the groundwater well network -- excuse me -- the groundwater monitoring well network. What is your understanding of the groundwater modeling -- excuse me -- the groundwater monitoring network? Do you have opinions with respect to the groundwater monitoring network?

A Yes.

Q And what are your opinions?

A Well, there are wells that are placed to monitor discharge from the TWIS as it enters the groundwater flow system and there are wells that are proposed to test the infiltration system associated with the TWIS is working.

Q Do they accomplish this?

A I believe they'll have problems with these locations in the way they presented it.

Q Let me show you what is part of MDEQ Exhibit 143; it is Appendix B to the groundwater discharge permit application, MDEQ 010823.

MR. EGGAN: This is Tab 11, Counsel.

Q What does this tell us about the groundwater monitoring network and the adequacy of that network?

A Well, I don't think it considers -- it shows that these low permeability units weren't really considered in the placement and design of the proposed infiltration monitoring well and it will likely influence the placement of up-gradient versus down-gradient wells to monitor the discharge from the TWIS.

Q Are you saying that the monitoring wells are just not placed in the right place?

A Well, with respect to the gradient, yes.

Q Well, tell the judge what you mean by that.

A Well, the -- there's the current system gradient where the flows look like they're to the east, the southeast possibly and wells are placed around the perimeter or proposed wells are placed around the perimeter, the side and the north, and they're referenced as down gradient. Don't have a problem with those really; it's the wells that they -- and I think I have an exhibit to this that demonstrates that, but the wells up-gradient, if the mounding is significant and you get a flow reversal and the flow gradient is oriented towards the southwest, then the up gradient wells as defined in this upcoming exhibit would be in fact down gradient.

Q Okay.

MR. EGGAN: It's about 10 to 12:00, your Honor. I probably have another half hour. Would this be a good time to break?

JUDGE PATTERSON: Yeah, I think if you have that much.

MR. EGGAN: I do.

JUDGE PATTERSON: Okay. Back at 1:00 o'clock.

(Off the record)

Q Dr. Prucha, when we left off this morning you and I were talking a little bit about groundwater monitoring and the well network that has been established by the company to monitor. Have you reached a conclusion about whether the groundwater monitoring network established by the company is going to adequately monitor groundwater in the vicinity of this mine?

A Yes.

Q What is your conclusion?

A Well, can I draw a simple diagram?

Q Yes, please.

A I can just use this (indicating) diagram here that I drew showing the TWIS in the center. And if you are infiltrating a lot of water through this TWIS and the mound ends up developing and forcing groundwater to flow back to the southwest and your presumed upgradient wells are located within this mounding zone, they'll become downgradient wells. So I noticed in the permit application report that there were different water sampling criteria for those

upgradient versus downgradient or sidegradient wells. And I think these were placed assuming that the mound would cause water to flow to the northeast but that these would remain somehow as background or upgradient wells.
Q So it sounds to me as if the groundwater monitoring system is set up with the assumption that the water is going to flow in one direction.
A That's right.
Q But the groundwater based on your calculations may actually be going in a different direction?
A Yes.
Q And do they have adequate wells in the locations where groundwater is going to flow to actually monitor that groundwater?
A In terms of the gradient, no.
Q Okay. In terms of what? In terms of the gradient. What about other issues?
A Well, I think in terms of the upgradient wells that we just described, I think these are going to be downgradient wells.
Q Okay. And for the judge's benefit, what is the import of that?
A Well, the importance is that their reporting limits are different for upgradient versus downgradient wells.
Q Okay. Switching gears to a subject that we might have discussed this morning, and that's the non-contact water

infiltration basin. Should there have been a consideration of modeling in the area of the non-contact water infiltration basins?

A Yes.

Q Why?

A I believe that water is focusing a lot of localized runoff to infiltration basins that allow the water to then infiltrate into the groundwater system, and on my review of the reports, I don't see that that was considered in the modeling. And I believe that this could significantly impact any mounded groundwater propagation away from this TWIS infiltration gallery.

Q In what way? How could it affect that?

A Well, it could mound up under each one of these infiltration basins and force water that is mounding away from the TWIS infiltration gallery to project into different directions. And I just don't think this was considered in the modeling or analysis.

Q Was this well thought out? Was this an issue that impacts your overall conclusion of the modeling that was done here?

A Again I think it lacked -- their model lacked in estimation of the mounding effects and discharge of the water and its travel to venting locations. I think this was an oversight and should have been included in the models and predictions.

Q Are you aware of this company's plan when the mine closes?

A Yes.

Q All right. What is your understanding of what will happen to the mine as the mine itself closes? What are they going to do in terms of the hole in the ground?

A The dewatering will cease in the mine area, and my understanding is that water will also be injected through wells in the vicinity to increase the groundwater to recover in that area to natural conditions.

Q Okay. What you're saying is they're going to fill the mine up with water?

A Yes.

Q Do you have an opinion as to whether or not when this water is put into the well at the close -- or excuse me -- into the mine at the close of mining operations -- you've talked about faulting in this area. Do you have an opinion as to whether or not water will escape from the mine itself?

A Yes.

Q Is this -- I guess what I'm asking is, is this a Mason jar, or is it a colander?

MR. LEWIS: Objection; foundation, your Honor.

MR. EGGAN: Is the question whether this witness is qualified to testify about whether water will leave the mine through these faults?

MR. LEWIS: No, it goes to the foundation, not the qualification.

MR. EGGAN: Okay. I guess I'd like to know a little bit more about what the objection is then.

MR. LEWIS: I haven't heard that he's done any kind of analysis or what kind of data or other information would support any opinion he may offer on that subject.

Q What information do you have that might support an opinion on this issue?

A I think I've developed an understanding of the bedrock system as presented in the various reports, any unconsolidated material that overlies it, and developed an understanding of what happens to the water in the -- groundwater in the bedrock system as you dewater, by running their models with modifications, so --

Q And I think I also heard you testify about the faulting that may occur in these systems and the impact that it's going to have on groundwater flow.

A The faulting and the potential for permeable zones along dikes.

MR. EGGAN: Your Honor, I think the witness is certainly able to answer this question.

JUDGE PATTERSON: I'll allow him to answer.

MR. EGGAN: All right. Very good.

Q Is this mine going to be a Mason jar at the end, or is it going to be something more permeable?

A Could I draw a small diagram?

Q Please do.

A Again, if the mining orebody area is here (indicating) tunneling off here, the Salmon Trout River is here, there were a number of faults that were drawn through the area that were trending northwest. There were certainly dikes that were propagating -- or trending through the orebody that likely line up with the river because they may be permeable and connected. When the system comes back to a natural state, unfortunately we don't have enough data in terms of the bedrock aquifer saying what direction groundwater actually flows 'cause that wasn't included in the analysis, which I think it probably should have been, but I think the dominant features that will control groundwater movement through the area once the mine's closed will be these water conductive features along the dikes, the faults. And I believe that it's very possible that water can leak out of this system into the river if you have the dikes that -- their own cross section showed were right under the river, faults through the area. This system -- these lineaments are extensive. They're kilometers, miles long, so --

Q Well, you talked about those lineaments yesterday, those --

A That's right.

Q -- am I correct to call them fault lines and --

A Yes; uh-huh.

Q And you talked about those yesterday. They're miles long.
A That's right.
Q Okay. And do those -- do those lineaments have the potential for transmitting groundwater that is leaving the mine to other places?
A Yes.
Q Are there aquifers -- obviously we've talked about this, but are there aquifers in the vicinity of the mine itself?
A Yes.
Q Okay. Are the aquifers -- and I'm going to ask you to assume that water from the mine after closure will be flowing into those aquifers. Okay? I want you to consider those aquifers. Today before mining operations begin are those aquifers usable by, say, a family of four? Could you -- is there sufficient water quantity there to support a family that lived in the area?
A Yes.
Q What about aquatic life? Is it sufficient to support aquatic life in the vicinity?
A I can't tell.
Q You can't tell. Okay. We know that there are industrial uses that are already planned and that that aquifer is sufficient to support an industrial plant 'cause that's what this is, isn't it?
A Yes.

Q So do you have an opinion as to whether or not the aquifers that are in the vicinity of the mine into which this water post-closure will flow, are they useable?

MR. LEWIS: Objection; form of the question. This witness has not offered an opinion that water will flow anywhere. He's offered opinions -- hypothetical opinions is what I've heard, could flow.

Q If they flow, will they be flowing into a useable aquifer?

A In terms of the quantity, yes.

Q "Yes." Okay. Doctor, I want to conclude by covering your primary conclusions. Okay? And this is this list, 1 through 4, of those conclusions. Tell the court what the first of your main conclusions are.

A Well, the first conclusion is that the maximum inflow to the wastewater treatment system will be dramatically higher than was predicted by the company and MDEQ.

Q Okay. And your second conclusion relates to the hydrogeologic study and the modeling done by Kennecott to support their perspective on groundwater flow and direction.

A Yes.

Q What is your conclusion on that?

A The company's hydrogeologic study and modeling are inadequate and inaccurate.

Q Okay. And your third conclusion as prepared here is -- relates to the volume and the direction and the hydrologic

impact of the wastewater discharge. Can you tell the court what your conclusion is?
A The company's prediction of the volume, direction and hydrologic impact of the wastewater discharge are wrong.
Q And then the fourth with respect to post-closure issues, what is your conclusion regarding that?
A The leachate will escape from the mine after closure and contaminate surrounding groundwater and surface water.
Q Thank you. Did we miss any of your primary conclusions?
A No.
Q Very good.
MR. EGGAN: I have nothing further.
(Counsel reviews notes)
MR. EGGAN: Mr. Lewis, I do have -- I did have two more questions that I needed to ask. I had them on a separate pad so I didn't ask them. But, your Honor, if you can indulge me for a couple of more questions.
JUDGE PATTERSON: All right.
Q Just a question or two about drawdown. Okay? With your prediction of 3,000 gallons per minute, did you make a prediction of magnitude in the extent of drawdown that will occur in the bedrock aquifer?
A Yes. Under that scenario --
MR. LEWIS: Wait a minute. Objection; foundation.
Q Did you make -- did you make a prediction?

A Yes.
Q And is that prediction based on your analysis and review and calculation?
A Yes.
Q How did you -- how did you make that prediction?
A I made a simulation that was based on the company model, the FEFLOW model, and I made some adjustments that I think were more realistic to reflect what I was seeing in the geology and hydrogeology of the system and estimated on the order of 3,000 gpm as an upper limit. And I also calculated the aerial extent and magnitude of drawdown. And for that particular case, the --
Q Don't give your answer yet.

MR. EGGAN: Your Honor, I think we've established a foundation for his conclusion on this issue.

MR. LEWIS: All we've heard is a brief description of what he says he did. I think the court should have a fair understanding by now that the leap going from the mine water inflow number that Dr. Prucha talked about earlier today, he's -- going from that number to now a prediction as to what drawdown there may be in the aquifer above and surrounding the mine is not a simple transition. And I think there's been a lot of testimony and discussion by Dr. Prucha himself as to how complicated these analyses are. He spent some time talking about all the data that would be necessary to gather about the characterization that would have to be done and about the very intricacies of different kinds of models. And I assume all those things would go into transitioning from the one number to the other. And we have heard nothing about any analysis he's done in that regard.

MR. EGGAN: Well, I think he's indicated that he did do that analysis. He used the model -- or he used the numbers that Kennecott provided and used those numbers and, while he may have reached a different conclusion, the data was their data. So I think he -- I think he has established a foundation to --

JUDGE PATTERSON: I'll allow him to answer, for what it's worth.

Q All right. You've indicated you have reached a prediction of the magnitude and extent of drawdown in the bedrock aquifer?

A In the bedrock aquifer; that's right.

Q What is the prediction that you have reached?

A That the drawdown would be about a foot or more within a radius of about two miles from the mine based on the model that I used.

Q When you say "two miles from the mine," do you mean from --

A The orebody.

Q -- can we use the orebody?

A Right.
Q What about the drawdown impacts in the unconsolidated aquifer system?
MR. LEWIS: Same objection, your Honor.
JUDGE PATTERSON: Okay.
MR. EGGAN: Same response, your Honor.
JUDGE PATTERSON: Same ruling.
Q Go ahead, Mr. Prucha.
A Okay. That is more complicated to answer that, and it very much depends on the unconsolidated material overlying the bedrock and the connection that it has with the bedrock and faults within the bedrock and dikes, et cetera. But I think at 3,000 gpm, a lot of that water is going to be coming from the overburden in the stream. This will certainly be dramatically more drawdown than what's been estimated with the current unconsolidated flow models we went over earlier, the Fletcher Driscoll model, the Golder or the latest GeoTrans model. I think the predicted drawdown impacts, aerial extent and the magnitude from those models is substantially underestimated, you know, in this 3,000 gpm scenario.
MR. EGGAN: Thank you. That's all I have, your Honor.
MR. LEWIS: Dr. Prucha, I'm Rod Lewis. I think we got introduced earlier. I represent Kennecott Eagle

Minerals Company.

CROSS-EXAMINATION

BY MR. LEWIS:

Q The subject came up earlier as to any mine -- or experience you may have had working -- doing anything related to the mining industry. I don't see any related to the mining industry listed in your CV. Is that true? There's nothing in your CV about that?

A That's right.

Q You indicated earlier, I think in response to an objection, that you had some kind of experience related to a surface mine. Is that what you indicated?

A Yes.

Q And as to underground mines such as this one, you have no experience; is that correct?

A That's right.

Q And you also indicated, I think, that you had -- and I don't want to mischaracterize it, but that you had had some kind of experience with some kind of facilities underground. And I wanted to ask you, do you have any experience in actually -- for any kind of cavity that may be created under the ground for any purpose, actually being brought in to do the background studies, do the data collection, do the characterization and then prepare a prediction as to what, if any, water might flow into that cavity?

A Yes.
Q And not mine; it's some other application? What kind of application is that?
A It was Department of Energy project site in Colorado, a former nuclear manufacturing, parts manufacturing facility.
Q What was the underground facility?
A They had several buildings that were built several stories below ground and well below the water table.
Q Buildings to store something in?
A Nuclear parts manufacturing facilities.
Q So in that sense it would be akin to buildings generally for which the lower levels may penetrate the area of the earth in which there's water?
A They did penetrate the groundwater table, and it was -- they had pretty complicated footing drains and, you know, designs to remove water from entering the building.
Q As to the alternative numbers that you put on the board yesterday, I think it was, for the potential flow of water into the mine, I had a couple technical questions for you. First of all, could you describe what you used for boundary conditions for the top, sides and bottom of your model?
A Yup. I started with the basic Kennecott flow model for the bedrock flow system. I don't recall the name of the file, but it was submitted as, I guess, an exhibit. It already had the basic FEFLOW grid structure and downward conditions

as defined and described in the 2005 bedrock flow model. So that condition had no-flow boundary conditions on the side. Those were unchanged in the modeling simulation that I did. The upper --

Q That's the 2005 model -- I'm sorry -- 2005 report?

A Right. The model that -- well, actually -- I'm sorry -- that is -- I think it must be the 2006. The 2005 had a lower flow rate estimated. It's the model that was used to generate the flow estimate of 215 gallons per minute.

Q For the upper bound?

A For the upper bound as defined in their report. And I took that model and reviewed that along with several other model inputs, including the one that was used to calibrate the bedrock model to the 1084 well test. But the particular model that I had made adjustments to, I looked at the model input and wanted to -- I ran it first to verify that I --

Q Just a minute. My question right now is only about what boundary conditions did you assume in your modeling?

A It's a series of boundaries conditions that I changed. There were a series of scenarios --

Q Oh, you changed them?

A Yup.

Q I thought you indicated earlier today that you kept Golder's. But you did change them?

A You're referring to the boundary conditions, external side

boundary conditions and the top boundary condition?
Q Top, sides and bottom, you gave us new numbers. I want to know what boundary conditions you used when you did that.
A Okay. Let me go back for a second. The side boundary conditions didn't change for anything that I did.
Q Change from what?
A From what was already in the company mine.
Q The 2006 Golder?
A The 2006 upper bound mine inflow model.
Q All right. The upper boundary condition in there had been changed to a general head boundary condition in that particular model from the 2005 model. I changed that upper bound condition to include a thickness of overburden. And I believe I put in 100 feet for that, and I assigned at the top of that a boundary condition of a constant water level.
Q So do you have 100 feet of overburden above the mine -- the rock in your model?
A That's right. It was just a constant. It's a --
Q Is that based on any data?
A When you look across the Yellow Dog Plains -- and again --
Q No, I mean any data for overburden above the mine.
A Not immediately over the mine, no.
Q And did you also adjust the bottom boundary for your model?
A I didn't. I kept that the same.
Q So you're telling me, then, just to be clear, your boundary

conditions for your model for the mine for the sidewalls and the bottom are the same as Golder's in his 2006 reporting?
A Yes.
Q And the one you changed was the top, and you just described the change you made?
A That's right.
Q Now I want to turn to what I understood to be some key assumptions for your alternative numbers, Dr. Prucha. And the first one, as I understand it, is that you talked about various faults and dikes and lineaments and so forth, and we saw some of your slides that depict these various things. And number one assumption that you made -- and tell me if I'm wrong -- is that those things actually exist; right?
A Which slide are you referring to?
Q Any of them where you showed these lines, these faults and lineaments and so forth from Klasner's article.
A Well, I also --
Q You assumed those things exist; is that right?
A The potential for those exists and --
Q The potential. That's what you said: There is a potential; right? They may be there; right?
A I showed the Klasner faults as he mapped them and the company fault lines and dikes as they mapped them.
Q Also from geophysical data; right?
A That's my understanding. It's largely geophysical although

I believe Klasner did field verification as well.
Q Well, we'll look at that in a minute. But at any rate, so your first assumption is that those lines up there from Klasner actually exist. That's number one; right?
A I would say that they -- there's a likelihood that they do exist and it seems like there is consistent field information to support their existence.
Q All right. And then number two you have assumed for your alternative numbers that not only do those features exist but they have a high hydraulic conductivity; right?
A Yes.
Q And thirdly you have assumed not only that those features exist, not only that they have a high hydraulic conductivity, but that they are interconnected; right?
A Yes.
Q And it's true, is it not, Dr. Prucha, that if any one of those three assumptions are wrong, that you're going to have a much lower number?
A No.
Q Well let me ask you: It is true that these things have to actually exist to support your 3,000 number, isn't it?
A Yes.
Q And it is true that they have to be -- have high hydraulic conductivity in order to get that kind of number, is it not?
A Higher but -- higher conductivity than was initially assumed

in the Kennecott model that I started with, but which I believe is well within the range of conductivities for large-scale faults.

Q Again, you're assuming a large-scale fault, and you're assuming a high degree of hydraulic conductivity; right?

A I would say that it's not exceptionally high. I mean, I did a simulation with a much higher range, but I would say that it's within the range of what I would expect for a fault.

Q A fault that was conductive?

A Sure, a water conductive feature.

Q And your third assumption is also necessary to your recalculated number, that being that these conductive features are interconnected?

A A simulation that I ran showed them as being interconnected with the basic design in the Kennecott FEFLOW model, but I don't believe that that's absolutely necessary as a requirement to generate a high inflow rate. For instance, you could have a series of north-south faults as opposed to having east-west and north-south and still generate substantial mine inflow on these levels.

Q If you make them -- if you make them long enough.

A Actually I found that by extending the faults, that doesn't have as big of an impact. It's really the more -- one of the biggest changes I found was just by extending the fault that was placed as an isolated little slit in the lower bedrock, if you just extend that up through the upper bedrock, which seems very reasonable, and connect it to the overlying overburden which is much more permeable, that acts as a local drain. And for some reason, after a certain distance it doesn't become so important how long the faults are.

But one thing I did find was that the faults that were specified in this original modeling report didn't actually extend all the way through the lower bedrock as sort of implied in the report, which I didn't even extend the faults below where they had over the full extent of the mine. And faults can easily extend several kilometers below the ground surface. So I didn't include that. I didn't include permeable dikes in my analysis. I was just looking at the fault network. And it was interconnected in the model, but still that was only in the lower bedrock.

Q Well, you interconnected it in the model; right? You made it that way in the model.

A It was already that way in the basic model that I started from.

Q And then you increased the conductivity of those features for your modeling.

A But only by a factor of 10 which I think is --

Q Only by a factor of 10; only by one order of magnitude, as you described it earlier. That's what you did.

A By a factor of 10 and by a factor of 100.
Q Okay. I want to look at Klasner's article a little bit with you, Dr. Prucha. And I believe this is Petitioner's Part 632 Exhibit 59. Is that the Klasner article, Dr. Prucha?
A Yes.
Q This is page 3 of that article, Dr. Prucha, and I wanted to direct your attention to that first paragraph. It indicates, does it not, that:

> "The present study was undertaken to determine if a relatively large differentiated igneous complex is beneath the Yellow Dog Plains, and if so, to determine its configuration and potential economic mineralization."

That's what it says; right?
A Yes.
Q And that is the purpose of the study; correct?
A As stated there, yes.
Q And you do know, I believe, without me reading parts of this for you, Dr. Prucha, that this study here was based entirely what's called geophysical studies?
A I don't remember the entire report verbatim, but they used magnetics and gravity surveys to help determine the location of faults and dikes through the area.
Q Which are aboveground techniques, are they not?
A That's right.

Q And they're used to -- the word I see in here a lot is to infer whether certain structures may actually be under the surface; is that true?
A That's right.
Q And then the results that we see in here and that you talked about earlier are inferences based on such aboveground electromagnetic and other type of studies; isn't that correct?
A Could you repeat that?
Q The maps and so forth, these dikes and faults that you've talked about, those are an inference based on these electromagnetic studies; isn't that correct?
A And to some extent ground truthing, the fact that they have the outcrops of East Eagle Rock and the orebody.
Q But the point is, they're not based on drill core information, are they, sir?
A That's my understanding.
Q And, in fact, that's why they refer to them -- well, let's look here. Here's one of the maps I think you referenced and on which you based some of your slides. And these are some of the lines that you talked about. And we see there -- I've circled where they've drawn arrows and so forth. They say "inferred fault, inferred fault"; right?
A Yes.
Q That's the language; right? And then in the explanation

under here they refer to "designating location of geophysical anomaly." Do you see that, sir?
A At the bottom?
Q Yes, sir.
A Yes.
Q And the reason they used the word "inferred" in characterizing these structures is because one cannot actually draw the conclusion that these exist only from geophysical data. Isn't that also true?
A I think this technology is something that gives you a good indication that something might be there and you follow up with other information to conclude that they're actually there.
Q And the best information would be drill core data, would it not?
A I would agree that you can confirm the existence of faults.
Q Do you have any idea how many drills or drill holes have been made around and in the vicinity of the crown pillar for this mine, Dr. Prucha?
A I've heard estimates, and I did look at, I think, an exhibit that had a lot of red dots. And I think one of the reasons I plotted Klasner's map here along with the company's geology map was to correlate those features with the red dots to see if, in fact, there had been an effort to actually go confirm the existence of these longer lineaments

that seemed like two studies had confirmed exist.

Q Oh, is that your position, that all these lineaments and so forth in Klasner's article have been confirmed by Kennecott through its drilling? Are you telling me that?

A I'm sorry. Could you rephrase that?

Q Are you telling me that all these faults and lineaments we just looked at on Mr. Klasner's figure have been confirmed by Kennecott's drilling?

A No, I'm not saying that.

Q Okay. Now, let's look a minute at what the author of this paper says about the use of such studies in making the assumptions you have made, Dr. Prucha. On page 9 at the bottom there where I've got a line under it, it says, does it not:

> "Complications of interpretation arise, however, from several factors. Most important are 1) the complexities of the magnetic field caused by the interaction of the induced field and the irregularly oriented natural remnant field; 2) the possible variations in density of the peridotite due to variable degrees of serpentinization; 3) imprecise knowledge of the densities of all rock types in the area; 4) variations in thickness of plasticine drift; and 5) the imprecise understanding of the composition of the varied conductive bodies that produce the measurable

VLFEM response.

MR. HAYNES: Just for the record, what page are you reading from, Counsel?

MR. LEWIS: Page 10.

MR. HAYNES: Thank you.

Q That's what Klasner has to say about assuming things based on geophysical studies; correct, Dr. Prucha?

A As stated there, yes.

Q Now I want you to turn to your second assumption, and that is as to the conductivity of these structures. Again, in your testimony yesterday, what I heard and wrote down is that, when you described the potential water conductivity, you said -- used such terms as "could be." And I think you indicated that again earlier today. But Mr. Klasner in his article says absolutely nothing about the potential conductivity of these structures; is that not true, Dr. Prucha?

A I don't remember seeing that in his report.

Q But it is true, is it not, Dr. Prucha, that Golder in their reporting did have some data about the potential conductivity of some of those structures?

A I wouldn't say that they're of the magnitude of these water-conductive -- potential water-conductive features that were outlined by Klasner and the company geologists.

Q Well, certainly -- you're saying the test results are not of

the magnitude, or what's not of the magnitude?
A I wouldn't jump to the assumption that, in the wells that I looked at, that the pump tests performed on in the orebody had actually intercepted any of these larger lineaments as mapped by both the company geologists and the Klasner report that indicates --
Q No. I understand you wouldn't assume that. You don't have the information from which to conclude one way or the other, do you, sir?
A I can't conclude that they have not hit that, but I -- the reason I plotted the Klasner fault -- inferred fault map and the company geologist fault and dike map was to see if in fact the wells that have been pumped in the orebody have the potential of intercepting any of those or whether the faults would have crossed any portion of the area that would be dewatered.
Q In other words, you assumed, for purpose of your analysis, that, with all the drilling that Kennecott had done on this property, it had not intersected, described and characterized these features. You assumed that did not happen, merely because you did not have the data from which you could verify it one way or the other; isn't that right?
A It's true that I did not have the data that I saw on a recent plot or exhibit that had lots of red dots.
Q So as with your assumption as to the existence of the dikes

and faults referred to by Klasner, you also assumed, in the absence of any data to the contrary that you were aware of, that in fact all of these features had high hydraulic conductivity, Dr. Prucha; right?

A Can you rephrase that, please?

Q Let's look at Golder's -- one of Golder's tables here a moment.

MR. LEWIS: This is Intervenor Number 7, Counsel, Bates stamped 4442, very small numbers.

Q Now, I assume, Dr. Prucha, since you represented earlier that you had examined the various Golder reports and the various reports having to do with characterizing the hydraulic situation in the crown pillar, that you had looked previously at this table; is that correct?

A I don't recall it off the top of my head but -- I'm not sure. What report was this in?

Q It's in our Exhibit 7. It's one of the Golder reports, Dr. Prucha. But you don't recall, sitting here today, whether you've looked at it or not?

MR. HAYNES: Well, perhaps, if counsel could reference which appendix out of the EIA or the mine permit application this is, it'll help the witness recall.

Q It's in the environmental impact assessment, Appendix B-4, Dr. Prucha. Does that help?

A I read through that report, yes.

Q And you don't recall the table specifically?

A It's a lot of information. I don't recall it specifically off the top of my head but --

Q Well, there's a lot of information in a lot of reports, isn't there, sir? Right?

A Yes.

Q And some of it's more relevant than others; wouldn't you agree?

A (No verbal response)

Q And wouldn't a table showing the identification of various structures and testing them as to their hydraulic conductivity be relevant to the topics that you testified about?

A If you believe that these particular boreholes have intercepted the larger water-conductive features that are implied by the Klasner report and the company geologist's report.

Q And in the absence of hard evidence to the contrary, you're going to presume that Kennecott did not do its job and failed to intercept any of these structures which may or may not exist. Is that your opinion?

A In my opinion, that I don't believe that they attempted to characterize potentially larger-scale water-conductive features, which I think in a fractured system like this dominate the flows. I mean, I think, when I reviewed mining

efforts in nearby Marquette iron mining district --
Q Let's talk about this mine a minute. Okay, Dr. Prucha? I'm asking you about the data from this mine.
A Uh-huh (affirmative).
MR. HAYNES: Your Honor, perhaps counsel could allow the witness to finish his answer without interruption.
MR. LEWIS: I think I'm giving him sufficient --
JUDGE PATTERSON: And I think his answer was transcending something unresponsive to the questions.
Q Now, even though you may not recall this table, Dr. Prucha, it does show on the left-hand margin, does it not, borehole identification information? You can tell that, can't you, Dr. Prucha?
A In the very left column?
Q Yes, sir.
A Yes.
Q And in the very next column it shows the depth of various locations within the drilling?
A Within the drilling within the --
Q Within the well that's indicated in the borehole number. Each borehole number has various depths indicated in the next column; isn't that correct?
A Depths, yes.
Q And we have the length in meters, and then the next column in fact has the heading on it "Structure," does it not?

A Yes.
Q And that's what you've been talking about also, structure; isn't that correct?
A Yes.
Q And it gives various characteristics of those structures such as broken, sheared, gouged and so forth; right?
A Yes.
Q And I think you'll recognize this middle column, sir, as some indications that have some relevance to the hydraulic characteristics of these structures, does it not?
A The "Temperature or Fluid Conductivity" column?
Q Yes, sir.
A It says "No" under each one?
Q That's right; indicates "No flow anomalies detected in the testing," does it not, Dr. Prucha?
A It's says "No" on this table.
Q That's all I'm asking you about, Dr. Prucha. And on the right-hand column we have some data under the heading, "Hydraulic Conductivity Meters Per Second," do we not?
A Yes.
Q And there this in fact for many of those parameters a number such as the first one in the right-hand column "2.00E-09." Do you see that?
A Yes.
Q And tell me if you don't know -- but I'm presuming you

know -- that that means that the conductance in that structure is 2 times 10 to the minus 9 meters per second.
A The hydraulic conductivity, --
Q Yes, sir.
A -- is that value? Yes.
Q And that's 2 -- that's the numeral 2 with a whole bunch of zeroes in front of it, is it not?
A 2 with zeroes in front of it?
Q 2 times 10 to the minus 9. Isn't that .000 and so forth -9?
A Right; yes; yeah.
Q Thank you, sir. Now, we've been through two of your assumptions so far. One is that these so-called faults and dikes and so forth really exist and your foundation for that based on Klasner's article. Second we've talked about your assumptions as to the conductivity of these features based on what you told us earlier. And the third one I wanted to ask you about was your assumption as to the interconnectedness of these inferred features from the Klasner article. And I think you talked earlier yesterday or today -- I forget which -- about some pump tests that Kennecott had done. Do you recall that?
A Yes.
MR. LEWIS: This is from Intervenor Exhibit 7 also, Counsel, Bates stamped 4463.
Q And again tell me if I'm wrong but, since you talked about

this, I assume that you had seen and examined this figure before, Dr. Prucha?
A I've seen that figure.
Q And you're aware, are you not, that this is a pump test performed by Kennecott?
A The pump test response shown in one of the mines.
Q And you're aware, are you not, that this was pump test results from a feature that was identified as the most conductive feature in the rock?
A Over the area that the boreholes that were located, yes.
Q Okay. Now, again, since you studied this -- the text is a little hard to read, but you may remember it. The first line at the top -- well, first of all, we see on the left-hand margin it shows "Units Drawdown in Meters." Do you see that, sir?
A Yes.
Q And then across the top is "Elapsed Time in Hours"; correct?
A Yes.
Q So what this figure reflects is a drawdown of water in this highest conductive feature identified by Kennecott -- the drawdown of water in terms of depth over time; is that right?
A The lower number -- the lower graph?
Q Yes, sir.
A Okay.

Q And let me ask you something just to make this clear. If we do this testing in a borehole, this so-called pump testing, and we get a lot of water out of the hole, to try to put this into simpler terms, that would indicate that there is not a connectivity between that feature we're pumping and other features which may hold substantial water; is that correct?
A I'm not sure I understand the question. Could we --
Q Let's look at it this way: We got two potential outcomes here when we pump test down here in one of these features -- right? -- relatively speaking? We can get a lot of water coming out of it, or we can get a little water. Let's take those two scenarios. All right?
A Sure.
Q And I know it was counterintuitive to me for awhile, and I still have trouble with it. All right? But my understanding is, then, if in effect -- let's look at it this way: If we have a tube like this that's closed -- right? -- and we put a well down there and we pack that off and we do that so-called pumper test and we pump water, we're going to quickly draw out the water, which is going to effect a rapid drawdown in that structure; isn't that correct?
A So this tube is a horizontal tube?
Q Let's make it one for now. All right? The point is, if

we've got a feature down there which could hold water -- and let's assume it has water in it -- okay? -- for this purpose --
A The tube?
Q Yes.
A Okay.
Q -- and we pump the water out, we're going to see a rapid drawdown in the water level?
A I think that that rapid drawdown would depend on the volume or the size of that tube. If it was a large volume, then it would take a long time to draw down.
Q That's the other factor -- right? -- how tight it is. Let's take --
A Well, that's not about how tight it is. It's the volume of that tube. So the larger the -- and if you had a gasoline truck tank below the ground versus a small bowl, if you pump from the small bowl, the drawdown would be nearly instantaneous if you were pumping at a decent rate. But for the gasoline tank, that drawdown would take a lot of time, because that volume of tank underground is pretty large. So what I'm saying is it depends on the volume of that tank.
Q Well, I think we're on the same page. I understand that, I think. But let's assume that we've got one tank. Okay? And then the other scenario, let's assume we've got a whole bunch of interconnected tanks, kind of like your

interconnected faults and dikes. Okay? All right?
A (No verbal response)
Q And we put our well in there. We're going to have a greater drawdown, are we not, in the smaller unconnected bowl -- if you want to call it a water bowl, Dr. Prucha -- than we are in this greater interconnected water bowl. Isn't that the point you just made?
A If you're saying that the diagram on the left is a much bigger volume, then --
Q No. What I'm saying, sir, is what this test reflects. And again, tell me if you don't know how this is done and what this means, but I'm assuming you do. So all I'm asking you is, if we put our pump in here (indicating) and we pump the water, we're going to get a drawdown of the water level in there, are we not?
A You will get a drawdown of the water if it's an isolated chamber, yes, I agree.
Q All right. And if we have a relatively small chamber compared to a relatively large or greatly interconnected chamber, we will have a greater drawdown in the small chamber than we will in the large chamber; isn't that correct?
A Well, I would say that that's not necessarily correct. Because if -- once you drain out the larger-volume cavity, it may end up being about the same drawdown amount.

Q I'm just talking we're putting the pumps in there. We're going to start pumping at the same rate -- okay? -- ten gallons a minute, let's say. Is it not true that in this small container we're going to have a more rapid drawdown of the water level than we are in this very large chamber over here?
A I agree with that.
Q All right. That's all I'm talking about. All right? Now, you see that top red line. Do you understand that to be the pump test results that were simulated and assumed for Golder's upper bound case model?
A Yes, that was the simulated drawdown in the upper bound model, FEFLOW model, as I understand it.
Q And do you recognize the bottom line, the bottom part of this figure, to show the actual drawdown in the pump test of the figure Golder had identified as the most highly conductive feature?
A Yes.
Q And it shows, does it not, that, in that feature they had identified and target for pump testing, because it was the most highly conductive, that, in actual fact, there was a very rapid drawdown of the water as a result of the pumping test?
A You're talking about the lower line?
Q Yes, sir.

A I don't know what to reference the rapid drawdown to, but the magnitude of the drawdown appears to be large.
Q And that does not support your theory that this largest conductive feature was connected to a -- was interconnected with a great deal of other high hydraulic conductive features, does it, Dr. Prucha?
A Well, my argument was that this presumed that it -- this well that was being pumped and the zone of this most permeable water-conductive feature that it intercepted was in fact related to the large water-conductive features that were -- I understood were possible from both the Klasner report and the company geologist's map that seemed to have a large degree of overlap. They seemed to correlate pretty well. The point is that it didn't seem like the pump test performed in well 084. Because it was so localized, I felt like it didn't necessarily intercept any of the larger fault features that I was seeing on these other maps or the dike -- an intrusive dike brecciated zones that could be very water conductive and extend for long distances.
Q So again, your opinions are based on, number one, assuming that the inferred structures in the Klasner report are real, for which you have no data to support from actual drilling and, number two, your assumption that Kennecott for some reason failed and neglected to actually search for, look for and find any such features and test them and, lastly, your

apparent willingness to ignore the fact that in the record there is evidence that they did find these structures, that they did put -- they did test them for conductivity and that the results indicate well conductivity.

MR. EGGAN: Your Honor, is this a question or a speech?

MR. LEWIS: It's a question.

MR. EGGAN: Well, can we have it phrased in a question that asks individual questions rather than a paragraph of several questions?

MR. HAYNES: And I'll also object because the question mischaracterizes the testimony.

MR. LEWIS: I can move on, your Honor.

JUDGE PATTERSON: All right.

Q So we've covered the three assumptions now, Dr. Prucha; again, one, that the inferred structures shown in the Klasner report really exist; two, that not only do they exist, but they're highly conductive and, three, not only do they exist and are highly conductive, but they're interconnected. I wanted to turn next to a couple other bases for your opinion that you've offered as to your number for some mine inflow. You also testified, I believe, Dr. Prucha, that you had done no calibration for your analysis; is that correct?

A It wasn't the intent to calibrate the flow model.

Q You had not done any calibration; is that correct?
A I did not perform any calibration on the company model.
Q And I believe you testified earlier that without calibration the results of such analysis are meaningless; is that not true?
A Without calibration I would not predict -- I would not put forth an unqualified single value for an estimated amount of flow or impact to a system.
Q So you've got these assumptions we just reviewed. You admittedly did do, could do no calibration for your analysis, and yet you offered your opinion yesterday during your testimony; right?
A I did offer my testimony yesterday, but I --
Q Did your analysis follow these so-called ASTM standards, Dr. Prucha?
A I don't think they necessarily apply in terms of calibrating the model.
Q They don't apply to your analysis. Is that what you're saying, Dr. Prucha?
A That's not what I'm saying.
Q They didn't follow what Mr. Haynes characterized the other day and asked you about what he called best practices, would they, Dr. Prucha?
A I don't think that they fall under that from the standpoint that what I was doing wasn't to produce a model from the

start and try to reproduce the actual site conditions.
Q In fact, what you were asked to do was come up with an opinion for purposes of this litigation; is that not true, Dr. Prucha?
A I was asked to assess the hydrology of the system.
Q As Mr. Eggan said from time to time and you agreed with, you would agree as to your model, sir, garbage in, garbage out?
A I wouldn't say that in this case.
Q Now, Dr. Prucha, another thing you talked about -- and I think I made a note here in one part of my notes from yesterday -- is you said -- commented from time to time about the uncertainty of this type of modeling. And I wrote down here -- I mean, you said it several times, but you said, "Models by design are uncertain." Is that your view?
A Yes.
Q And given that there is inherently the degree of uncertainty in this kind of modeling, whether it's yours or Golder's or whose it is, wouldn't it be prudent, then, sir, in your opinion, to require someone in Kennecott's position, before we actually go down there and mine this ore and create this cavity, to gather the additional data -- to gather, additional data to more fully characterize the area above the mine, including these potential conductive features? You would agree with that, wouldn't you, Dr. Prucha?
A Could you restate that, please?

Q Given the uncertainty in modeling that you've talked about, wouldn't it be prudent to require in such circumstances that additional data be gathered before we commence the mining of the ore?

A I would agree that more characterization would be a good thing.

Q In fact, that was one of your criticisms, was it not, that not enough characterization had yet been done?

A Yes.

Q And it would also be prudent, I assume you would agree, to not only require in this case that Kennecott gather additional data once underground, do additional characterization of the hydraulic properties in the rock; do additional 3-D modeling of such things; not only that but that there actually be performance requirements in the permit covering such things as the amount of water which may be flowing into the mine and covering ultimately the amount of drawdown in the aquifer which will be tolerated or not tolerated. Wouldn't you agree it's also prudent to do that under these circumstances?

MR. HAYNES: Objection. That's a seriously compound question, and it mischaracterizes the testimony.

MR. LEWIS: I think he can follow it, your Honor.

JUDGE PATTERSON: Could you understand the question?

THE WITNESS: No, I didn't.

JUDGE PATTERSON: All right.

Q Are you aware of the permit conditions in this case that pertain to Kennecott?

A Which permit?

Q Are you aware that there's a permit condition that requires Kennecott before they mine the ore underground to do additional drilling of the rock, to do additional characterization of the rock, including the hydraulic conductivity? Were you aware of that?

A In addition to what's already been done?

Q Yes, sir.

A That hasn't been done now?

Q Were you aware of that permit condition, sir?

A I'm not aware of a permit condition to that --

Q But you agree it would be a prudent thing to have Kennecott do that?

A Before --

MR. HAYNES: Your Honor -- just a moment. Before counsel asks questions about whether the witness knows if there's a permit condition, perhaps counsel could offer the witness the permit so that he can verify whether the condition exists or not.

MR. LEWIS: Your Honor, I've read that into the record in the prior proceedings. The court is fully aware of that condition. I'm just asking the witness if he's aware of it or not. I haven't mischaracterized the condition -- the permit condition. So I just want to know if he's aware of it, and I've asked him whether it wouldn't be a prudent thing to do exactly what's been done.

JUDGE PATTERSON: I think you can ask if he's aware of it.

MR. LEWIS: And I think he's already answered that question. That's all I have, Dr. Prucha.

MR. REICHEL: Good afternoon, Dr. Prucha. My name is Bob Reichel. I represent the Department of Environmental Quality.

THE WITNESS: Good afternoon.

MR. REICHEL: A relatively few questions for you, sir.

CROSS-EXAMINATION

BY MR. REICHEL:

Q I believe on your direct examination you -- by Mr. Eggan, you testified about -- you made reference to Part 22 rules. Do you recall that?

A Not off the top of my head.

Q Okay. I'm sorry. Let me back up. You understand, I assume, sir, that one of the issues in this case is a permit issued by the DEQ under the State Water Pollution Control Statute, which happens to be called Part 31, and specifically a discharge -- a permit that authorizes under certain conditions discharges to the groundwater of the state. Do you understand?

A Yes.

Q Are you aware, sir, from your work on this project, review of the file materials, that the DEQ has promulgated formal administrative rules dealing specifically with groundwater discharges?

A Am I aware of that?

Q Yes.

A Yes.

Q And again, I'm not trying to trick you or anything.

A Uh-huh (affirmative).

Q I believe there was some testimony on direct examination where you made reference to -- I thought, to certain requirements with respect to groundwater discharge permit applications. Do you recall testifying about that?

A In Part 22?

Q Yes.

A Yes.

Q Okay. That's what I'm asking about. All right. To the extent that you've looked at those administrative requirements governing groundwater discharge permit applications, you're aware, are you not, sir, that those rules do not actually require a permit applicant to conduct numeric groundwater modeling? You're aware of that, aren't you?

A I'm not sure of whether that is required or not based on my review of Part 22.

Q So you don't know?

A I don't know that that's required or not required as part of the analysis.

Q Are you aware, sir -- again, I -- have you had an opportunity to look at the groundwater discharge permit that was actually issued by the DEQ to Kennecott Eagle Minerals Company in December of last year?

A Yes.

Q You're aware, are you not, sir, that that imposes certain specific limitations both quantitatively and qualitatively on what may be discharged to the groundwater? Is that your understanding, sir?

A I'm not sure I understand the --

Q Okay. Let me break it down.

A Yeah.

Q Are you aware or are you not, sir, that the groundwater discharge permit that is one of the principal issues in this case imposes or limits the volume and the rate of groundwater that is authorized to be -- excuse me -- the volume of treated water that is authorized to be discharged into the groundwater through this TWIS system? Are you aware of that?

A I -- in terms of the actual -- I don't know whether you're referring to the actual discharge permit --

Q Yes, that's what I'm asking. I'm not trying --

A -- that specified 504,000 gallons per day?

Q That's exactly what I'm asking about. You are aware of that?

A Yes, I have seen that and am aware of that.

Q Okay. And again, I don't mean to trick you. But do you know or have you attempted to -- if I were to suggest to you that that specified rate of 504,000 gallons per day converted to an equivalent rate in gallons per minute would equate to 350 gallons per minute, would you have any basis for disagreeing with that?

A Assuming it was continuous all day long, yeah, that's what I calculated it to be; yeah.

Q So you're aware, then, that the permit as it now stands would not authorize Kennecott to discharge into the groundwater through this TWIS system in excess of that work; correct?

A That's right. I understand that.

Q One of the subjects you testified about earlier today had to do with the provisions in the permit that have to do with groundwater monitoring. Do you recall that?

A Yes.

Q And you expressed some concerns about the monitoring requirements in the permit; correct?
A The groundwater monitoring well network?
Q Yes, exactly.
A Yes; uh-huh.
Q And if I understood your testimony correctly, you were focused upon a concern that, under an alternative analysis of the potential flow direction of groundwater from this TWIS system that you've done -- you expressed a concern that particular wells designated in the permit as -- at issue today -- identified as, quote, "upgradient wells," might not in fact be upgradient. Am I understanding your --
A That was my understanding, yeah.
Q And that is part of your concern; correct?
A Yes; that they may become downgradient wells if too much mounding occurs or if the conditions beneath the TWIS had been better characterized and perhaps the low-permeability units had been considered, that mounding could in fact go back to the southwest into the area where these background wells -- upgradient wells were located.
Q Now, sir, as a part of your review on this project, you've actually looked at the permit conditions that involved monitoring requirements; is that correct?
A You're talking about Part 22?
Q Yeah. I'm talking about the groundwater discharge permit --

A Okay.
Q -- and the conditions in that permit that specify the monitoring that has to be done by Kennecott --
A Yes.
Q -- in order to lawfully discharge. Correct?
A Yes.
Q And are you aware, sir -- well, let me back up. If -- just assuming hypothetically that the situation you posited that there was mounding to an extent or in a way that caused an increase in water elevation in wells that have been presumed to be, quote, "upgradient wells" -- first of all, is it your -- isn't it true, sir, that under the permit there would be regular monitoring observations, both groundwater-level observations and in some cases water quality observations made in various monitor wells? Correct?
A I'm not sure I follow. You're asking whether I know that --
Q Let me rephrase the question. Are you aware, sir, that the permit has specific conditions that require the permitee at specified intervals to take measurements from various monitor wells? Correct?
A Water quality measurements or water levels?
Q Both.
A Both. That's my understanding, yes.
Q Correct. Okay.

A And if there's --
Q And so in order to comply with the permit, there would be at regular intervals measurements of water elevation in various specified wells; correct?
A Yes.
Q And isn't it true, sir, that those -- one of the purposes of those measurements would be to identify changes in groundwater elevation at the monitor locations that occur as a result of the discharge? Correct?
A Yes.
Q And in fact, isn't it true, sir, that, through the monitoring program that would be required to be implemented by the permitee here -- if in fact there were increases in elevation in these wells -- in any of the wells, that would be detected; correct?
A Not necessarily. I mean, if the low-permeability units above the water table act as a very effective perched --
Q Let me rephrase the question. I'm -- let me be specific about the -- this concern that you posited about upgradient monitoring wells not being upgradient. Okay?
A Yes.
Q If in fact mounding occurred in these upgradient wells, the regular measurements of water levels taken from those and other wells in the network would be recorded over time; correct?

A The water levels in those wells will be recorded in the wells, right; yeah.
Q And so that would require the permitee to monitor groundwater conditions in these wells over time; correct?
A Yes.
Q And those results are required to be reported under the permit to the Department of Environmental Quality, are they not?
A That's my understanding.
Q And again, from reviewing the permit, are you aware, sir, that the permit specifically authorized the DEQ to require changes or modifications of the monitoring and sampling program required under the permit as originally issued if circumstances warrant? Are you aware that that -- the permit authorizes those kinds of changes by the DEQ?
A I'm not sure that I am aware of the actual language, no.
Q Do you have any reason to disagree with that?
A Can you repeat the language so I understand that clearly?
Q Sure. Okay. Fair enough. Sir, I'm going to put up on this overhead projector, sir, what I'm going to represent to you is an excerpt from the --
MR. REICHEL: Thank you, Counsel. Just so the record is clear, this is an excerpt that appears from page 10 of 32 of the groundwater discharge permit issued by the DEQ and directing your attention to the middle of this page

under "Sampling Locations A." There's some language highlighted there.

Q Do you see that under the heading "Sampling Locations"?

A Yes.

Q It says in the last sentence of that paragraph, "The Department may approve or require alternate sampling locations which are demonstrated to be representative"; is that correct?

A That's correct.

Q And similarly, with respect to the next page --

MR. REICHEL: And this appears at page 11 of 32. This is, I believe, Condition 4a, "Sampling Location."

Q Again it indicates, "The Department may approve or require alternate sampling locations which are demonstrated to be representative." Do you see that, sir?

A Yes.

Q And turning now to page 15 of 32, this is, I believe, Condition 10F, as in "Frank": "Pursuant to Rule 2223(1), the Department may modify the effluent or groundwater monitoring parameters of frequency requirements of this permit, or they may be modified upon request of the permitee." Again, you do -- these conditions appear in the permit; correct?

A Yes.

MR. REICHEL: May I have just a minute?

JUDGE PATTERSON: Sure.

MR. REICHEL: I have nothing further at this time.

MR. HAYNES: Your Honor, I have some redirect.

JUDGE PATTERSON: I assumed you would.

REDIRECT EXAMINATION

BY MR. HAYNES:

Q Dr. Prucha, Mr. Lewis asked you about your experience in the mining industry. Do you recall those questions?

A Yes.

Q And for purposes of modeling a subsurface groundwater regime as was done in this case both by the Kennecott consultants and by you, is it critical that you have had experience in the mining industry to do that kind of modeling?

A I would say no.

Q Why is that?

A Well, I think it's the hydraulics and hydrology of systems or sort of independent, really, of exactly how you're drawing down the water. In this case it's going to depend on the natural system outside of the actual dewatered area that supplies water to that actual mine.

Q So the modeling is, in essence, independent of the fact that there's going to be a mine here or some other subsurface structure; is that right?

A That's right.

Q Mr. Lewis asked you about the boundary conditions in the --

both the Kennecott model and your model. Do you remember that testimony?
A In the model that I modified, yes.
Q Yes, the model you modified.
A Uh-huh (affirmative).
Q And you testified that you added overburden as a boundary condition of your model. Do you remember that?
A That's right.
Q And is adding overburden in the regime, as you understand it here, a reasonable thing to do from a modeling perspective?
A Yes.
Q And why is that?
A Well, because that occurs in the vicinity of the mine. There is overburden. Bedrock is just not at the surface, and, in my opinion, is a better boundary condition because the flow into the bedrock is now limited by the overburden hydraulic properties that -- and we chose the hydraulic properties used for the overburden from the GeoTrans model -- latest GeoTrans model for hydraulic properties.
Q And the GeoTrans model is Exhibit --
MR. LEWIS: -- 591 of --
MR. HAYNES: Thank you, Counsel.
Q -- 591 of Kennecott; correct?
A I think so.
Q That is --

A Right.
Q Those are their numbers; correct?
MR. LEWIS: Objection; form.
Q The numbers that you chose from the GeoTrans model are the numbers that Kennecott produced; correct?
A That's right; yeah.
Q Okay. Mr. Lewis asked you about the Klasner study, which is Petitioner's Exhibit 59.
MR. HAYNES: Sorry. We have to do that technology switch, your Honor.
JUDGE PATTERSON: Okay.
Q Mr. Lewis asked you about page 10 of the Klasner report, again, Petitioner's Exhibit 59, and he read to you the first of the two paragraphs shown on the screen here from page 10. Do you recall that?
A Yes.
Q And this paragraph deals with complications arising from several factors. Do you recall that?
A Related to the geophysical interpretation, yes.
Q Yes. And you read the Klasner report cover to cover, didn't you?
A Yes.
Q Did you also notice, after this paragraph that Mr. Lewis read, the next paragraph that says, "In spite of these difficulties, much useful information has been obtained on

the geologic nature of the area, and geophysical models were prepared that seemed consistent with the observed geological and geophysical data"?

A Yes.

Q And what does it mean to you when it says that, "The models were prepared that seemed consistent with observed geological data"?

A Well, the outcrops, for example, where the intrusive was observed, they -- Klasner has mapped the dikes in that location.

Q And from a modeling perspective, did you consider it important to use all available information at your disposal concerning geologic features in the area?

A Yes.

Q And that included the features mapped by Klasner; correct?

A That's right.

Q Mr. Lewis asked you about whether you could confirm the existence of faults, and you -- your answer was that you referenced two studies. Which were those two studies?

A It was the Klasner report and the geologic report that the company did. I think it's Appendix C by --

Q Appendix C-1 to the mine permit application?

A -- Coombs and Rossell. I can't remember the names off the top of my head, but it was the one that was presented in their reports.

Q All right. Mr. Lewis asked you about Table 7.1 in Appendix B-4. And I'm sorry. I don't have that slide available. But that was the table that described the four boreholes, numbers 54, 73, 83 and 84. Do you remember that?
A Yes.
Q All right. And those are four out of the six boreholes that you studied for part of your exercise here; correct?
A Yes.
Q And Mr. Lewis asked you about the tables report on the various hydraulic conductivities of those boreholes. Do you recall that?
A That's right.
Q Now, is it your understanding that those four boreholes represent the sum total of all of the geologic structures in the area?
A Over the 87 square kilometers that they modeled, no.
Q And so would you as -- from a modeling perspective rely on the hydraulic conductivity represented in those four boreholes to construct a model of the groundwater flow regime in this area?
A They're just not effective parameters to characterize the systems, so, no.
Q Mr. Lewis asked you about calibrating your model. Do you recall that testimony?
A Yes.

Q And you testified that you would not put forth a single number based upon the model that you performed; correct?
A Yes.
Q All right. And the numbers that you gave us yesterday, which I recall from your model -- the output numbers, which were 280 to 3,000 gallons per minute of inflow into the mine -- do you recall that?
A Yes.
Q And you gave us a range in numbers. Is that range in numbers consistent with your view of the uncertainty with any type of model?
A Yes.
Q Mr. Lewis asked you about whether it would be prudent for Kennecott to gather additional data before mining occurs. Do you recall that testimony?
A Yes.
Q And in your view, it would be prudent, would it not, to gather additional data in order to appropriately model the groundwater regime in the mine area?
A Yes.
Q And could that work be done before mining begins?
A Yes.
Q And could it occur before Kennecott starts constructing the tunnel?
A Yes.

Q In fact, it could be done now?
A Yes.
Q It could have been done two years ago?
A Yes.
MR. HAYNES: I have nothing further. Thank you.
MR. EGGAN: Just two or three questions, your Honor.
JUDGE PATTERSON: Okay.

REDIRECT EXAMINATION

BY MR. EGGAN:
Q Dr. Prucha, following up on what brother counsel, Mr. Haynes, just asked about whether it would be prudent and whether or not this could be done before the permits were granted -- and the question was -- from Mr. Lewis was, wouldn't it be prudent to conduct these tests? But my question would be this: Given the potential impact and the size of this site, wouldn't it really be prudent to do this testing -- all the testing that Mr. Lewis referred to before the permit is even granted?
A Yes.
Q Are you aware of the public hearing requirements under Part 632 and the involvement of the public in this process?
A Yes.
Q Would it be prudent to allow the public to vet some of these issues before this permit is granted, as the statute appears

to require?
A Yes.
Q Would it be prudent to do that?
A Yes.
Q Now, Mr. Reichel asked you some questions about the Part 22 rules. Are you an expert in the Part 22 rules?
A No, I'm not.
Q Okay. Well, let me show you just a couple of rules here in Part 22. And what I'm referring to specifically is the rule requiring a hydrogeological report for this kind of discharge. It's rule 323.2222(1). And I'm going to refer you specifically to that rule at (4)(b)(ii). Okay? And what we're talking about here is a requirement that an applicant evaluate the vertical and horizontal extent of mounding resulting from the discharge. Okay?
A Yes.
Q So I want you to think about that requirement, and I also want you to think about the requirement in that same provision. And this is under (4) of that rule -- (4c), and again it's (ii): "An applicant is required to analyze the interconnections between the aquifers receiving a discharge and other aquifers in the vicinity of the discharge location."
A That's correct.
Q Do you think that you could really analyze those two issues

without doing some sort of modeling regime?

A No.

Q Do you think that the company -- in the evidence that it has presented, the modeling that it has conducted, do you think that the company has done modeling that is consistent with what this rule would require?

A No.

MR. EGGAN: Thank you. I have nothing else, your Honor.

MR. LEWIS: Nothing further.

JUDGE PATTERSON: Thank you, Doctor. You may be excused.

THE WITNESS: Thank you.

MR. HAYNES: Your Honor, perhaps it would be appropriate for a break now before we call our next witness. Thank you.

(Off the record)

JUDGE PATTERSON: Ready?

MR. HAYNES: Yes. Petitioners call Ann Maest.

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

DR. MAEST: I do.

ANN S. MAEST, PH.D.

having been called by the Petitioners and sworn:

DIRECT EXAMINATION

STATE OF MICHIGAN

STATE OFFICE OF ADMINISTRATIVE HEARINGS AND RULES

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

HEARING - VOLUME NO. XL (40)

BEFORE RICHARD A. PATTERSON, ADMINISTRATIVE LAW JUDGE

Constitution Hall, 525 West Allegan, Lansing, Michigan

Wednesday, July 16, 2008, 8:00 a.m.

APPEARANCES:

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

ROBERT H. PRUCHA, PH.D.
having been called as a rebuttal witness by the
Petitioners and sworn:

DIRECT EXAMINATION

BY MR. HAYNES:
Q Dr. Prucha, good morning.
A Good morning.
Q You testified before so we can dispense with the preliminaries. Dr. Prucha, for your rebuttal testimony this morning have you prepared a series of slides that will assist your testimony?
A Yes.
MR. HAYNES: For the record these will be marked as Petitioner's Proposed Exhibit 191 for demonstrative purposes only.
Q Dr. Prucha, to prepare for your rebuttal testimony this morning did you review the testimony of certain witnesses in this matter?
A Yes.
Q And did you review the testimony of Mr. Beauchamp, Dr. Carter, Mr. Chatterson, Dr. Council, Mr. Eykholt, Mr. Janiczek, Mr. Logsdon, Mr. Thomas, Mr. Ware, Mr. Wiitala, Mr. Wozniewicz, and Mr. Zawadzki?
A Yes.
Q Now, and did you also review exhibits including the

demonstrative exhibits that they prepared for their testimony?

A For most of them.

MR. HAYNES: Now, if we can go to the next slide, please.

Q Dr. Prucha, you reviewed the testimony of Mr. Thomas who testified on behalf of the DEQ, and on page 6803 of the transcript Mr. Thomas testified that he doesn't agree that mine inflows can high because country rock is low permeability. Did you review that testimony?

A Yes.

Q And do you have -- do you take issue with that testimony?

A Yes.

Q And in what way?

A Well, I think he doesn't assume -- I think he assumes that all the flows through that low permeability country rock matrix, I don't think he really acknowledges the potential for major water conduits, such as the faults and brecciated dikes and --

Q And would that be an acknowledgment that a prudent groundwater modeler should acknowledge?

A Yes. And I think that it in a way he's not really justified for making that statement, because they didn't really characterize the hydraulics of the Met or inferred locations of these.

Q So did they map what you consider to be the major water conduits, such as faults?

A There are Met locations of these features and they did not hydraulically test them.

Q I see. Those would be faults and dike-breccia zones?

A Right.

MR. HAYNES: All right. The next slide, please.

Q Dr. Prucha, you reviewed the testimony of Mr. Ware who testified on behalf of Kennecott, who on page 3134 of the transcript testified that there had been no hydraulic testing in the Klasner fault zone. Now, just for the court's -- to bring the record current, tell us again what the -- what you consider the Klasner fault zone to be.

A Well, it's -- the way he mapped it it was a 500-meter-wide zone extending north-northwest between Eagle Rock and the orebody. And my understanding of the testimony by Mr. Ware was that they hadn't performed any hydraulic testing to confirm in sort of a conclusive fashion that these were -- there were no water-conductive features in that zone, nor did they do any flow metering, geophysical logging like they had done for the test wells that they had associated with a well pump test at 084.

Q And, Dr. Prucha, what should Kennecott have done in your opinion --

A I believe they --

Q -- concerning the Klasner fault zone?
A I believe based on, for example, the testimony by Dr. Karasaki yesterday that really seeing a fracture doesn't necessarily -- in a borehole doesn't necessarily mean that you're going to actually get water coming out of that; you actually have to hydraulically test that. So I think that's an important point to make here.
Q And by "hydraulically testing" do you mean intercepting the major water-conductive features in the zones of interest?
A Attempting to do that -- and I have seen a map that suggests that there are some boreholes in that location, but it doesn't seem to be a priority to have gone out there and hydraulically test the zones, so you really can't confirm whether there is or there isn't good, major hydraulic, you know, water-conductive features in that zone.
MR. HAYNES: The next slide.
Q Dr. Prucha, on slide number 5 of your presentation you have reviewed the testimony of Mr. Logsdon, have you not?
A Small portions of it associated with these two issues.
Q And did Mr. Logsdon say in his testimony that not much water would flow through the crown pillar?
A That's my understanding.
Q And did he also testify that the crown pillar will in effect remain saturated, therefore limiting the air flow --
A That's right.

Q -- through the crown pillar?
A That's right.
Q Now, in your view are these statements conflicting?
A It does seem like they conflict, because in one case you can't have it saturated and then have it dewater at the same time. And by the dewatering of those pores his implication is that the flow of water through that crown pillar area reduces to a small amount. So I think those conflicts in that statement, it's either one or the other.
Q I see. And to test the veracity of one or both of these statements, did you review the results from the FEFLOW model for the crown pillar -- or for the mine area?
A I did.
Q And on slide 5 have you presented the results of the FEFLOW model that was on the file submitted by Kennecott?
A Right. And that file name is located down on the lower left.
Q For the record that's "Eagle_97_base_Case_Version_01.fem"; is that right?
A That's right. And my --
Q And -- go ahead. I'm sorry.
A My understanding is that this is the one that was developed in December of 2007 and I believe that that had the latest adjustments for the crown pillar and that -- being adjusted in height.

Q All right. And would you then take the pointer and explain for Judge Patterson the results of this FEFLOW model developed by Kennecott in relation to the question of the saturation of the crown pillar?

A Right. And really the column I want to focus on is the one that says, "Percent saturation" second from the right. And this table basically outlines the model layers. The model is made up of layers and the layer number is on the left column. And the next two columns say "top elevation" and "bottom elevation" of that layer. And effectively the crown pillar, the bottom of the crown pillar at 327 and a half feet -- or meters is occurring in layer -- sort of the bottom of layer 3, and you can see in column -- the column that says "percent saturation" that it is partially unsaturated from their own code. But still my point would be that, you know, the results from the model show that you get between 60 and 210 gallons per minute, so a significant portion of that water comes from the overburden and effectively will come through that crown pillar area just based on this FEFLOW model that they performed.

Q And when you say for layer 3 of the crown pillar that there's 87 percent saturation, that means that there's 13 percent of the area has voids or --

A Has air in it, and air is starting to creep into the voids, but water still flows under those conditions.

Q I see.
A It may -- it just doesn't flow quite as much as if it's fully saturated. So if it said 100 percent saturation, that's the maximum -- you know, and it would depend on the amount of head, but that would -- okay? Yeah.
Q All right. And just for the record, Dr. Prucha, the table that you prepared that's on slide 5 is taken from the Kennecott model; correct?
A Yes. I prepared this table.
Q Right, but you -- but there is -- but the figures in -- the numbers in the table are derived from the Kennecott model; is that right?
A That's right.
Q You didn't make up these numbers yourself?
A I didn't modify the model at all; I just -- it was run and those were the numbers that it produced.
MR. HAYNES: All right. The next slide, please.
Q Dr. Prucha, when you reviewed the testimony of Mr. Ware did you review his testimony where he testified that he assisted Dr. Pope in developing Kennecott Exhibit 214?
A Yes.
Q And when -- you reviewed that exhibit, have you not?
A Yes.
Q And have you found in your view problems in that exhibit?
A Well, I did.

Q And what are they?
A I guess the issue I saw related to the development of the conceptual model for the bedrock flow system and then the bedrock flow model was that this 90-meter total vertical depth delineation between the upper bedrock and the lower bedrock, which is an important break in the bedrock and an important conceptual feature and it does affect the flow results. That depth seems to come into question. And this Exhibit 214 shows a series of fault traces at different levels that extend into the upper bedrock zone and those fault traces seem to indicate that you have fault trace -- a fault that extends through there.

In the bedrock model, in the conceptual model that was -- there was an implicit assumption that the faulting -- faults in that lower bedrock didn't extend up into the upper bedrock. And in my initial testimony I -- and the modeling that I had done before associated with that I had extended those faults because I thought those -- up to the overburden. I thought that was an important oversight in the conceptual model, and it just seemed interesting that this Exhibit 214 didn't -- wasn't taken into consideration in developing that 90-meter depth.
Q And in your view should that fault trace -- should it have been taken into consideration in the modeling that was performed by Kennecott?

A Right; I do think that. And I do think they -- this was just occasion for extending the faults that you see in the lower bedrock into the upper bedrock, even to the overburden.
Q Dr. Prucha, when you reviewed the testimony of Mr. Ware did you note that on page 3179 he testified that the fault displacement must be observed to verify its existence?
A Yes.
Q And do you see a problem with that testimony?
A I do.
Q And what is that?
A I don't believe it has to be -- that you have to demonstrate that it shows displacement to actually be a water-conductive zone.
Q Why is that?
A I think that the displacement could be, you know, two planes coming apart a little bit and water can still flow through those, and --
Q And what would you have done in view of your finding a problem with Mr. Ware's testimony?
A Attempted to more adequately characterize those fault zones and brecciated zones along with that, and then testing those hydraulically.
Q And did you observe that that was ever done by Kennecott?
A No.

MR. HAYNES: All right. The next slide.

Q We heard a lot of testimony about this -- the flow of -- through the system and the conceptualization of the flow through this groundwater system, Dr. Prucha. And you've reviewed the testimony of Mr. Ware where he described the conceptualization by Mr. Segerstrom; is that right?

A Yes.

Q And that is in -- that was in Intervenor -- I think Kennecott Exhibit 323; correct?

A That's what I remember, yes. It's on this --

Q Yes. And what is your understanding of the Segerstrom conceptualization as it relates to either surface or subsurface features?

A Well, I think the discussion was -- and these cross sections come from that paper and I -- my sense was that they -- that Kennecott was using this as a basis for their conceptualization and they were using it to describe the development of this Negaunee moraine and the general structure of the plains and also its relation to the Salmon Trout and the Yellow Dog River.

Q And in your review of the Segerstrom paper did you note whether or not Segerstrom Met the subsurface structures?

A I didn't see any indication of that, and I think that's kind of a big oversight because he was really limited to interpretations at the surface; whereas, the current data set that's available has a significant amount of subsurface information available.

Q And so in your view did Mr. Ware rely or over-rely on the Segerstrom conceptualization for purposes of conceptualizing the system flow?

A Yes. One other point I want to add is that I drew the yellow intrusives here and I put an arrow to the Eagle Mine. And I think what I see in the data set and being mapped by people like Klasner and even the Kennecott geologists is that there are other additional dikes throughout the area, and I think that this could easily have helped in the development of that whole Yellow Plains -- Yellow Dog Plains geomorphology and stratification, so --

Q In reviewing Mr. Ware's testimony, Dr. Prucha, did you note that Mr. Ware said that, "The Segerstrom report concluded that the hydrology of the principle aquifers in the area is controlled by the main drainage at the Salmon Trout River" on page 5052 of the transcript?

A Yes.

Q And do you see a problem with that view?

A I do.

Q And what is your -- what is your opinion about that view?

A Well, I didn't see anywhere that Segerstrom really gets into discussing groundwater. It really wasn't the point of this paper. So I think it was sort of stretching what

Segerstrom's paper was about. And he doesn't really even indicate that the Salmon Trout River is the main surface drainage in the Yellow Dog Plains. In fact it's the Yellow Dog River that the plains are named after that -- and that river was active throughout the whole glaciation period. And Segerstrom's trying to make a point that the Salmon Trout is more currently attempting to head up towards the Yellow Dog. But I would have probably improved on this Segerstrom conceptualization and not relied on it so directly; used more subsurface information, the current information to enhance that.

MR. HAYNES: All right. The next slide.

Q Dr. Prucha, we've had several witnesses for Kennecott and for the DEQ testify that the geology of nearby mines in the Marquette iron range is dissimilar to the geology at the proposed Eagle Mine. You've reviewed that testimony, haven't you?

A Yes.

Q And in your view considering the proximity of the nearby mines in the Marquette iron range, what would a prudent hydrologist or a prudent modeler do in relation to those nearby mines?

A I think it's -- a prudent hydrogeologist would not ignore that range of inflows and would look into what's causing that and what are the ranges and try and relate that back to the Eagle Mine.

Q And why would that be? Can you explain based upon the bullet points in slide 10 why a prudent hydrogeologist or modeler would look at those nearby iron mines?

A Well, I believe they're more similar than dissimilar, and there certainly are differences but I think some of the key features are the same in terms of the hydrology. And I think, for example, both bedrock systems or the metasediments -- both Eagle and the Marquette area have similar overburdens soil types and thicknesses, so they consist of outwash, sands and tills. That's an important -- probably one of the most important points, because the majority of water is really stored in those overburden sediments. They have similar climates, similar fracturing and dike intrusion in the area where I would expect brecciated zones to exist, offer conduits.

And I think the last point is that the mines in the -- in this Marquette iron mining district don't have a river running over it like at Eagle, so I think that's kind of an important distinction to make, that at Eagle you have -- you run a greater possibility of water coming directly into the mine by river leakage.

Q Dr. Prucha, we've had a lot of discussion during this hearing among modelers and hydrogeologists concerning the FEFLOW bedrock model calibration. You've testified in that

regard, and others have testified in that regard. And in particular Mr. Zawadzki testified regarding the calibration on page 4871 of the transcript where he said that he calibrated the modeling transient mode to the pumping test in hole 084. You've reviewed that testimony, haven't you?
A Yes.
Q And you've reviewed the modeling results as well, have you not?
A Yes.
Q And do you see problems with Mr. Zawadzki's statement?
A Right. I reviewed his presentation of the modeling results and --
Q And what problems did you see?
A Well, I have them numbered here, bulleted, but I don't believe he calibrated the natural flow conditions in the bedrock flow system; he calibrated to the pump test, but it seems to me that it would have been better to calibrate to the actual natural flow conditions so that you have an understanding of how that system changes once you start pumping.
Q And the second problem that you have with Mr. Zawadzki's calibration?
A Well, this kind of goes back to what Dr. Karasaki said yesterday, but they didn't calibrate both the bedrock and overburden flow systems simultaneously, and that -- as a

modeler that's a real important point, because that -- trying to disassociate these two zones with two different models leads to a lot of problems. And they didn't attempt to simulate the whole system as one. The whole system is one aquifer system.

Q And what about the density-dependent flow?

A Well, the reason I bring that up is because the FEFLOW code is capable of simulating density-dependent flow.

Q And tell us please for those of us who don't model for a living what density-dependent flow is.

A Sure. The fact that the TDS appears to increase with depth means the density of the water increases; it's heavier down at depth. This would have been nice to see what kind of effects occur when you're dewatering a substantial area for the mine. The density-dependent flow will be an important factor I think at some level.

Q And so having reviewed Mr. Zawadzki's calibration and considering the problems that you have identified, what should Mr. Zawadzki have done in his calibration?

A Well, I believe to calibrate the natural flow systems in the bedrock and overburden simultaneously, they should have started by characterizing the bedrock system better. I think they should have considered effects of all the major structural features that -- in that -- that have been mapped or inferred. They should have considered a direct

connection to the Salmon Trout River where their own maps show that the overburden is absent, and the Salmon Trout River goes right over it.
Q Let me stop you there for a moment. When you say the "overburden is absent" what do you mean by that?
A The unconsolidated soil that occurs over the bedrock, so the --
Q That is absent because of what reason? What causes its absence?
A Its erosion. And then the last two bullets, the -- they should have simulated the simultaneous flow in the bedrock and overburden, and then attempted to simulate the density-dependent flow. And that's probably more important when they do the -- you know, they pull the water down through dewatering and then watch it come back up.
Q And are these points that you've made points that are tasks that a prudent modeler would take in order to calibrate a model?
A Yes.
MR. HAYNES: The next slide.
Q Dr. Prucha, Mr. Zawadzki testified at page 4974 of the transcript that they pumped 1.6 gallons per minute during the pump test at well 84 and saw 195 meters of drawdown at the well, and he further testified that this pump test information was used to calibrate the Golder bedrock model.

Do you remember reviewing that testimony?
A Yes.
Q And do you find a problem with that technique and those efforts?
A Well, I -- as I testified before my main concern about that pump test was that it isolated a small fracture and that it was presumed to be the major water-conductive feature throughout the mine areas, which certainly is a lot bigger area that was actually tested. It doesn't appear to be the major conductor just based on the faults that were mapped, fault lines that were mapped. And the breccia zones.
Q And so what should Mr. Zawadzki have done rather than focusing on this small fracture?
A I think looked at more appropriate well testing locations and more rigorous hydraulic testing.
MR. HAYNES: The next slide.
Q Dr. Prucha, Mr. Zawadzki also testified on page 5032 of the transcript that he extended the mine workings 30 meters in all directions to be conservative and to take into account Dr. Carter's findings. You've reviewed the testimony, haven't you?
A Yes.
Q And do you find a problem with what Mr. Zawadzki testified about?
A I do.

Q And what is your -- what problems did you find?

A Well, in the review of the FEFLOW model input that we obtained this zone didn't appear to be continuous; the zone around the tunnels from the portal all the way down to the mine where it starts entering the mine. And I think that's important because it runs -- or limits the amount of water that could potentially come in from the overburden or near the surface down through that zone. In fact that was one of the modifications that I made in the original runs with FEFLOW, the sensitivity runs. The second thing was just it seemed in the Sainsbury report -- and I don't know the name or the number of that exhibit off the top of my head, but it seems he was suggesting that the zone of increased permeability several orders of magnitude was more like 400 feet around and not the 30 meters, which is about a hundred feet.

Q And would you agree with that suggestion from Dr. Sainsbury?

A It seems like that should have been tested. I'm not a rock mechanics person so I wouldn't know exactly what distance out.

Q And so in view of what Mr. Zawadzki said about extending the mine workings 30 meters, what in your view should a prudent modeler have done when testing this question?

A Again, it's the same point that I've been making before. I think they should have just simulated a combined model. And the reason I say that is that if they had included the overburden in this particular case they may have seen more drainage from shallow zones down into the mine workings as they dewater along these permeable zones, so --

Q Dr. Prucha, on page 4974 of the transcript Mr. Zawadzki testified that model results aren't really sensitive to the topmost model boundary because, as he says, "it doesn't matter." Do you have a problem with his view about that?

A I do.

Q And what is your problem?

A Well, when you assign the boundary condition that he did to the top of the bedrock model that he was simulating, he didn't simulate the overburden, so he made an assumption that it -- with a very simple boundary condition at the top and it requires specification of two different factors: one is you have to specify the level of water you think is in the overburden, and I didn't see any documentation to justify what he put in there or what the values were. The second factor is effectively a resistance or a -- you know, a conductance that allows the water to flow through at what rate from the overburden into the bedrock.

Again, there was no information I could see on how they -- what values they used, but there's no way that he could have calibrated the amount of water coming through because he didn't simulate the overburden. So these numbers

are really questionable and to me it says that the simulated amount of inflow, which is very dependent on the overburden and how you simulate that, really isn't realistic. It's just not realistic. And I really feel like they should have used the FEFLOW model just -- it's a capable code to simulate these conditions. They should have combined the overburden and bedrock into one model.
Q Dr. Prucha, we've had testimony from many witnesses about the sensitivity analysis of these various models, and in fact Mr. Zawadzki says that he performed various sensitivity simulations and that's on slide 17 of his presentation, which comes from Kennecott Exhibit 399, Figure 4. Have you reviewed that slide and that exhibit?
A Yes.
Q And what -- do you have a differing view from Mr. Zawadzki about the effectiveness of the sensitivity analysis performed by Kennecott?
A Yes.
Q And what is your view?
A Well, I felt he was biased in the adjustments that he made to the model input.
Q When you say "biased" what do you mean?
A Well, for example, in the graph that he showed here all of the changes that he made were to individual parameters in the model, and I think Dr. Karasaki yesterday mentioned that

he thought they should be in a combined fashion. And I -- my former modeling was in a combination, which means I didn't just adjust one parameter and see what happens and then go back to the BASECASE and adjust another parameter; I put all of those features in at once. And in a sense this is a worst-case scenario and I believe those changes were all very realistic. And I think he should have looked at the combination.

The second point was I think it's important to distinguish that in this graph it says "upper bound" and "lower bound"; that that shouldn't be confused with the upper bound model case that they ran, which -- they only ran this with the BASECASE model, so they didn't test the sensitivity on their upper end case; they only did it with a BASECASE model that simulated 60 gallons per minute. So if they'd run this with the 210 gpm or gallons per minute model, the one that had some faults in it, water-conductive features, that that would have produced even more significant changes I believe.

Q And that would have been -- the way that you would have conducted the sensitivity analysis is the way that a prudent modeler would have done this?

A Absolutely.

Q Is that standard operating procedure for modeling?

A Yes.

Q That was not performed here by Kennecott's consultants as far as you can tell?
A No.
Q Dr. Prucha, Mr. Zawadzki in his testimony on slide 18 of his presentation said that he simulated a three-kilometer-long, hundred-meter-wide fault zone 100 meters from the tunnel. Do you remember that, --
A Yes.
Q -- reviewing that in his testimony and in his presentation?
A Yes.
Q And in your view was that simulation an appropriate simulation?
A No.
Q Why not?
A Well, from the start I wouldn't have even really considered running that because you already know the results. And you know the results because the bedrock matrix conductivity starts out -- is specified as being pretty low. So you just -- if you put a high permeability zone and don't connect it to the mines, it's being limited by the low permeability rock between that fault and the mine opening. So there's really not going to be much flow through here no matter what you do to this fault. So it sounds like it's really permeable and that they tested this Klasner fault zone, but in reality the Klasner fault zone was 500 meters

wide; goes right through the access tunnel. And I believe that that is sort of misleading. What they should have done was connect it to a mine tunnel or a fracture coming off of the mine tunnel so that it has a way to essentially "hook up the pipes," to so speak.

Q All right. And just for the record, Dr. Prucha, the portion of Mr. Zawadzki's presentation was taken from Kennecott Exhibit 399, page five; is that right?

A Yes.

MR. HAYNES: The next slide.

Q Dr. Prucha, Mr. Zawadzki said that he "simulated two additional 'BASECASE' sensitivity simulations that extended the faults to the upper bedrock and the lower upper bedrock bottom contact." Do you remember seeing that in his presentation?

A Yes.

Q And reviewing that in his testimony?

A Yes.

Q And do you find problems with his technique?

A Yes, it's for the same reasons as the previous slide.

Q And why is that?

A Well, he uses the BASECASE model instead of the upper bound, so you really don't get a good sense of what it does to -- in a worst-case scenario. But he also specifies 120 meters total vertical depth and I'm wondering why wouldn't it be maybe 200. I believe he should have done a simulation that combined these effects.

Q And why would 200 meters total vertical depth be more appropriate than 120 meters?

A I'm not saying it's more appropriate; I just think that that would have been testing a bigger zone that's possible in my opinion. I didn't see the justification for choosing 120.

Q And is there a reason for choosing 200 then?

A When I looked at some of the electrical conductivity logs it seems like it's possible that that could extend down. I didn't see any indication that that 90-meter depth break between the upper and lower bedrock was -- had been defined accurately.

Q And so rather than simulating these two additional BASECASE scenarios, what should Mr. Zawadzki have done?

A I just question why he used 120, but ultimately he should have combined the effects of all of these modifications, so changing that depth, adding -- extending fault lengths.

MR. HAYNES: Your Honor, one moment if I may. Thank you.

Q Dr. Prucha, Exhibit 29LL from the Part 31 case is -- shows the prediction -- shows the FEFLOW model under-predicts most of the mine inflow; is that right?

A Yes.

Q And you have put up here on slide 18 a longitudinal section

of the mine workings. And can you explain for Judge Patterson what the relevance of this figure is?
A Sure. When I looked at the simulated drawdown plots that were provided in the reports -- and I don't recall exactly what report off the top of my head, but I think in Exhibit -- the one in parenthesis it says "Exhibit 29LL"; that should be "29QQ."
Q I see.
A But that simulated drawdown appears to be inadequate to actually drop the water table down into the -- you know, so that it's below the access tunnel.
Q And what's important about drawing the water table down below the access tunnel?
A Well, I would expect a lot of inflow into that mine and it's not being accounted for in the mine inflow estimate. And from my -- just looking at the plan view plots of the drawdown and then looking at this cross section, and they have on here one horizontal line that represents the upper and lower bedrock contact at 90 meters total vertical depth, I come up with about a hundred feet of simulated water level above that tunnel. And all I can think is that they're not simulating enough drawdown, which would only increase the mine inflow if you actually did draw it down below the mine tunnel.
Q I see.

A So this is another scenario where I think they should have done a combined bedrock and overburden simulation.
Q To more accurately predict the mine inflows?
A Right.
Q I see. Now, on the next slide, which is number 19 -- you've reviewed the testimony of Dr. Council; is that right?
A Yes.
Q And Dr. Council testified that the drawdown in the wetlands could be as -- up to six inches -- from six inches up to several feet in the upper aquifer. Do you remember that?
A Yes.
Q And do you find a problem with that statement?
A Yes.
Q And what is that?
A Well, I think he fails to consider the potential for direct connection of the bedrock, especially the brecciated dike zone, which is in this area of the mine; it's connection to the stream and wetland, and --
Q All right. On slide 19 you've attached Figure 13 from Appendix B-1 to the EIA, which is the Quaternary Deposit Isopach. By the way, what's an isopach?
A It's the thickness that unit.
Q All right. And can you show on this figure where the bedrock connection is to the stream and wetland?
A Well, I would expect that just based on this drawing -- what

this drawing is showing is these contours represent different thicknesses of the unconsolidated material overlying the bedrock. And where it says "zero" here over this large area they're -- basically the conclusion there is that there is no soil, so bedrock's right at the ground surface. And the stream, you can see the Salmon Trout River going right through that over a fair distance, but I would expect that to be a zone where bedrock would be in direct contact with the stream. And I don't think they did adequate characterization or testing to even look at whether the current bedrock system is being influenced hydraulically by the stream, but I would guess it could very well be.
Q And in your view would a prudent modeler take that into account in modeling the effects of the drawdown on the wetland and the stream?
A Absolutely.
Q Dr. Prucha, you've reviewed the testimony and the presentations of Mr. Zawadzki and Mr. Wozniewicz; correct?
A Yes.
Q And in your view did they simulate worst-case predictive scenarios of mine subsidence?
A I don't -- I didn't see that.
Q All right. And what do you define as a worst case from a modeling standpoint?
A Well, I couldn't imagine a case going beyond that based on

reasonable assumptions about the system.
Q And did they simulate worst-case predictive scenarios of increased permeability?
A Associated with?
Q Associated with mine subsidence.
A No.
Q And did they simulate worst-case predictive scenarios of direct connections to the Salmon Trout River?
A No.
Q And in your view did any of the models that they performed do these worst-case scenarios?
A No.
Q And what should they have done?
A Well, I think they should have simulated potential subsidence in the area and looked at its impact to the Salmon Trout and estimated what could be coming in as a maximum amount of inflow.
Q And in your view would that be prudent because of the proximity of the Salmon Trout River to the proposed mine?
A That and because other nearby mines had had that problem and generated lots of inflow.
Q Now, Dr. Prucha, for slide 21 you have prepared a figure that shows various -- has various lines and figures drawn on it around the proposed mine area. Can you explain for Judge Patterson what this is?

A Well, this is a map that -- I just have this information in the Geographical Information System which is a mapping software you can effectively line up things. I think I testified to this originally. But the idea here is that the fact that, you know, Klasner's mapped faults here and other folks have mapped fault lines and dikes through this area -- this is superimposed on the surface topography where the darker green colors are lower elevation and the lighter white areas are topographic high, that it didn't seem like there's an explanation for the topographic high in terms of shallow groundwater levels up towards this area and how the structures could possibly influence that.

Q And could you for our benefit explain the various colored lines that appear on this figure?

A Well, the orange ones are the --

Q Let me back up. Tell us again where you derived the information that you plotted on this figure.

A Well, from several sources. One is the DEQ's website, GIS, and then the Klasner information I got from his report. And the well points here that are shown in different colors are from the maps that I -- the reports that I reviewed.

Q The reports prepared by Kennecott and its consultants?

A Kennecott; right. And the red lines here represent my input here that follow surface drainage features. And I guess one of the main points to this diagram was to -- I'm still perplexed about the -- in general as a hydrologist you run with theories where shallow groundwater generally tend to mimic the surface topography and what I see here is the Salmon Trout River here going by the mine ends up going up the north along the stream and that drainage is pretty well defined. But there is another drainage feature that heads off around to the east and down to Yellow Dog River, and it seems like those -- that depression is actually larger topographically than the Salmon Trout River. In fact a wetland comes up into this area. And one could argue just based on the faults-and-dike structure that Klasner has drawn here that that feature has been developed, as the Kennecott geologists have suggested. And it doesn't seem like these features were really considered in the development of the conceptual model or the numerical model. But it does show a drainage feature going towards the south.

Q And would a prudent modeler have taken these features into account in doing the modeling for the proposed inflow to the mine?

A Yes. I mean, it is -- I think as Dr. Karasaki pointed out yesterday, we always want more data to get a better understanding of what goes on below the surface. But in this case I'm trying to point out that there are obvious data that don't really cost too much money that you should be taking into account in trying to correlate. In a lot of

cases I've been involved with these features are pronounced and they're generally correlated with subsurface structures.
Q And was that the case here?
A Well, I don't believe that they necessarily considered that in their conceptualization.
Q Okay. Now, Dr. Prucha, slide 22 contains another figure that -- did you prepare the figure on slide 22?
A I did.
Q And what did you -- where did you derive the information shown on the figure on slide 22 from?
A Well, basically it has the same information that I had on the previous plot that I described, but in addition I added dikes as mapped by Klasner to the south of the Eagle orebody.
Q And how are those dikes represented on this figure?
A As the large red lines that extend here for miles and keep going off to the west.
Q These are lines that seem to trend east and west?
A That's right. And it's kind of a coarse depiction. I mean, I had to go off of his old report and try and bring that in and line it up. But in addition the purple lines are the lines -- represent dikes that were mapped by Kennecott geologists.
Q These are the purple lines that trend east and west?
A East and west. And then there are dark red lines here

heading off to the northwest. And I think I've shown that before. Those are faults that were mapped by the Kennecott geologists. And of course, then I have the Klasner information in here in the -- looks like this is dying. There you go. So I will add that these lines heading off to the northeast were lines that I drew.
Q And why did you draw those lines?
A Well, the intent of those was to kind of follow up on the suggestion, not just by the Kennecott geologists, that the drainage features and Yellow Dog Plains and the area generally are -- you know, their belief is that they're aligned because of the faulting in the area, major structure, but you know, in other reports that I've read in the area that seems to be the case too. So I took these lines and aligned them with drainages as possible inferred fault locations. And it seems like in some cases they can justify the abrupt 90-degree-angle turns on things like the Salmon Trout River.
Q And why would the -- why would there be a relationship between the abrupt 90-degree-angle turns on the Salmon Trout River and these inferred faults?
A The basis is that those are large structural features that happened a long time ago and as the basin develops the things like the rivers tend to follow those lines.
Q I see.

A And I just didn't see that even this level of an attempt to identify features like this was made, so the location of the boreholes and testing didn't seem to want -- you know, wasn't designed around identifying impacts of these possible features; and yet, I think they -- as Dr. Karasaki pointed out yesterday, they can dominate the flow field.
Q And in your view an effort similar to the one that you performed here on slide 22 would be sort of an elementary first level attempt at characterizing the subsurface structures for purposes of modeling groundwater inflows to mines?
A Yes; yes. Given the importance of faults and the dikes, which have brecciated zones around them that can be there. But this is certainly, you know, a complicated diagram; shows a lot of information, but I just didn't get the sense that this was taken into account in the characterization or a conceptualization or the modeling.
Q Now, Dr. Prucha, did you review the testimony of Mr. Chatterson from the DEQ?
A I did.
Q And did you review the testimony of Mr. Chatterson on pages 7509 and 7510 of the transcript where he testified that the model -- or the predicted mounding effect on Rico Torreano's property was -- in his view there would be no appreciable impact on Mr. Torreano's property?

A Yes.

Q And what is your view of his -- of Mr. Chatterson's testimony based upon your review of the documents in this case?

A Well, I believe that you could see impacts at his property and that they would increase the amount of flow that you would have going through that area.

Q And would you expect, based upon your review of the documents in this case, to expect an observable impact on the Mr. Torreano's property from the mounding from the TWIS?

A Yes.

MR. HAYNES: At this time petitioners move to admit as substantive evidence from the slides presented by Dr. Prucha the FEFLOW model results table on page five. If we could go back to that, please. And that would be Petitioner's Proposed Exhibit 192.

JUDGE PATTERSON: I'm sorry. 192?

MR. HAYNES: Yes. We move to admit that exhibit.

JUDGE PATTERSON: Okay. I'm waiting for --

MR. LEWIS: Well, I'll object. As I understand it this is new information, a new table that Dr. Prucha created. We were given no opportunity to -- we didn't have this beforehand; we had no opportunity to review the data on which he claims to have relied for this, so no opportunity to cross-examine on it. And I think if counsel's intent had been to submit this as substantive evidence they would have given this to us in a more timely manner and -- so that we could have examined it ahead of time.

MR. HAYNES: Well, your Honor, we presented this to counsel yesterday as part of the rebuttal slides for Dr. Prucha. And the figures are taken from Kennecott -- or the numbers here on this table are taken from a Kennecott model, so it's really -- it really should be no surprise to counsel.

JUDGE PATTERSON: It's just a recompilation of --

MR. HAYNES: It's a compilation of their data.

JUDGE PATTERSON: That was my understanding.

MR. HAYNES: Right.

JUDGE PATTERSON: I'll overrule the objection and admit Petitioner's 192.

(Petitioner's Exhibit 632-192 received)

MR. HAYNES: Next petitioners move to admit from slide 21 -- if we can go to that slide -- the figure prepared by Dr. Prucha that he -- as Petitioner's Exhibit 193. The data shown on this or the figures shown on this slide as he testified were developed from either Kennecott data or data that's available on the DEQ website, and for that reason it's available data. And also from the Kennecott -- materials from the Kennecott data. So since it's available data, available to all sides we move to admit it as Petitioner's Exhibit 193.

MR. LEWIS: Same objection, your Honor. And I would add to that; when I was presented with these slides I assumed it was -- these were going to be offered as demonstrative evidence, and again had no indication that counsel intended to offer any of these as substantive evidence in this case. Secondly, as to the foundation, I believe that Dr. Prucha -- I may be wrong, but I believe Dr. Prucha added these red lines at least, and I don't think there's been any foundation for whatever he said or meant to say with those red lines.

MR. REICHEL: Your Honor, may I voir dire?

JUDGE PATTERSON: Sure.

VOIR DIRE EXAMINATION

BY MR. REICHEL:

Q Dr. Prucha, you said that you took some of this information from the DEQ GIS or Geographic Information System website, is that correct?

A That's what I --

Q So what type of information? Is it just the base map basically?

A I think in this case that the den, the topo information.

Q So that was the only source?

A That's right, but it's --

Q From the DEQ?

A I believe for this particular figure, right.
Q And when did you --
A Well, actually the roads that you see on here I believe also were from that.
Q Okay. But basically you're talking about the geographic features as opposed to the colored fault lines, your red line that follows the Salmon Trout River, et cetera?
A Yeah; that's right.
Q Dr. Prucha, when did you prepare this document?
A This document or the figure?
Q The figure. I'm sorry.
A The figure, yeah. In the preparation of this rebuttal testimony, so over the last couple of weeks; I don't recall the exact day.

MR. REICHEL: Your Honor, in addition to the objection raised by Mr. Lewis in looking at the substance or the content of this -- first of all, it's not immediately clear to me that this properly characterizes rebuttal. I mean, to a large extent this appears to be a rehash of some of the testimony offered by Dr. Prucha in their case in chief several weeks ago. There's nothing on this figure, as far as I'm able to determine, that is truly rebuttal to any testimony offered by either Kennecott or by the DEQ. In other words, this is something that is simply just trying to reiterate or bolster Dr. Prucha's opinions in their case in chief. I don't think this properly characterizes rebuttal.

MR. HAYNES: Well, your Honor, on the other hand, in response to the objections: First, a great deal of effort was expended by the Kennecott witnesses to deprecate the Klasner mapping of the various faults, and so this exhibit is an effort to show why the Klasner mapped dikes and faults are relevant to a modeling exercise here. So it's directly responsive to the evidence submitted by Kennecott and the DEQ. Secondly, as to the generation of the various figures shown on this -- the lines and so on. As Dr. Prucha testified he inferred some of the lines, like the red lines showing the drainage areas, drainage patterns; otherwise, this is information that is either readily available, or taken from the Kennecott information.

So in that sense it is truly a rebuttal exhibit meant to meet or explain or rebut the testimony of in particular Kennecott witnesses who, as I said, deprecated the Klasner study as somehow irrelevant to this entire exercise that we have before us. So we think it's entirely rebuttal.

JUDGE PATTERSON: All right. I'm going to overrule the objection and admit. So P-193?

MR. HAYNES: That would be 193, your Honor.

(Petitioner's Exhibit 632-193 received)

MR. HAYNES: With that I have no further questions at this time.

JUDGE PATTERSON: Okay.

MR. EGGAN: I'm prepared to proceed, your Honor, with some additional questions for Dr. Prucha.

JUDGE PATTERSON: Okay.

MR. EGGAN: Bear with me, Judge.

JUDGE PATTERSON: Okay.

DIRECT EXAMINATION

BY MR. EGGAN:

Q Dr. Prucha, I have some questions too related to groundwater related issues and we're looking at slide number 24 which is simulated -- titled, "Simulated groundwater mounding." Can you talk about that a little bit and why this slide is here?

A Actually, I think that might have been related to this issue about Rico Torreano. I think that was a graphic that we wanted to have on that. And this was the simulated output from the recent GeoTrans model for the BASECASE and I was asked whether the Rico Torreano property would be impacted. And I think one thought just in looking at this diagram is that if the upper bound case had been run, then I would expect more of an impact in that property area.

Q Okay. We can move on to the next slide then. All right. Let's go ahead then and talk now about discharge permit issues. And just to give a preview of what it is, some of the issues we're going to be talking about, we're going to

be talking about an issue that you thought was important in your direct testimony -- two issues: characterization and conceptualization. What are we going to be talking about with respect to that? Again, just an overview of what we're going to be talking about.
A Well, basically how they characterized the hydrogeology beneath the TWIS and the groundwater flow conditions beneath the TWIS, where that water flows to: seep areas, downgradient.
Q And we're also going to be talking about modeling I take it?
A That's right.
Q And the mounding issues, the flow direction and velocity as well as the discharge location?
A That's right.
Q I think we're also going to talk a little bit about the monitoring, aren't we?
A That's right.

MR. EGGAN: Okay. Let's go ahead to the next slide.

Q Before we begin the next slide, Doctor, I need to ask you just a basic question about the information you read. And it sounds like you read a lot of testimony from witnesses who testified in Kennecott's case and the Department of Environmental Quality case. Is there anything in the information you read or the materials that you reviewed that would have led you to change the conclusions you offered in your direct testimony?

A No.

Q Okay. So that testimony from your perspective remains the same; we don't need to repeat it or modify it?

A That's right.

Q Okay. Then let's begin with a statement by a Department of Environmental Quality witness, Mr. Eric Chatterson. He indicated that there is not going to be mounding beneath the treated water infiltration system. First of all, that comes from page 7505 of his testimony. What is your observation with respect to that? Why is that issue important in this case?

A Well, I think as he points out --

MR. REICHEL: Well, I'm going to interpose an objection here to the -- I don't think there's a foundation for counsel's statement that Mr. Chatterson testified there wouldn't be mounding beneath the TWIS in reality or in the transcript, including the page cited on the slide that was written by Dr. Prucha or counsel. In fact, if you look at page 7505 of the transcript there's no such statement.

Q Dr. Prucha, you pulled that statement out. What is your thought?

A It's Respondent Exhibit 189, page eight that this text comes from, and then 7505 is from the testimony.

MR. REICHEL: Well, maybe we need to read it back, but, your Honor, my -- Mr. Eggan's initial question I believe stated as a premise that Mr. Chatterson had testified that there would not be mounding beneath the TWIS and that there is -- that is absolutely without foundation.

Q Dr. Prucha, let me show you page 7505 and ask you to find that reference for us.

A Of course, that was sort of paraphrasing, but I believe if you go back to page 7504 the one question on line -- starting line 18 starts talking about groundwater perching over some clay lenses or clay formations and that the -- in the vicinity of the proposed TWIS. And then on 7505 it continues and I think the question goes into asking Mr. Chatterson about whether that's possible.

Q Let me -- maybe I can --

A I can read it exactly.

MR. REICHEL: Well, your Honor, the question was mounding. Mounding is not perching. The word "mounding" does not appear in that transcript; there was no foundation for the question.

MR. EGGAN: All right. Hold on, Mr. Reichel. We'll get this corrected.

Q Mr. Prucha, maybe a better way of phrasing this -- how about if we ask it this way? Mr. Chatterson indicates that there won't be an issue pertaining to groundwater collection in the area above the non-permeable layer. Does that make sense?

A Yes.

Q Is that a more -- is that more accurate in response to Mr. Reichel's concern?

A Or we could just use the word "perch" as well, --

Q "Perch." Okay.

A -- which is what is stated here.

Q All right. Well, let's go ahead with that then. Mr. Chatterson indicates that there won't be perching beneath the TWIS, and what is your observation?

MR. REICHEL: And again, I don't think that's an accurate representation of the testimony.

Q Well, let me ask you this: Would Mr. Chatterson stipulate then that there will be perching in the area above the TWIS -- beneath the TWIS?

MR. REICHEL: Counsel, this is not a question of stipulation. You asked a question; I'm saying there's no foundation for it. The transcript at 7505 speaks for itself.

MR. EGGAN: It does and at 7504 and 7505 there is clearly a discussion and Mr. Chatterson's view is that there will not be this perching effect that will occur in the area beneath the TWIS.

MR. LEWIS: I think, your Honor, if counsel wishes to pose questions based on prior testimony that there ought to be some care in what that testimony is. And secondly, I would suggest that if Mr. Prucha wants to offer, again, his views on perching that that could be done with a question simply soliciting or asking him to again restate his views on perching and we can avoid this argument.

MR. EGGAN: And that's absolutely right. And I'd be very happy to do that, but every time we've attempted to do that we have had an objection suggesting that we are not engaged in rebuttal; that we are engaged in repeating testimony that has been offered in the direct case. And so we simply wanted to make a reference to the witness who talked about this issue. And we even provided a transcript page where the issue was discussed. And so that's where this is going and --

MR. REICHEL: And which has mischaracterized the testimony.

MR. LEWIS: I'm just suggesting --

MR. EGGAN: Well, it has not mischaracterized the testimony, Mr. Reichel. If you look at 7504 and 7505, it doesn't say that. What it says is a series of questions related to perching in that area beneath the TWIS. Absolutely does; you know it does.

MR. REICHEL: Well, we can -- the line of questioning, your Honor -- and we can bring this out -- is whether or not there would be perching that would cause water from the TWIS and possibly break out to the surface. That is not mounding.

JUDGE PATTERSON: I don't have the testimony in front of me.

MR. REICHEL: I can show you the transcript, your Honor.

JUDGE PATTERSON: Okay.

MR. EGGAN: Well, we've got the transcript right here and you -- we may want to look at 7507 and 7508. Look, I don't think that there is a dispute here, because I think that Mr. Chatterson has testified -- and I know you would agree -- that there is no perching that occurs, in his view, beneath the TWIS.

MR. REICHEL: Mr. Patterson's testimony -- excuse me. Mr. Chatterson's testimony was to the effect that there would not be water breaking out to the surface.

MR. EGGAN: And that is the issue that we would like to go into. And the reason that he said there will not be water breaking out to the surface is from his perspective this non-permeable layer, from his perspective, doesn't exist. Dr. Prucha has testimony that he wishes to offer that is contrary to that. And that is not mischaracterizing the evidence or the testimony, Mr. Reichel.

JUDGE PATTERSON: I don't recall Mr. Chatterson denying the existence of those potential clay lenses. I think his opinion was just that those wouldn't cause any significant perching that would reach ground level.

MR. EGGAN: That would reach the ground level; that's correct.

JUDGE PATTERSON: Right.

MR. EGGAN: Well, we would like to counter that, your Honor. Dr. Prucha has some thoughts on that and we would like to be able to offer --

JUDGE PATTERSON: Okay. I've read Mr. Chatterson's testimony. Go ahead.

Q Dr. Prucha, let's go ahead with this. With respect to this issue of perching, you've indicated that there is a reference in Respondent Exhibit 189 related to this. Let's talk about it.

A Okay. This text I pulled directly out of that basically indicates that --

Q Directly out of?

A Directly out of Respondent Exhibit 189 on page eight. And it says,

"Upon entering the subsurface environment the discharge is expected to perch on top of the low permeable deposits that have been identify as transitional deposits located directly below the discharge area at approximately 50 plus feet below

ground surface."
Q Go on.
A "These low permeability -- low permeable deposits may be present across some of the southwest portions of the discharge area but do not appear to be present in the downgradient flow direction northeast."
Q Very good. Does what we read in Exhibit 189 -- is that consistent with the testimony that you believe was rendered by Mr. Chatterson?
A Not the way I understood it.
Q Why?
A Well, because of the wording. It just seems like he's indicating that he doesn't believe that the groundwater will perch above these low permeability units that he's identified in this Respondent Exhibit 189. He does go on to say he doesn't believe that they'll mound at the surface, but I think offer some additional information towards that.
Q Okay. What should he have done?
A I believe he should have acknowledged that those exist in his testimony and that that should have been something that he looked at in the assessment by -- in the discharge permit application and how that might influence the mounding and flow from the TWIS, away from the TWIS; being discharged at the TWIS.
MR. EGGAN: Let's go on to the next slide.

Q In his testimony, I asked Mr. Chatterson about some contour maps. And your testimony was that the groundwater in those contour maps actually shows groundwater some 30 feet above the surface of the ground. When I asked Mr. Chatterson about that, he indicated that that was acceptable. What is your -- do you have an opinion as to that -- on that issue?
A I do.
Q What is your opinion?
A Well, I think that's incorrect and misleading. I don't think it's a standard industry approach. I've never seen that, especially where you have acknowledged information in various reports that the seeps are groundwater discharge. And as such, you know their groundwater elevations. You have a surface topography. You know where they come out. They're effectively known as contact springs. The conceptual models that have been presented in the reports don't indicate any potential for developing artesian pressure, or they don't have a confining layer over it so that that would allow the pressure below there to somehow rise above ground surface.

I just think, in the area where the groundwater seeps out to the north -- as they say, "seep" -- I don't see any evidence for groundwater -- any rationale for groundwater being 30 feet above the ground surface. And I think the most important point is, as a hydrogeologist, you want to develop the most accurate possible groundwater flow map -- groundwater potential metric map, a map of the groundwater surface, and that allows you to understand where groundwater is actually flowing to. From those maps you actually can draw flow arrows, indicating where the seeps come out.

Now, if it's 30 feet off at the drainages, you're not indicating where that groundwater flow actually goes. It's incorrect at a variety of levels and to use this information as sort of one of the fundamental inputs to models in developing conceptual models and then the numerical models. So if this is flawed, the whole series of analysis after that is flawed.

Q What do you think they should have done? When you see that sort of condition on the contour map, what should they have done?

A Well, he talked about some hydrologist's map contours going back upstreams. I think in every case I've ever seen you want to do that to reflect the fact that the groundwater is below the surface, as in this case here.

MR. EGGAN: Can I go back one slide, Jan?

Q Dr. Prucha, I want to just correct one minor thing with respect to your reference to a statement by Mr. Chatterson regarding the perching issue that we talked about. You referred to Respondent Exhibit 189 at page 8. It's actually --

MR. EGGAN: Your Honor, this is correcting -- it's a typographical error there. It's 198. It's Respondent Exhibit 198 and not 189.

Q Dr. Prucha, there was some testimony from Mr. Chatterson related to the contours. And the Department of Environmental Quality rules appear to require contours and contour mapping that show 1-foot contour intervals. He indicated it was acceptable to accept the 10-foot groundwater contours. Do you have an opinion about that?

A Yes.

Q What is your opinion?

A I think the 10-foot contours are too coarse. And I think the observed data that was contoured up into potential metric maps or groundwater surface maps and the simulated maps in several cases were just too coarse to actually determine what the flow directions were in key areas like the mine dewatering or the TWIS infiltration area. So I think those -- one easy way that I've, you know, addressed that in reports that I've done is to just simply zoom into those areas and make a map that provides more detail at --

Q Well, that, I think, was Mr. Chatterson's response when I asked him. He said, "Look. You really can't -- if you accept 10-foot -- 1-foot contours in an area like this, you're just going to end up with one solid line." What is your thought on that?

A Well, I think you --

MR. REICHEL: Objection to the form of the question. I didn't think he said 10 foot. He was talking about 1 foot, Counsel.

MR. EGGAN: You're right. He was. Let me rephrase.

Q I indicated that, if you -- he was indicating that, if you utilized 1-foot contours, that it would just end up as one solid dark line and be virtually impossible for someone like him to read. How would one handle that?

A By creating a zoomed-in plot of the key areas at -- with contours at an appropriate level to reflect what you think the flow directions actually are and what the levels of the groundwater are and what controls those levels.

Q The next slide, sir, slide number 29, is titled "Hydrogeologic Characterization." And it's got quite a bit of information on it, and it -- what it relates to is testimony from Mr. Wiitala indicating that he really sees no southeast gradients -- gradient on his maps. Let's talk about that. What -- let's deal with the area on the left-hand side of this slide first, the area that shows the map with the contours on it. First of all, where did that figure come from?

A Figure 29, Appendix B-8 in the EIA.

Q So this is material submitted to the Department of Environmental Quality?

A Minus a couple of arrows that I've drawn on this map and then the text labels.

Q All right. Why don't you -- using that as our background, why don't you explain what this is and how this relates to Mr. Wiitala's claim that he sees no southeast gradient on his maps?

A Well, this green boundary right here is the boundary of the TWIS and --

Q And that's the small green rectangular boundary area?

A Right. It's oriented lengthwise to the northwest. And that's superimposed on a series of light-blue contours, which represent the -- I believe it's the A zone groundwater levels. Actually, it might be the D zone. The -- and these red lines are inferred groundwater flow directions that show flow going up to the northeast. But keep in mind that we have no data up here at all, so this is --

Q So we have no data up to the northeast?

A Right. So these lines aren't dashed, but they should be to indicate that this is really inferred up in this direction. It's -- to the level of the groundwater. And then this green line that I've placed here -- well, actually, let me start with the two red lines. These are approximately in the direction and location of the cross-sections -- not direction but the locations of the two cross-sections that I show on the right.

Q All right. Let's talk about the cross-sections, then, that you have provided on the right. What are those cross-sections, and where do they come from?

A Well, these are sections EE prime and FF prime. I don't recall the exact figure numbers, but they're from Appendix B-8 in the EIA.

Q Very good.

A And these are two cross-sections that show several boreholes and the geology interpretation and a groundwater table in dark blue. And these cross-sections are slices or profiles along these -- approximately on these two red lines here. And I have shown two yellow arrows here, indicating the groundwater gradient is in this direction or the slope is off to the southeast. So these cross-sections are viewed as though you're standing in the southwest -- southwest of the TWIS looking to the northeast.

So the left side of this cross-section is up here on the northwest side, and the right side is on the southeast side. And I clearly see a strong gradient from the northwest to the southeast, and yet the flow arrows here that were shown on this original diagram show a groundwater gradient heading to the northeast that are developed based on available wells in this area southwest of the TWIS. But the important point that I want to make here is that, when you look at the degree of the slope going to the southeast, it's actually almost twice the slope going to the northeast. And to me that means that the water is -- if you add up those two slopes, that there's going to be a greater slope that results from those across these -- the length of these two cross-sections heading to the east, southeast.

So that's what I used to justify my original testimony that I believe the gradient could be east of southeast in this area. And remember, there's just no data in this area or to the south to confirm away from the TWIS that the groundwater gradient doesn't continue going east, southeast.

Q Now, I've asked several witnesses about the absence of data between the TWIS and the seeps. How would that data have assisted us in determining groundwater direction?

A Could you repeat that question?

Q Yes. I've asked several witnesses in this case --

A Yeah.

Q -- about the absence of monitoring points between the TWIS and the seeps, --

A Right; right.

Q -- that area up -- that you're referring to up to the northeast.

A Up northeast, yeah.

Q Yeah. And what I'm -- and you just mentioned it in your -- and made reference to it.
A Uh-huh (affirmative).
Q Would information, data points, monitoring wells in that area have assisted us in determining the groundwater flow direction?
A Yeah, I -- yes, I believe that you would have determined a couple of very important things. One is, do the low-permeability units that you see beneath the TWIS actually pinch out, as being suggested, without the aid of data, and what happens to the groundwater? Does it really continue down like this, or is there perching to the north?
Q All right. I want to just focus in on these cross-sections we have on the right-hand side of this slide. Those are cross-sections that are from Figures 24 and 25 of Appendix B-8, information provided by Kennecott to the DEQ; is that right?
A That's right.
Q And the yellow lines there that -- the yellow arrows you have there showing the gradient, what direction does -- do those yellow lines show in terms of groundwater flow?
A Well, they're facing in the direction of these red arrows that I've shown on this plan view diagram on the left, and they point to the southeast.
Q How could they have done this directly and done it better?

What should they have done?
A I guess that brings into question the methodology for developing the groundwater surface maps. But in general I think they should have improved the characterization and conceptualization and then the modeling of this area, and it should have included this kind of information.

MR. EGGAN: Next slide, please.

Q The next slide is titled "Wetland Characterization." And there was testimony from Mr. Wiitala related to wetland piezometers and stream hydrographs. What is it about the information that you've provided on this slide down on the left-hand slide that you wish to comment on?
A Well, on this slide he shows the water elevation and --
Q All right. Let's first identify where this -- there's information down in the left-hand corner of our slide, and we need to tell Judge Patterson where that came from.
A This is page 38 in Wiitala's -- Mr. Wiitala's presentation.
Q It's page 38 of Mr. Wiitala's slide show; right?
A Right.
Q Okay. Go ahead. Now, what does that depict, and what is your thought on that?
A Well, his plot shows water elevation data. And on the left column it's water elevation in feet above mean sea level, and on the bottom axis it's months. I guess they're not at every point. They're jumping in months. But this shows the

wetland piezometer 025 and the stream gauge 011, and it plots in time the change in the water levels at these two locations. And at the wetland piezometer they show the water level that they've measured at different depths below the water table.

And I guess the problem I have with this is that they show an intermediate and upper level at 1 foot and 4-1/2 feet, so the purple dot -- I don't know exactly what color that is -- and the red line -- seem to be at a lower elevation than the stream, which is plotted as a dark purple line that seems to overlap this green line, which is the water level in the lowest piezometer at 9-1/2. But I guess what bothers me about this is I don't see how that's possible, because you have the groundwater discharging to the stream as it passes by the mine. And this stream gauge 011 is several-hundred feet downgradient past the mine. Wetland well 025 is east of the mine in the wetland.

And to me it just suggests there is a data accuracy problem, because I can't imagine how you could have a lower -- what this suggests is that the stream is actually flowing towards the wetland well by this data, so I'm not quite sure how that happens in almost any scenario.

Q What should they have done to handle that issue?

A I think they should have checked the survey data. I mean, this to me would have -- I would have really questioned. I can't think of a conceptual picture that explains that behavior so -- and it -- you know, giving the importance of wanting to know how mine dewatering might affect the wetlands, I think that was -- that would be an important thing to do.

Q There was testimony by Mr. Chatterson indicating that, "2-dimensional groundwater contour plots provided by Kennecott were adequate to show a 3-dimensional flow path." There is a rule that the MDEQ has that requires an applicant to provide information evidencing the 3-dimensional flow path. That was not done here. What is your comment on that issue?

A Well, it is complex to try and show a 3-dimensional flow path on a 2-D piece of paper but -- and I agree to some extent that you -- you know, I've seen this in the past where you want to show contour plots to show 2-dimensional groundwater flow paths. But you really have to provide two contour plots, one in plan view and then one in profile and recognize that those represent just two planes and not the full 3-dimensional picture. And I guess, when I looked at things like the Golder -- Golder's model of the TWIS mounding, it was oversimplified. And they presumed a northeast flow direction to start, so right there they're not even predicting -- the model's not even predicting a flow path.

But the second point is that they did provide contours in a 2-D -- and arrows in a 2-D plan view, but they never provided arrows on a third profile. So somebody left reviewing this is left on their own judgment to assume where they think the flow might be going. And this Golder model is oversimplified so -- in my mind, and I think it wasn't really attempting to try and determine that flow path.

Q When you say, "The Golder model was oversimplified," which of the Golder models are we referring to?

A This would be the one developed, I believe, in 2006 as part of the discharge permit.

Q Now, does this relate to shallow perching -- to the issue of -- the shallow perching issue that we talked about earlier?

A I believe it does.

Q In what way?

A Well, I believe that both Golder's analysis and Eykholt's analysis didn't consider the effect of shallow perching on flow path. I believe that, if you're going to define a 3-dimensional flow path, you ought to start at the point at which it discharges from the TWIS. And I believe that that has -- by not considering that, you're missing a big part of where you think the flow is going to go.

MR. EGGAN: Can I go back to -- I think it's slide 25.

Q I want to talk about this shallow perching issue in the context of the two cross-sections that we have on slide number 29. Okay? Talk about where you see this perching occurring and why it is you believe it's going to occur in the area beneath the TWIS.

A Right. Remembering that these two cross-sections are located lengthwise along this TWIS, I believe EE is located out here and -- to the northeast, and section FF I believe is located to the southwest. But the low-permeability units are really shown with the red and the purple. And I don't believe this is necessarily accurate -- an accurate depiction of those low-permeability units. I think another slide I have points that out. But the groundwater would essentially come down over this area and infiltrate down through what they're showing as being unsaturated sands, and that water, as I see it, would perch over these low-permeability units.

Q Now, this is the area -- this area where this perching is going to occur, is that above the groundwater?

A The groundwater table is located here with a blue line so, to answer your question, it is above the blue line and --

Q And beneath the TWIS?

A And directly beneath the TWIS, over the majority of the TWIS. And I think -- well --

Q One of the questions I asked Mr. Chatterson about is whether

or not he knows whether or not these -- this area is continuous beneath the TWIS. And he indicated that he was actually standing at the site and watched them pull out a core and that there was no permeable -- no low-permeable material in the core that he observed. What are your thoughts on that?
A Above the water table?
Q Above the water table. That's right.
A Right. I think that's true, because the -- that well that he was looking at is this well 008. I believe that's this one on Section EE. I can't quite read it but -- which doesn't show any low-permeability material above the water table, but all of the other ones seem to show that.
Q When you say "all of the other ones seem to show that," how do you know that?
A With the exception of 036, just based on looking at this cross-section, but I've also looked at those logs and their reports.
Q Well, talk about that, that you've looked at the logs, and what does that show?
A Well, it reflects that they do have low-permeability material that's above the water table, as these cross-sections indicate.
Q What is the real impact if there is this low-permeable soil in that area? What is the ultimate impact?

A Well, depending on the rate of flow coming in and where those low-permeability units sit, you could get groundwater reaching the ground surface right in the TWIS area. In fact, because we don't know what the configuration of these units are to the northeast, it's hard to tell what will happen -- or to the south, really, it's hard to tell what -- whether these are continuous or disappear, as been -- as has been suggested.
Q Well, water perches there. What difference does that make? If water that is discharged from the TWIS gets down to this area and perches, what ultimately --
A Yes.
Q -- what difference does that make?
A Well, I believe, if it reaches the ground surface, then that violates the permit -- the discharge permit.
Q Is that the breakthrough issue that Mr. Chatterson was talking about?
A That's right.
Q So there is a potential for breakthrough?
A That's right.
Q Will this have any effect -- any impact on monitoring at the location?
A I believe it will.
Q What is that impact?
A Well, in terms of where the monitoring wells that I've seen

described or located, they were really located more around where the current water table is. But if you're not locating those wells in this -- to cover this perched area, you might in fact entirely miss where the water discharging from the TWIS actually goes. It may not actually even intercept in a significant way the groundwater immediately below the TWIS, the current groundwater table.

Q What should they have done to have resolved or investigated this issue?

A Well, I believe they should have considered these low-permeability units in terms of their analysis of the mounding or perching -- actually, not perching but the mounding beneath the TWIS and where that water eventually goes.

Q Flow direction?

A Flow direction.

Q Okay. We're at slide 32, sir. Mr. Chatterson, when I asked him about the simulation of the perched condition, I asked him whether or not a MODFLOW program can be used to simulate a perched condition. Mr. Chatterson had indicated that he was familiar with MODFLOW, does not -- had not done as much work with FEFLOW, but he was very familiar with MODFLOW. And I asked him whether or not MODFLOW could simulate this perched condition, and he said, "Oh, yes, it can." What are your thoughts on that?

A Well, MODFLOW was developed to simulate what is called saturated groundwater flow. That means that the pores are completely filled with water, and they call it a single-phase code. And it clearly can't simulate it. It wasn't designed to simulate perched conditions where the zone below those low-permeability units were names in this partial saturation state. And in order to simulate that correctly, you can't use a code like MODFLOW. It's really well-known in the industry that it can't simulate perched conditions.

Q What should they have done?

A I believe they should have used what is better known in the industry as a variable saturation code. There are numerous codes that are able to simulate variable saturated conditions. In other words, when perching develops and there's zones around it that are unsaturated or below it -- more importantly, are unsaturated, that those codes are able to handle that condition.

Q Now, Mr. Eykholt also talked about some simulations that he did, and one of the things he did was used an analytical solution to simulate mounding beneath the TWIS. We know that from his testimony. Do you have any observations with respect to the tool that he used?

A I do.

Q And what are they?

A Again, this code is a simple analytic math tool that's used to estimate the mounding beneath the TWIS and how it radiates away from that. And I don't -- again, this tool clearly doesn't consider the flow that can develop above low-permeability units. So just by design it's not even applicable to this problem of evaluating the flow that builds up above the low-permeability units above the water table.

Q Now, Mr. Eykholt also indicated that there's really little chance of the groundwater -- a groundwater breakthrough to the surface. What are your thoughts on that?

A Well, when I -- I looked at those initial cross-sections that we had on that former slide, EE and FF, and I noticed that they had plotted those low-permeability units. But I went back to the original logs, and I was sort of surprised to see that in well 41 and 42 that it did show low-permeability material, which I would have classified as low permeability and put on those logs -- on those cross-sections. The one that really struck me was well 41 that shows a silty sand from 30 to 45 feet below ground surface.

Q Is that the reference to "SM" there, the silty sand?

A That's right. And that -- that's a reference to silty sand. It's a code -- standard code that's used to describe silty sand. And I guess the implication of that is that, taking

Eykholt's estimate of between 30 and 33 feet mounding, assuming that that actually would develop, that, if you have low-permeability material that's at 30 feet belowground and you have 30 to 33 feet of potential mounding, just in that scenario alone in that area you could get breakthrough at the ground.
Q Let's talk about this in -- a little more slowly. You're indicating that Eykholt estimated a mound of approximately 30 to 33 feet beneath the TWIS?
A That's right.
Q Okay. And then just explain how your review of the well information contradicts that.
A The borehole geology indicates that the material from 30 to 35 -- 45 feet below the ground surface at well 041 is the silty sand. It's a lower-permeability unit. And that has the potential for building up groundwater -- perching the groundwater above that layer. And it's not characterized in the northeast or anywhere outside of those immediate boreholes.
Q And how does that suggest to you that there's going to be a breakthrough, I guess is the ultimate question.
A Well, my experience with modeling unsaturated zone flow where you're introducing water at the surface, the permeability of that unit is very sensitive in terms of its ability to mound water above it. So I think it's really

important to consider in this kind of an environment if you -- if you're looking at mounding.

Q Let's talk about the modeling that was done in the TWIS discharge area and focus for a few minutes on what Mr. Council's testimony was. Initially I want to note that Mr. Council noted a problem of dry cells in the Fletcher-Driscoll 2006 model, and he concludes that the calibration quality is good. That's from slide 23 of his presentation. What are your thoughts with respect to Mr. Council's comments on the dry cell issue in the Fletcher-Driscoll model and his conclusion that the calibration quality is good?

A Well, I agree with Mr. Council's conclusion that the Fletcher-Driscoll models were seriously flawed in that respect, this dry cell problem. And I guess, though, I'm also concerned that he fails to note that MODFLOW really doesn't simulate the unsaturated zone flow.

Q Why is that a concern?

A Well, because he's using it in his modeling.

Q So Mr. Council's model is based on MODFLOW?

A That's right. And I don't -- he doesn't actually simulate a worst-case scenario like the Fletcher-Driscoll 2006 model did, where they're trying to simulate the effect of dewatering at the mine -- below the mine. But I suspect that's the model that Fletcher-Driscoll had problems with dewatering when they tried to simulate the bedrock and dewatering occurred just by design, because you're dewatering the mine area, and MODFLOW doesn't simulate that. So I think he's only -- in this model that's developed by Mr. Council, he's only simulating the overburden. But he's transferring the boundary conditions of the mine inflow from the Golder model, and he doesn't simulate that Upper Bound or worst-case -- what they called a worst-case, I guess, scenario.

Q Is that important?

A Very important.

Q Why?

A Well, because if your cells go dry in the model, the model basically shuts off those cells from any further calculation, and you actually would probably limit the amount of flow that would be draining into the mine.

Q What impact would that have on the results of your model?

A Well, they would be inaccurate.

Q Now, you also indicate in one of your bullet points that there's no indication that the 2006 predictive model was ever calibrated. Talk about that.

A Well, I think there were things noted by Mr. Council as to the problems with the Fletcher-Driscoll model in 2006. But my understanding of it was that they developed a preliminary model in 2005 that they used to calibrate to the natural system unstressed. And then they took that model, and in 2006 they made a number of what I believe were significant changes to that input; changed the recharge; changed the hydraulic conductivity; started simulating the bedrock down in a layer they hadn't before. And he didn't seem to acknowledge that that model -- I mean, to me that would have been a bigger problem if the model wasn't calibrated, so I would have said, "That's -- you really can't use that for predictive simulations."

Q What should they have done?

A I think they should have acknowledged these problems and used probably FEFLOW to simulate the combined bedrock and overburden.

Q All right. We're again talking in slide 36 about Mr. Council's testimony, and it relates to this issue of predicted flux. Talk about your thoughts pertaining to Mr. Council's testimony.

A Well, this is a plot here with the colors down below that I obtained from his report, and it basically shows the information he took and used as input into his MODFLOW model. The zones of higher -- the higher-color zones in the center represent higher amount of water that's flowing into the -- being withdrawn from the overburden back -- right over the crown pillar area you see a higher -- much higher flux and then over the area of the access tunnel, and then it diminishes as you go out.

But he takes that data -- information and applies that as a boundary condition in his MODFLOW model to simulate just in the overburden the effect of the mine dewatering. I guess my problem is it seems like he fails to acknowledge that that Golder FEFLOW model doesn't realistically simulate the overburden for the reasons that I mentioned earlier today.

Q A question about the -- about slide 36. We've got this depiction in the lower right-hand side. And just to make sure that we're all on the same page here, where does that depiction come from?

A His report, I believe.

Q Mr. Council's report?

A The -- yes, and --

Q What should he have done?

A Well, I believe, again, as I've stated before, this really would have been a lot simpler and probably more realistic to simulate both the bedrock and the overburden simultaneously using a code like FEFLOW. It's fully capable of doing that.

Q What impact would that have had? How would that have changed the ultimate result?

A Well, I wouldn't question the flows between the overburden and bedrock as much, because you're letting the model calculate that instead of assuming what it might be.

Q It would have perhaps decreased the uncertainty?
A To some extent.
MR. EGGAN: Next slide, please.
Q On slide 37, Dr. Prucha, we've got two slide references down on the bottom. Let's talk first on this slide what the slide reference is down on the bottom left.
A This is a picture of the confining unit thickness, so these are the low-permeability units in the unconsolidated material between the A and the D zone, which are permeable aquifer materials. And so this is from slide --
Q Where does that -- yeah, that's my question.
A This is slide 30 from his presentation.
Q Okay. And then on the right-hand side we have another reference showing contours. What is that?
A Well, this is the same plot but taken from his report.
Q Talk about this issue of confining unit thickness and some differences in the report and the presentation.
A Well, it's pretty standard when you draw an interpretation of, say, a thickness over an area that you're putting into your model to show the points that you use or the borehole locations that you use to construct that so that an external reviewer can look and say, "Well, I know that he has a lot of data in this location but hardly any here, so I know that this is more of a guess than the area where he has a lot of data that's constrained by that actual data." So I guess,

when I looked at these two, I was uncertain why he placed what looks to be four -- like, four wetland piezometers in this location.

Q "In this location." Now, we want to make sure we know for the record where we're talking about here. On slide 30 you're talking about the three dark --

A Four dark -- four, yeah.

Q -- dots -- four dark dots on the slide 30 from his presentation indicating wetland piezometers?

A Right.

Q Okay.

A But my main point on this was that, even on the plot to the right where he does show boreholes that he's using the constrained -- this pretty complex contour plot depicting the thickness of the -- this confining unit, he shows several blue areas where it's apparently absent. And you'll notice the one blue area that I'm pointing to, which starts kind of at the mine and heads up --

Q And this is on Figure 10 of his report?

A On Figure 10 of his report. It's on both figures -- but Figure 10 of his report. And I don't see any control points in the middle of that blue zone. I don't see anything controlling. He stops it right at the Salmon Trout River, but the problem with that is it means that it's really unconstrained. And I could have made this five times as big. I could have made it five times as small. And this is an important feature in the model. It controls how the drawdown or the mine dewatering in the bedrock translates into the overburden and how that affects the drawdown that you're predicting all around the mine. But you can also see there are other zones around the TWIS off here.

You have one point in a large area, and he's predicting that confining unit to exist over here, but that's -- you know, this is probably a mile. I mean, I don't have the scale.

Q Now, the area that we're pointing to is on Figure 10 of his report. It appears to be a large area to the north --

A To the east.

Q It would be to the east of the TWIS?

A Right; immediately to the east and then sort of oriented up to the northeast. But my point is that, in his simulations and his sensitivity analyses, he doesn't consider the uncertainty and changes to that zonation. And the -- in other words, I mean, he doesn't consider what -- if I had assumed, because I don't have any constraints on this map, that those blue areas are half the size or a tenth the size or ten times the size, how does that change my model results? And this is what I mean by "uncertainty," and this is sort of more typically referred to as conceptual uncertainty.

It's not so much the standard approach where you just adjust one value for the whole zone. This is actually changing the configuration, and it's all interpreted. Your interpretations have uncertainty. And this just doesn't translate into how uncertain the predictions are.

Q What would a prudent modeler, what would a prudent hydrologist have done to correct this problem?

A You would have acknowledged that uncertainty. I mean, it is challenging in a field where you have limited data, but it is what it is, and given that, you just acknowledge that you have limited data. And the general industry standard these days is to develop multiple interpretations of this that test the range of what you think might happen there. So when I think that blue area off the orebody might be half the size or a fifth the size, let's try it at ten times that. Look at the output and see how much it varies. If you find that the output changes dramatically or your conclusions change dramatically, that's a good indication that you need to go back to the field and collect more data to refine the understanding of that area. It's a sensitive parameter.

MR. EGGAN: Next slide, please.

Q In his testimony Mr. Council indicated that there is a low hydraulic conductivity zone over the orebody in the model that he created. What is your observation with respect to that?

A This is pretty much the same feature -- observation I made on the previous slide; same concept. He's developed another distribution of important model input. And this is the hydraulic conductivity of the aquifer but -- of a certain layer in the aquifer, and I just -- I guess I was surprised that this only occurs in this area of model, and he's modeling quite a large area.

Q We need to give some context to this slide. It's our slide 38, and in the lower left-hand corner you have inserted what? A slide from his presentation or a reference to his report?

A That's right; yeah, from his presentation, I believe. I don't know the slide number, actually.

Q Okay. And what does this depict? What does this --

A Well, this is a distribution of the hydraulic conductivity in one of his layers in the model. And in particular he shows one zone that he's defined from the orebody running kind of along downstream of this Salmon Trout River, and it's just kind of a blob sitting there. And he does show points that I'm not quite sure. I mean, it says "monitoring stations," but I'm not quite sure. Usually you'd say "borehole locations," because the borehole information is -- or actually "monitoring stations," I guess. Forget that. Either way, I'm not sure that those were the actual points that he used to create this contour map.

But the zonation -- and it doesn't really show up well -- has several points within this brown area. Most of those are actually wetland piezometers and, from what I can tell in the report, those were slug tested. And for the same reason that Dr. Karasaki pointed out yesterday, the slug tests always kind of bias your hydraulic properties to the low side. And unconsolidated material, when you do slug tests, you don't test much of the area around a piezometer or well, and so you typically are biased towards the low side. It could be easily an order of magnitude. But this zone bothers me because, again, it doesn't seem constrained outside. I don't see any data points outside of it, so that zone could be much bigger, or it could be much smaller.

Q Ultimately what is the impact on the accuracy of his predictions?

A Well, for the same reasons as before, it -- I didn't see that he tested this kind of adjustment in the model input in terms of how it affects the model output, and it could be very significant.

Q And are we to -- when we're talking about Mr. Council, are we talking about the 2008 GeoTrans model?

A That's my understanding, yes.

Q That's the April 2008 model?

A That's right.

Q Okay.

MR. EGGAN: Next slide, please.

Q Again, I think we're referring now to -- continuing to refer to model inputs that were utilized by Mr. Council. And you indicate in this slide number 39 that Mr. Council specified a top of bedrock for a model input. What is the issue here?

A It's the same issue as the last two slides. Again, it's another surface that's being generated over a very large area. I don't think this is the same 87-square kilometers, but it's a large area. And this is the top of bedrock, another important input for the model. And I see in some areas that the lowest point in the bedrock is this big hole -- big depression right just east of the TWIS, which --

Q All right. Now, I need to slow us down just for a minute. On our slide number 39, we have inserted a figure. Where does that figure come from?

A This comes from Figure 8 in Exhibit 591.

Q So it's Exhibit 591 -- Intervenor's Exhibit 591?

A Correct, which I believe was the report.

Q Yes. And you were indicating that -- you were talking about the problem, and I interrupted you. Talk about the issues that you are seeing with respect to this.

A Well, again, it's an interpolated surface. It's estimated based on available data, and it's only going to be as good as the available data and where you've located those data.

But it clearly seems like you have a very high bedrock elevation kind of radially going out from both the orebody and Eagle Rock. And everywhere else it seems to fall off, and then you end up with depressions, the lowest point in a surface, and I don't see any data points concerning that low point. And you generally don't come up with an estimate on the surface that's outside the range that you see from available data in the field that you collect.

Q And this is an issue related to inputs in his model?

A That's right.

Q Ultimately what was the impact? What is the issue or the -- I'm sorry. What is the impact of this issue on his predictions?

A Well, again, it's, in my mind, fairly uncertain, and that certainty in this model input wasn't considered in evaluating model output uncertainty.

Q You know, I asked witnesses who testified in this case about whether they did an uncertainty analysis, and I don't really recall from the testimony whether they gave me an answer. But can you talk about uncertainty and what you saw in the answers that were given by their witnesses with respect to uncertainty?

A It seems like there's a confusion between a sensitivity analysis and a more classic uncertainty analysis.

Q Are they two separate analyses?

A Completely different.

Q All right. Talk about those differences and why it makes a difference in this case.

A Well, there are two types of sensitivity analysis. One I think we went over in my testimony earlier on calibration sensitivity, where you're looking at the sensitivity as you calibrate the model when you're developing it initially. And then there's what's called predictive sensitivity analysis, where you look at the output -- the predictive model you've developed. You've changed parameter. You're trying to simulate something in the future, and you run another sensitivity to look at how sensitive your prediction output is to changes in your parameters.

And an uncertainty analysis really is much broader, where you have -- I mean, first of all, you should be aware that uncertainty encompasses things like not just parameter uncertainty, where you're adjusting the parameter values in a model, but there's also terms called conceptual model uncertainty or structural uncertainty, which go kind of towards the structure of your model, and also input uncertainty; what kind of data you're using to drive the uncertainty. And all of these things are contributing to the amount of uncertainty that you get in the output. And in my estimation, they were really only looking at in their sensitivity analysis adjusting parameter values, but they weren't really looking at uncertainty in the output and trying to bracket that.

Q Do you have the impression that the modeling that was done by Kennecott included this uncertainty analysis?

A No.

Q What was your impression from the witness testimony that you looked at?

A Well, they looked at sensitivity predictions. But I think, like Dr. Karasaki pointed out yesterday, they looked at changing one parameter one at a time. And if you're going to do anything that even approaches a more standard uncertainty analysis, you would start adjusting combinations of those parameters and looking at the full solution space that's possible. And that's important because, if you're just changing one thing at a time, it's not all of the possible solutions. There are many, many more possible solutions that would yield an equivalently -- you know, an equivalent calibrated model; one that's equally valid.

Q Did you have an impression that the witnesses that talked about an uncertainty analysis here knew what uncertainty analysis was?

A I didn't get that sense.

Q Would a prudent modeler have utilized an uncertainty analysis in the modeling that was done at this site?

A I would.

Q Was it done?
A It wasn't done.
Q This is a reference to Mr. Council's testimony and a scenario 2 from his model analysis. I'm sorry. It's from scenario 1, isn't it?
A 2.
Q Is it from scenario 2?
A Yeah.
Q I'm confused by the --
A I'm sorry. That's a typo. It should say "scenario 2" in the text to the right.
Q Okay. All right. Very good. On slide 40, then, what we have is a map, and it looks to me like these are some references that you have created?
A These are the wells that were used in the latest GeoTrans model, and I'm simply showing the results for what is being considered to be a calibrated model, scenario 2. He ran two scenarios. And the point here is that at these well locations these values show the difference between the predicted and the actual or observed level that was measured in the field. And the idea is, when you develop the model, to develop an adequate conceptualization and characterization of the model that you are able to reproduce the observed levels where -- you know, you'd want to reproduce them exactly. But because the models are

typically a simplification, there is some difference.

But in this case I thought it was useful to point out that the single statistic that people often -- modelers often throw out to represent how good their calibration is often masks the distribution of the model performance across an area. And I think, in my mind, the two most important areas in a model to calibrate well, which is where you tend to have more data, are around the orebody and around the TWIS. And these differences in feet --

Q Now, you're showing these differences in feet. What reference are you making?

A I'm pointing to wells around both the orebody and around the TWIS. The numbers -- I've seen numbers like 22 feet over-simulating the observed, and nearby them -- near the TWIS I'm at minus 14.05 feet.

Q So these are the numbers in the little yellow boxes on this slide?

A Little -- yes, the yellow boxes, the labels, right.

Q Yes. The 22 that you referred to is here where this red dot is, number 22?

A That's right.

Q And again, what is -- what do these numbers represent? And talk in lay terms, because I, at least, am not a groundwater --

A The bigger the number, either positive or negative, is a bigger error. Your model is doing the worst job at predicting what it should be. So a number like 22 means that the model is trying to predict a level that's 22 feet higher than the actual level it's observed in that well and --

Q What would a good number be?

A Zero is the ideal number.

Q Zero. Okay.

A But maybe in this -- I think around, say, for instance, the mine when they're -- when you're trying to predict drawdowns that you're saying are within a foot, half a foot, that makes a difference. The errors here are well above that or well above it, so they're greatly over-simulating and greatly under-simulating in a key area. There are some wells that appear to have, you know, a closer value. But in general I wouldn't -- I think this is why I always tend to plot the difference between simulated and observed data physically, as opposed to giving one number, to try and represent how good your calibration number is.

And in this case the -- it ended up averaging out to make it look like it was maybe 1 -- on the order of a 1-foot error. But you see a lot of pluses and minuses here, and they tend to cancel each other out. But to me this is to some extent the result of what I think is oversimplifying the aquifer system.

MR. EGGAN: Next slide, please.

Q This is slide number 41, and it relates to Mr. Council's -- the results of Mr. Council's predictive sensitivity -- his predictive sensitivity results. On the right-hand slide you -- on the right-hand side of this slide, we have a reference to slide 51 from his presentation?

A That's right.

Q What are we showing here? What's the issue?

A Well, as part of his predictive sensitivity analysis, he's showing two things. One is a value called RMSE, this upper line in blue, that is meant to represent the degree that you're -- you know, how well your model is calibrated. And on the bottom he's showing maximum drawdown at this wetland 024 piezometer close to the orebody. And I see a pretty noticeable change as you're changing the anisotropy or the ratio of the horizontal-to-vertical hydraulic conductivity as you're heading to the left here, lower numbers.

And I guess what I -- what struck me was that for this plot I see that effectively any of these changes in this parameter result in a model that you could call calibrated based on his definition here, and yet you're changing the drawdown at a very important well or piezometer near the orebody in the wetland by several feet, and that's very important in the wetland. And when you look at ASTM standards for sensitivity -- conducting a sensitivity analysis, this, based on their text, represents a sensitivity-type IV. In other words, as I read here:

"Type-IV sensitivity can invalidate model results, because over the range of that parameter in which the model can be considered calibrated, the conclusions of the model change. A Type-IV sensitivity generally requires additional data collections to decrease the range of possible values to that parameter."

So that means that, because this blue line stays fairly constant as you're adjusting these parameters and the green line goes up, which is your conclusion, more -- something should have been noted about that. That would have raised a flag in my mind and suggested, "Maybe my model's too simple. Maybe I don't have enough data."

Q This would be referred to as a Type-IV sensitivity?

A Based on ASTM standards 5611.

MR. EGGAN: Your Honor, ASTM standard 5611 from 2002 is Intervenor's Exhibit 66 in this case.

Q Do you consider the modeling that was done, then, by Mr. Council to be contrary to ASTM 5611?

A I don't know that it's contrary as much as just not considering implications of this standard.

Q All right. This is a reference -- the next slide, which is slide 42, is a reference to Mr. Wiitala's 2-dimensional conceptual profile from slide 9 of his presentation. In the

lower left-hand side of this particular slide, we have a reference to an exhibit, Intervenor 007, which is from the application at B-1, Figure 6. Tell Judge Patterson what the issue is with respect to the 2-dimensional conceptual profile that Mr. Wiitala offered.
A Well, these conceptual models are used to build your model upon, and they are supposed to represent your best understanding of how the system operates.
Q Now, Mr. Wiitala didn't do a model?
A I know.
Q Okay. Then how does this fit into the model at issue?
A Well, this is a conceptual figure that it's just -- is presented and, you know, presumably used to develop models on. And I guess what's interesting about this is that it does show an intrusive dike here in the Yellow Dog Plains that clearly shows a drop in the water table across both sides of it, implying that the dike has a pretty noticeable impact on the groundwater flow. Groundwater flows down here through these metasedimentary rocks, reaches granite and gneiss that appears to go all the way to Lake Superior. And I guess -- I know I'd seen maps showing that Jacobsville -- I think that's spelled wrong -- sandstone off of Lake Superior, not that it really would influence what's being modeled here.
But I guess the main point I wanted to make on

this is that, if you show one dike and you're conceptually thinking this has a pretty significant impact on the groundwater flow as it moves through the system, even on the flow in the overburden, that -- I showed that map earlier that showed several dikes going off to the north and to the south of this intrusive at Eagle. Why wouldn't you assume that those could have controls also on the groundwater flows and possibly the whole structure of the sediments in this area?

Q What should they have done?

A I think they could have spent more time developing more realistic, better-supported conceptualization. Things like this, this is really important in terms of where you think TWIS water is going to go. And I think in my original testimony I'd suggested that an alternative was that water could flow to the east, southeast, and one reason might be starting because they're not really even considering major structures; that clearly at Eagle deposit where they have all this data they know that it comes up, blocks flow. But where they don't have data and they don't show the other dikes that have been mapped, even by their own geologists, in addition to Klasner, those could offer pretty important clues as to what's happening northeast of the TWIS where we don't have any data.

Q Conceptualization is the issue here?

A And to some extent characterization.
Q And conceptualization and characterization are the building blocks, aren't they, of a hydrogeologic investigation?
A That's right.
MR. EGGAN: Next slide, please.
Q This again relates to Mr. Wiitala's testimony and these clay deposits pinching out north of the TWIS. Can you talk about that issue, please? What issue do you see with that?
A Well, if the lack of stream clay deposits tend to pinch out to the north in a nice, big lake that occurred in the area, you know, a long time ago, this -- I'm not sure that I fully buy that, you know, the clay units would just pinch out right at the TWIS. I mean, this map tends to show that there's a break between the outwash and coarse, textured till.
Q Maybe we should talk a little bit about the map that is depicted on this particular slide number 43. Where does that map come from?
A I believe I obtained this as -- it's a 1982 quaternary geology map from the MDEQ website.
Q Okay. And what about the lines that are depicted on this geology map? Where did they come from?
A These are the same lines that I had shown on a previous plot earlier in the testimony that -- well, these are fault lines and dikes from the Kennecott geologists that they've mapped,

and then, as --
Q Okay. So these are lines that you put on there. And explain to Judge Patterson what those lines depict and how they impact your testimony here with respect to these clay deposits.
A Well, I'm just trying to use this as a diagram to say, you know, from the TWIS I don't know that I'm convinced that -- you know, the confining unit that you see south of it pretty well disappears and pinches out. And, I see a break in the geology well north, kind of at the top of the slope outwash -- between the outwash sands and material to the south and then a coarser textured till to the north. But that's well north of that TWIS, so it seems like that would --
Q Well, what impact could that have?
A Well, in terms of where water goes from the TWIS, I believe, you know, if -- the low-permeability units that I am seeing and the majority of boreholes beneath the TWIS well above the water table, if those don't pinch out to the north, northeast immediately around the TWIS, you know, that water would be perched for a good distance away from the TWIS.
Q And again, what impact could that have?
A Well, you're not going to know where it goes, but there is the potential, like I showed before, that it could reach the surface. And I think more importantly those

low-permeability units -- the configuration of those below where you're discharging is very important to map out, because that water's going to perch on it and then be directed based on the configuration of that low-permeability unit.

Q Have they done a good job of mapping that?

A I don't believe they've done a good job of mapping it or really describing and showing what's going to happen. There's this -- I still feel there's this presumed northeast direction to the groundwater flow and, without data between the TWIS to the north, northeast, it's kind of an open guess.

Q What should they have done?

A Well, put more data here; better characterized this area all around the TWIS where you thought -- and even to the south. There's a possibility -- just based on the cross-sections that I showed earlier with the gradients going southeast right at the TWIS, there's a possibility that groundwater could go southeast and into the Yellow Dog River Watershed.

Q We talked about characterization and conceptualization a moment ago. Is this more evidence about the characterization and conceptualization that was done that was a building block of their hydrogeologic investigation?

A Yes.

Q Was it adequate?

A I don't believe so.

MR. EGGAN: Next slide, please.

Q Let's talk about monitoring in the area of the TWIS. And what are your thoughts on that?

A Well, could I just draw a simple diagram?

Q Yes, please.

(Witness draws diagram)

A What I want to show is just sort of a cross-section that might represent the TWIS here, and maybe this is the area where the water is infiltrating down from the TWIS. And the current groundwater table looks like it's sloping off this way, but you have those low-permeability units in here that I -- seems to me that they occur about the same elevation, so I would be connecting these as though they were connected.

And I think, if you're putting in monitoring wells within 150 feet of the TWIS, which is where I saw the monitoring wells being proposed, and you're assuming that the mounding all occurs on your current groundwater table, which I'll denote with a little inverted triangle, and your wells go down and they're screened over this current water table, maybe a little higher to see the mounding that is presumed to occur here, but in fact, all the water that infiltrates comes down and it starts mounding instead on this zone here, the low-permeability units -- and in fact,

remember, one of the wells I actually said I saw 30 -- from 30 to 45 feet belowground. I saw a silty sand, which is a low-permeability unit. That water could mound above this low-permeability unit and breach the surface in that area. But more importantly, this water will mound up above this and --
Q When you say "this," it'll mound up above the --
A The low-permeability units above the water table. But we don't know what's happening in most of the directions other than southwest -- what's happening to these low-permeability units. These could continue up. They could continue in a variety of directions. They could go up or down, but we just don't have information outside of the TWIS. So I think that, if they do continue, this monitoring may never see the effect of this mounding. This could go out here and -- you know, this clay unit could go out here, and the water could drain down here, completely missing these monitoring wells.
Q What is the impact of that, Doctor? What difference does that make?
A Well, I just think, if you're not monitoring and, based on Dr. Maest's discussion yesterday -- and this water does have water quality issues -- this is the last point before it actually goes out to the north and seeps out of the seeps. Their wells currently are farther beyond the seeps or these contact springs. So basically there would be no knowledge

that you had water seeping out past the TWIS if -- and in fact did have the water quality issue, and you wouldn't know it until it was in the surface water.
Q Is that because of the testimony that we have from witnesses that there are no monitoring wells or no wells between the TWIS or 150 feet from the TWIS and then on almost a mile to those seeps? Is that the area you are talking about?
A That's right. That's my understanding. And just based on the regulations, it is -- you have to put a monitoring well within 150 feet. But it seems to me that this clay layer already just over, say, 3 of the boreholes from the southwest going up to the -- southeast to the northwest along that cross-section show shallow low-permeability units. So why would -- I mean, that's a distance of -- you know, if the TWIS is 1,000 feet long, that's 750 feet. It's pretty easy to imagine those could continue out beyond this 150 feet.
Q And what favorable impact would having those wells out there, that you're talking about, out to the northeast have?
A Well, it would be -- if they were put out there in terms of detection, at least you would know if you didn't -- if this did occur, that you would have some opportunity to detect some impact to the groundwater.
Q Before we get to your conclusions, I do have a question for you. One of the witnesses, a Mr. Fassbender, who testified

in this case and who have done some work related to a project in Wisconsin related to the Crandon Mine, testified he couldn't recall some information pertaining to the Crandon Mine related to inflow that was predicted for the Crandon Mine. Did you have an opportunity to review materials pertaining to inflow at the Crandon Mine?
A I did.
Q What did you review?
A The discharge permit application.
Q Okay. What did you learn from your review of those materials pertaining to input in the Crandon Mine specifically pertaining to predicted inflows?
A Well, my understanding is that a Base Case and an Upper Case inflow were estimated by the permit application permittee, I guess, and that was submitted, and apparently that wasn't -- the Base Case and Upper Bound estimates or the flow weren't high enough. And so I guess the values of the inflow or -- for discharge purposes were increased by a required increase by the --
Q Do you remember what the predicted inflow was?
A I believe it was in the 400 to 800 range, something like that, and then they used 600 gallons per minute, I guess, as a design basis.
Q Okay. And what did the Wisconsin Department of Natural Resources require?

A In the end 1500 gpm is what I believe I saw.
Q Okay. So they were predicting between 400 and 800, yet the Wisconsin Department of Natural Resources required almost twice as much, 1500?
A That was my understanding.
Q Okay. And did the materials you reviewed indicate who was it -- who it was or what company it was that had prepared the input data for that particular matter --
A I believe it was --
Q -- at the Crandon Mine?
A I believe it was Foth & VanDyke.
Q Okay. And did you happen to notice who the professional hydrologist was that essentially signed or stamped those documents for the Wisconsin study?
A I think there were three different engineers.
Q Was one of them -- was one of them Stephen Donohue?
A I believe so, yes.
MR. EGGAN: Okay. I have no further questions.
Q Oh, let's go to your conclusions. And these are conclusions with respect to your rebuttal testimony. We're not going to go back and revisit the conclusions you offered initially.
A Right.
Q So go ahead.
A Well, the first conclusion is just I think I pointed out that I feel like the hydrogeologic characterization and

conceptualization were, in my opinion, wrong on a number of accounts. And I would also say that the subsequent development and application of numerical models is, therefore, flawed. And finally, I think uncertainty in the predictions really wasn't assessed, from what I can see. These predictions that are put out aren't really qualified to assess that uncertainty.

Q Any other conclusions, Doctor?

A No.

MR. EGGAN: Thank you. I have nothing further. Your Honor, at this point I would offer the slide presentation that Dr. Prucha prepared in this matter as Exhibit 191.

JUDGE PATTERSON: And, again, it's for demonstrative purposes?

MR. EGGAN: Yes.

MR. LEWIS: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay. No objection, then that will be entered.

(Petitioner's Exhibit 632-191 received)

JUDGE PATTERSON: Can we take about five minutes?

(Off the record)

MR. LEWIS: I don't think it will take long. I think Counsel have agreed collectively that the due date for post-hearing briefs would run from today, and then they will be due 55 days from today. I think we're going to start counting tomorrow, and that that means the date would be September 9, Your Honor.

MR. HAYNES: That's a Tuesday.

JUDGE PATTERSON: Okay. Tuesday? Okay.

MR. LEWIS: Hello, Dr. Prucha. I'm Rod Lewis. We met the first time you were here. I represent Kennecott Eagle Minerals Company, as you understand.

THE WITNESS: Good morning.

MR. LEWIS: Could I look at Dr. Prucha's slide 41? Do you have that available?

CROSS-EXAMINATION

BY MR. LEWIS:

Q Do you have the slides up there, Dr. Prucha, a copy?

A Not the one that says 41.

MR. LEWIS: We can do it without the projector, if you'd just give him a copy of the slide.

Q Slide 41 --

A Yes.

Q -- is the slide where you had a table on there titled "Sensitivity Analysis Anisotropy," and you discussed the two lines on that graph being -- one being so-called calibration error and the other being maximum drawdown at a particular well. And I just wanted to clarify, the upper line there

indicates the calibration; that's right?
A Calibration error.
Q Okay. And the bottom line indicates various depths of drawdown?
A That's my understanding.
Q And this is from Mr. Council's model for the modeling of the potential drawdown in the glacial aquifer?
A Slide 51 of his presentation, yes.
Q "Yes"? I'm sorry.
A Slide 51 of his presentation.
Q And that was the subject matter?
A Yes.
Q And I just wanted to clarify, because I think in the prior testimony it was indicated that the bottom line, which indicates the range of potential drawdown, was several feet, that line shows, does it not, Dr. Prucha, that the range would be from roughly zero to a little less than three feet?
A That's my understanding, yes.
Q Let's maybe look at your slide two a moment, then, Dr. Prucha.
MR. HAYNES: Excuse me, Counsel. I think I'm going to have to take back my copy of the slide. So could we switch the projectors and have the slides --
MR. LEWIS: Well, that's fine. You can just have it. I can ask him whatever I need to ask him, I think,

without him having a copy.
Q That's the slide where you listed the various testimony that you had reviewed, testimony and exhibits and reports and so forth. And you listed a number of people there, Dr. Prucha. And just to review that, you listed Mr. Beauchamp. He's from Golder. And you understand that he did characterization of the rock mass qualities for the crown pillar; right?
A I do.
Q You interviewed (sic) the testimony and reports of Trevor Carter, also with Golder, also offered testimony and reports as to the crown pillar stability; right?
A I read his testimony and looked at his PowerPoint, yes.
Q And you've listed Mr. Chatterson of the DEQ. I believe that's as to the groundwater issues; correct?
A Yes.
Q And Mr. Council who did some groundwater modeling and predictions of potential drawdown in the glacial aquifer and potential effects on the streams and the mining; right?
A Yes.
Q Mr. Jerry Eykholt, who offered some testimony as to the TWIS and the flow of water that would be released from the water treatment system, which you discussed again today; right?
A Yes.
Q Mr. Janiczek with the DEQ also on groundwater issues?

A Yes.

Q And remember Logsdon, you talked about him some today. He's actually -- he testified on the subject of geochemistry; right?

A Yes.

Q Mr. Thomas, is that Chuck Thomas of the DEQ?

A That's my understanding.

Q Also on the groundwater issues?

A Yes.

Q And Mr. Ware, now he's with Kennecott. And you understand him to be a Kennecott geologist? You indicated you reviewed his testimony so you know that he was largely responsible for the drilling program undertaken by Kennecott?

A Yes.

Q And he was responsible and testified about the geological investigation conducted by Kennecott; you understand that?

A Yes.

Q And Dan Wiitala, he prepared various reports for the mine permit application and also testified about the groundwater characterization studies that he did; right?

A Yes.

Q And Mr. Wozniewicz and Mr. Zawadzki, also from Golder, prepared reports and testified about the bedrock hydrogeology and the modeling of the potential water inflows into the mine; you understand that?

A Yes.

Q And you in fact have offered testimony both in your initial direct examination several weeks ago and again today criticizing the work and conclusions by all of these people, have you not, Dr. Prucha?

A I wouldn't say that I criticized work on everybody's.

Q What are the exceptions?

A I don't know off the top of my head, but I don't -- I mean, it's a good bit of information here.

Q Oh, I agree. That's why I'm asking the question.

A Well, I mean, I think that the presentation I put forth had kind of specific points from specific testimony. So, for example, I didn't talk about Beauchamp or necessarily Carter in some of my responses. That's not my area.

Q Okay. Let's take a few of them. You have talked certainly about Andrew Ware and his testimony and conclusions about the geological characterization, have you not?

A Yes.

Q And you in fact disagree and offer a different opinion as to what Mr. Ware testified about as to the potential presence of the so-called Klasner fault; correct?

A That's right.

Q And as to Mr. Wiitala, you testified in your earlier examination and again today that you disagree with his studies on the groundwater characterization and his

conclusions about those studies, did you not?
A Some of the points, yes.
Q And Messieurs Wozniewicz and Zawadzki from Golder who did the bedrock hydrogeology characterization and the hydrogeology modeling of potential mine inflows, you disagree with their reports and their conclusions also, do you not?
A Some of their points and conclusions, yes.
Q And Mr. Eykholt who did some work on the modeling of the TWIS and the discharge of water there, you disagree with his work and his conclusions, do you not?
A Some of his points and conclusions, yes.
Q And Mr. Greg Council who, again, you talked about him the first time you were here and again today, you disagree with the work he did and the conclusions he reached, do you not?
A Some of the points and conclusions, yes.
Q Also as to Mr. Eric Chatterson of the DEQ, also as to Mr. Chuck Thomas of the DEQ, you disagree with the conclusions that they reached as well, do you not, Dr. Prucha?
A Certain points and conclusions, yes.
Q And in many instances, if not all, when you reviewed your criticisms of the various testimony and work done by these people from various companies and the DEQ, you were often asked questions as to, "Did they get it right?" You answered, "No." And then you were asked a question of how

you would have done it; do you recall that, Dr. Prucha?
A Yes.
Q And in all those instances, your testimony was you would have done it differently; right, Dr. Prucha?
A For the points that I introduced in the presentation, yes.
Q I wanted to -- it would take a lot of time for me to review with you the basis for the conclusions and opinions reached by that long list of people and in those various reports and in their testimony. So I think all I'll do today is spend a little time with you on one of those witnesses and one of those subject areas, if I might. And it goes to, I think, an issue that seems to be of some importance for your opinions. It's referenced -- it was referenced heavily in your first direct examination and your second direct examination and your slides today, and that's the potential presence and potential effect of this so-called Klasner fault on mine inflows and the potential for effects on the glacial aquifer and perhaps the stream. So I wanted to review with you some of Mr. Ware's testimony, he being one of those people on the list, again, the geologist whose work and conclusions you disagree with.
And I'm putting here on Mr. Elmo what was discussed with Mr. Ware in his testimony. It was Intervenor Exhibit 596. And then I want to read to you some of his testimony about this exhibit.

MR. LEWIS: This is page 2986 of Mr. Ware's testimony, Counsel.

MR. HAYNES: I'm sorry. Counsel, again?

MR. LEWIS: 2986.

MR. HAYNES: Thank you.

Q Mr. Ware was asked during his examination the following questions and gave the following answers: Question,

"Would you describe what's depicted on this figure, please?" And again, this is in reference to this figure in Exhibit 596. Answer, "This map shows drill holes that are being completed on the Eagle project. Those red dots, color locations, the black lines are what we call the trace of the hole."

Now, do you see the dashed lines there on the figure, Dr. Prucha?

A Yes.

Q Mr. Ware put those dashed lines on there to indicate the potential presence of this so-called Klasner fault. Do you recognize that?

A I recognize those two lines as representing the fault zone that Klasner said was between those that's about 500 meters wide.

Q But in general that's what Mr. Ware's depicting there? You understand that?

A That's my understanding.

Q And you see the red dots, which probably show up black in this view, but those represent drill holes. And he's going to talk about here. Okay, Dr. Prucha?

"Those red dots, color locations, the black lines are what we call the trace of the hole. So essentially what you're doing is looking down on the drill plan. And if the hole's at an angle, that black line indicates where that hole went in relation to that color. These two black lines indicating the Klasner outline of his CP interpreted fault zone. Within that fault zone we have 14 drill holes drilled at varying angles that to date don't indicate either the existence of an approximately 500 yard wide fault zone or indeed the existence of discrete features that could be represented by these black lines."

MR. HAYNES: Counsel, just for the record, my copy of the transcript on page 2987 at line three says 13 drill holes.

MR. LEWIS: That's what I said, isn't it?

MR. HAYNES: I think you said 14.

MR. LEWIS: If I did, I mis-spoke.

JUDGE PATTERSON: I heard 14.

MR. LEWIS: It does say 14. "Within that fault zone we have 14 drill holes."

MR. HAYNES: I'm looking at the final transcript, and it says 13.

MR. LEWIS: There may have been a correction, then. Well, let the record --

MR. HAYNES: 13 or 14.

MR. LEWIS: -- indicate that I'm referring to the first preliminary version of the transcript. Perhaps Mr. Haynes is referring to the second. So one version says 13, one says 14.

MR. HAYNES: I think I have the final version, but go ahead.

MR. LEWIS: Okay. Well, it's the only explanation I know.

Q And then I'm going to put the next figure up here that Mr. Ware talked about also from Intervenor Exhibit 596 and read to you what he had to say about that. Now, the first part of what I read to you is about some of the drill hole information. And I believe that you had indicated and implied in your testimony both the first time and again today that in your view the potential existence of this fault was not adequately searched for and characterized. Another point of your testimony, I believe, Dr. Prucha, again, is your reliance on this Klasner article from 1979. That's the main basis, as I understand it. But you've also referenced geophysical studies by Kennecott itself. So I wanted to read to you what Mr. Ware said about this figure and Kennecott's geophysical studies that you referred to. Question, "And did you prepare another figure to help illustrate" --

MR. HAYNES: I'm sorry to interrupt, Counsel. Which page are we on?

MR. LEWIS: Continuing on page 2987.

MR. HAYNES: Thank you.

Q "And did you prepare another figure to help illustrate that point?" Answer, "I did. There should be a figure showing the magnetics that we flew over the area." "Is that the figure?" Answer, "That is the figure." Question, "What does this show?" "Again, it shows the drill holes as distributed at Eagle and Eagle East. It shows the Klasner interpreted fault zone. It also shows very clearly this feature here, which is a dike. It's a magnetic dike." And I believe he's referring to the horizontal coloring below the two purple circles. "That's a magnetic high. It shows it's got another dike to the south of it. That's a magnetic low. And these are responses from peridotite rich sediments. Peridotite is a magnetic mineral that is commonly found in sedimentary rocks. The point of this is that these sediments dip at an angle. There's two lines of evidence that those faults don't exist. There's no offset on this dike." Question, "What does that mean?" Answer, "It indicates that there's no movement such as this on a dike -- I'm sorry -- on a fault that it could be like that. If there was, you would see this" -- and he was indicating -- "piece of rock either moved up or down in relation to these fault zones in addition to that. The other piece of evidence that there's no vertical movement on that fault is that you see no displacement on this bed here which is dipping." And then if I move to the next question, question, "Now, as you know, some of the Petitioner's witnesses have characterized these faults as meaning that the crown pillar cannot be stable. Does the information you're showing here in this figure address that claim, Mr. Ware?" Answer, "In part it does address that claim. It indicates that those faults don't exist. Those particular faults don't exist." You --

MR. HAYNES: Excuse me, Counsel. Just so the record is clear, when Counsel read the word "peridotite" -- and this is on page 2987 lines 19 and 20 -- my transcript says "pyrrhotite."

MR. LEWIS: I'm sorry. Again, I have the first version, I think, Mr. Haynes. I've got "pyrrhotite" with a little star in front of it. Does yours?

MR. HAYNES: Well, no. Mine has no stars. And I think the reference really should be pyrrhotite, rather than peridotite.

MR. LEWIS: That's fine. We'll go with pyrrhotite.

MR. HAYNES: All right. I just want to make sure the record's clear.

Q So, again, as an example here, Dr. Prucha, you simply disagree with Mr. Ware's conclusions as to what both the drilling information shows and as to what the geophysical information shows as to the existence of this so-called Klasner fault? You disagree with that; right?

A To some extent I do, yes.

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

JUDGE PATTERSON: Mr. Reichel?

MR. REICHEL: Yes. Dr. Prucha, again, my name is Bob Reichel. I represent the DEQ, as you recall. I just have a few questions.

CROSS-EXAMINATION

BY MR. REICHEL:

Q One of the things that Mr. Eggan asked you about earlier this morning had to do with testimony by Mr. Chatterson regarding contour intervals in the depiction of the area in the vicinity of the TWIS; do you recall that?

A I do.

Q Okay. Let me ask you this, sir: Based upon your training

and experience in hydrogeology, would you agree or disagree with the following proposition that 10 percent of the overall groundwater elevation change in the area subject to study is a commonly accepted method for determining a contour interval?
A I'm not sure I understand that question fully.
Q Okay. Let me try to rephrase it.
A Yeah.
Q When a hydrogeologist is determining what contour interval is appropriate, --
A Right.
Q -- would you agree with the proposition that a commonly accepted method for determining what contour interval is appropriate would be to look at an interval that represented 10 percent of the overall groundwater elevation change in the area under study?
A I think that would be fine if the complexity that you knew existed. And if you had no knowledge of how complex a system was over that drop, I think that would be fine.
Q So that is a commonly accepted principle; correct?
A Caveated with if it's a fairly -- I mean, if you're just doing an initial cut and you don't know anything about the subsurface and it's simple, you could do that. But once you start learning more information and it becomes more complex, your understanding of how the system operates, I don't think

I've run into a case where you don't want to increase the contours around key areas. So I don't like to just choose 10 percent.

Q No, that wasn't my question, sir, whether or not that was a commonly accepted method. And I take it your answer that in general, yes, that is true?

A It can be.

Q Okay. Now, Dr. Prucha, did you -- you've testified that you've reviewed testimony by a number of witnesses, including Mr. Chatterson. In reviewing Mr. Chatterson's testimony, did you read all of his testimony or just certain portions of it that you highlighted -- either you or counsel highlighted in response?

A I read through the entire document. I mean, it's a lot of information, so I don't --

Q Certainly.

A -- recall every sentence.

Q Understood. But you did read it all?

A That was my -- yes.

Q Okay. Now, in your slide 32, do you have those available to you, sir?

A I don't have the same number.

Q Here, let me give you a copy.

MR. EGGAN: I can give him -- I can give him one.

MR. REICHEL: Okay. Thank you.

MR. EGGAN: Did you say 32?

MR. REICHEL: Yes, I did; yes. And for the record, this has the heading "Modeling - TWIS Discharge."

Q Do you see that, sir? Actually, the --

A Yes.

Q And at the top of the slide it says Statement. "Chatterson indicates MODFLOW code can simulate perched conditions" and there's a parenthetical reference to the transcript page 7588. Is that correct? That's your understanding of what Mr. Chatterson's testimony was?

A Paraphrased.

Q Yeah. Okay. Do you recall whether or not, sir, within a line or two after that he testified on that subject he further qualified his answer?

A I understand there was discussion about that whole topic. But what I took from it was that it appeared that he didn't readily say MODFLOW is unable to simulate unsaturated zone flow. I mean, I can't repeat what --

Q No. I'm not asking you to repeat it. My question is, do you recall whether or not after giving that response he qualified that?

A I can't remember the statement or not.

Q Okay. Well, let me --

A Or the statements.

Q Let me read to you from the transcript at page 7588, which you cite here in your slide. Beginning at line 22 -- well, let me start at line 16.

"We know that MODFLOW" -- this is a question by Mr. Eggan. "We know that MODFLOW really cannot simulate the impact of these kinds of conditions." Answer, "Yes, it can." "Can MODFLOW simulate perched flow conditions?" "Yes." "Okay." Mr. Chatterson at line 22, "Well, I mean, I guess you have to qualify that, but" -- question, "Well, qualify it. Go ahead and tell us what the qualification is." Answer, "You can simulate all of, I guess, different layers within MODFLOW. You can break it up into as many layers as you want. And you have the ability in MODFLOW to interpret what layers. So you could -- at the area where the clay zone is, you could put in a very low hydraulic conductivity. And the areas lateral to that have sand and you can put in a higher hydraulic conductivity and you can interprelate the cell -- all the cells in between. So you can actually model it in that regard. There are some you can model there are certain assumptions that would make it difficult, I guess, so I guess you can't maybe model. MODFLOW doesn't handle perched zones real well. But there are ways you can, I guess, model it and ascertain a certain amount of information."

So in fact, the -- Mr. Chatterson's testimony on this subject was not an unqualified statement that MODFLOW can simulate perched conditions; isn't that true, sir?
A I wouldn't say that. I mean, I gathered from the last statements he made that MODFLOW can't really simulate it well. He doesn't say that MODFLOW can't simulate it in that dialogue. And so I just -- my understanding of it was that it wasn't that he still thought it might be able to by adding more layers and then --
Q Well, in any event, the excerpt that you quoted at page 7588 was taken out of context; correct?
A Maybe an additional page.
MR. REICHEL: Nothing further.
MR. HAYNES: I don't have any further questions.
MR. EGGAN: I may have an additional question. Bear with me, Your Honor. I wrote a note to myself, and I'm looking for it.
JUDGE PATTERSON: Okay.

REDIRECT EXAMINATION

BY MR. EGGAN:
Q Dr. Prucha, I wanted to follow-up on a question actually that I asked with respect to monitoring. Okay? Is there to be any monitoring between that TWIS area, 150 feet from the TWIS, and the area where the seeps are? Is there to be any chemical data that you know of that we're going to get

pertaining to the direction of that flow or to the -- or to the speed at which it is moving?
A I haven't seen any information.
Q Okay. But do you understand whether there will or won't be any monitoring at the groundwater-surface water interface there at the seeps?
A Based on Dr. Maest's testimony yesterday, my understanding is no.
Q Okay. So we'll never have any data with respect to that, will we?
A That's my understanding.
Q Okay. What about in the area -- you've indicated that there may be a southeast trend to the groundwater flow. Will we get any data based on monitoring that they've established if the water is indeed going that direction?
A Not at a sufficient distance away from the TWIS to, you know -- it'd be within 150 feet, roughly. But, no, I don't believe they would collect -- or it seems like they won't collect that data from what I can see.
Q Would you have expected them to have collected that data?
A Yes.
MR. EGGAN: I have nothing further. Thank you.
MR. LEWIS: Nothing further.
MR. REICHEL: May I have a moment, Your Honor?
(Counsel reviews notes)

MR. REICHEL: I have nothing further.

MR. HAYNES: Your Honor, one final bit of housekeeping with Dr. Prucha. When he was here several weeks ago, we introduced certain slides from Petitioner's Exhibit 63. And similarly with Dr. Maest, I have pulled out the slides that Dr. Prucha actually testified about and made them into a new exhibit, which is Petitioner's Exhibit 155. I've given those -- I've given the new exhibit to Counsel containing slides 13, 14 and 31 from Dr. Prucha's initial testimony, and move the admission then of Exhibit 155 containing those three slides.

MR. LEWIS: I can't recall, Mr. Haynes, are they proposed as a demonstrative or substantive?

MR. HAYNES: No; no. These were taken from the Proposed Exhibit 63, which was provided as part of the exhibits in the case. And Dr. Prucha testified only about three slides of that proposed exhibit. And per Mr. Lewis' (sic) suggestion, I've pulled those slides out, put them into a separate exhibit so that we're clear on what slides are actually going to be proposed to be admitted.

MR. REICHEL: Yes, I recall that discussion, Counsel. This is what you showed me, yes.

MR. HAYNES: Yes. I provided these to Counsel two days ago.

MR. LEWIS: I have no objection, Your Honor.

MR. REICHEL: No objection.

JUDGE PATTERSON: All right. No objection, they will be admitted.

(Petitioner's Exhibit 632-155 received)

MR. HAYNES: Thank you.

MR. LEWIS: We'll advise you about Tuesday, if that becomes necessary.

JUDGE PATTERSON: Okay.

(Proceedings adjourned at 11:11 a.m.)

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I certify that this transcript, consisting of 123 pages, is a complete, true and correct transcript of the hearing and testimony taken in this case on July 16, 2008.

July 17, 2008

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